

Highly Pathogenic Avian Influenza A (H5N1) in North America

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Table of Contents

Background	1
Transmission, Clinical Presentation, Diagnosis, and Treatment of HPAI A (H5N1)	2
HPAI A (H5N1) 2024 outbreak in the United States	2
Infected animals.....	2
Infected humans	3
Public Health Response and Risk Assessments	4
Useful Resources.....	5
References	6

Background

Since 1 April 2024 and as of 14 April 2025, the United States (US) has reported 70 laboratory-confirmed human cases of highly pathogenic avian influenza (HPAI) A (H5N1) across 13 states¹. HPAI A (H5N1) is part of the influenza A viruses. There are four influenza viruses (A, B, C, and D) belonging to the *Orthomyxoviridae* viral family²⁻⁴. Only influenza A is believed to be capable of causing a global pandemic and has caused four pandemics since 1900 (**Figure 1**)^{2,5-9}. Influenza A pandemics occur when a new virus emerges that can infect humans and sustain human-to-human transmission^{2,9}. There are over 130 subtypes of influenza A viruses categorised according to numerous haemagglutinin (H) and neuraminidase (N) antigens^{3,10}. Some subtypes, such as H1N1 and H3N2, routinely circulate among humans however, others, such as H5N1, predominantly affect animals with only sporadic human cases^{3,11}.

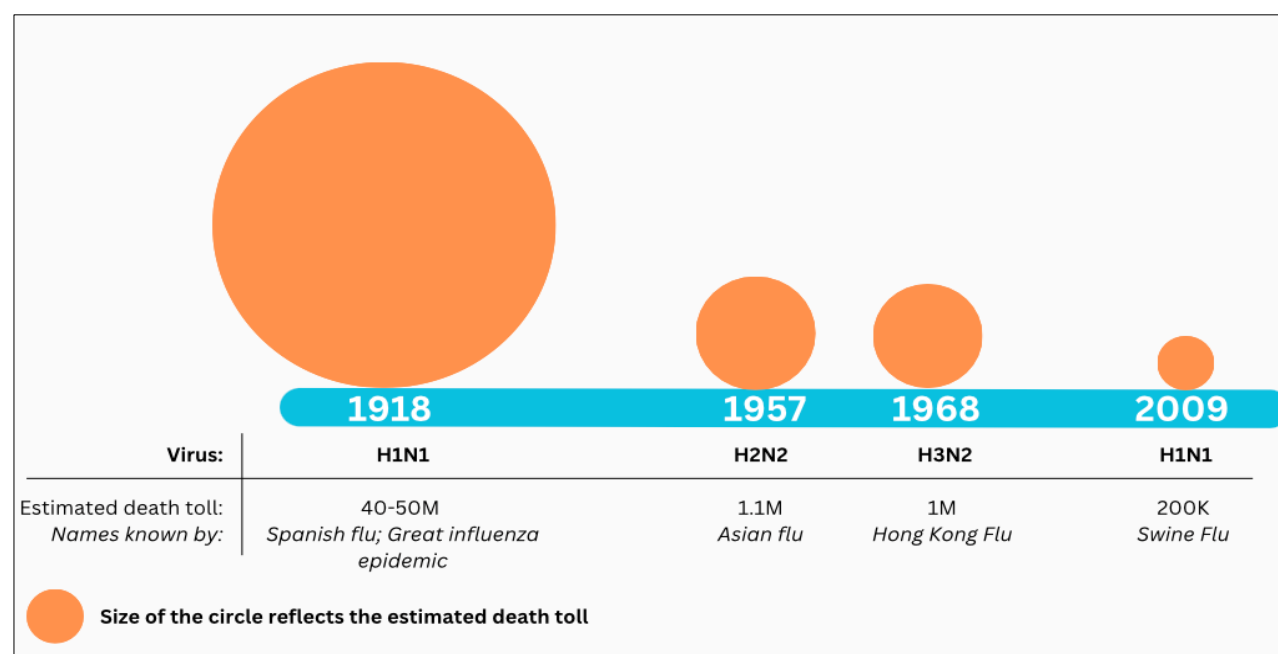


Figure 1:

Pandemics caused by influenza A since 1900

Data used: LePan N. (2020). Visualizing the History of Pandemics. Visual Capitalist. Healthcare. Available from: <https://www.visualcapitalist.com/history-of-pandemics-deadliest/>

Many animals are infected with influenza A viruses that do not easily transmit to humans². Animal influenza viruses are named according to the infected host species, for example, avian, swine, or equine influenza (**Figure 2**)². Avian influenzas (also known as bird flu viruses) infect birds globally and can be categorised according to disease severity: low pathogenicity avian influenza (LPAI) and high pathogenicity avian influenza (HPAI)¹². Some HPAI strains can infect humans such as HPAI A (H5N1).

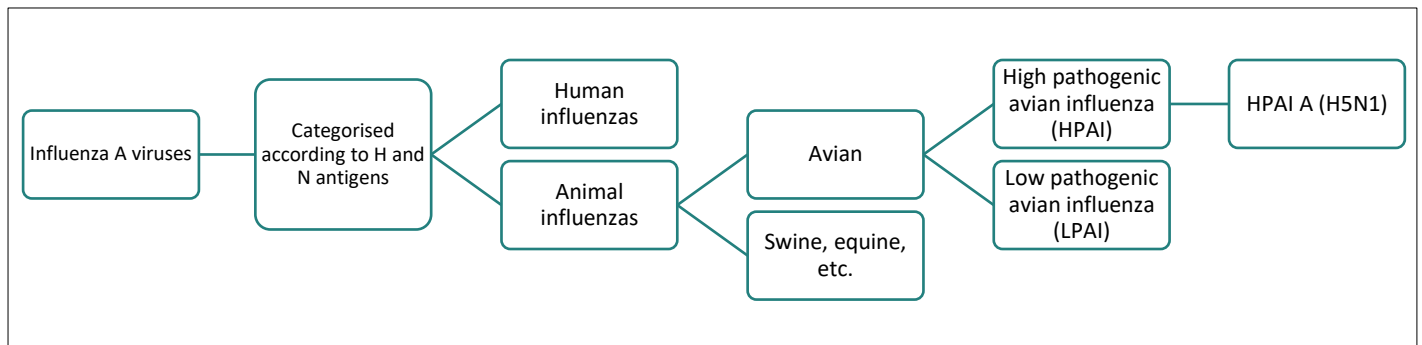


Figure 2: Categorisation of influenza A avian viruses to illustrate the category HPAI A (H5N1) falls under

Transmission, Clinical Presentation, Diagnosis, and Treatment of HPAI A (H5N1)

HPAI A (H5N1) can spread to humans when they come into direct contact with infected poultry or their contaminated environments¹³. Spread from direct contact with infected mammals such as cattle has also been reported however, this is rare¹³. There has been no known sustained human-to-human transmission of the virus yet¹⁴. Humans infected with HPAI A (H5N1) may be asymptomatic or present with mild symptoms of fever, cough, malaise, and a sore throat¹³. In some cases, the disease can become severe and lead to conjunctivitis, respiratory illness, or neurological complications such as seizures^{13,15}. Cases can be treated with antivirals such as oseltamivir and there are four antivirals recommended for use in the US^{13,16}. Vaccination with seasonal flu vaccines does not protect against H5N1¹³.

HPAI A (H5N1) 2024 outbreak in the United States

Infected animals

Since December 2021, poultry, wild birds, and mammals infected with H5N1 have been detected throughout North America¹⁷. Birds are more affected than mammals, and wild aquatic birds are considered to be the reservoir host for avian influenza A viruses^{17,18}. Between January 2022 and 14 April 2025, over 160 million poultry, 12,000 wild birds, and 1,000 dairy cattle, have been infected with HPAI A(H5) viruses across almost all 50 states in the US^{19–21}. The most recent state to become affected by H5N1 is Hawai'i, which confirmed H5N1 cases in a backyard flock of birds on 17 November 2024²². Genetic sequencing of poultry, where available, confirms infection with H5N1 clade 2.3.4.4²³. Infected dairy cattle have only been detected in the US since March 2024, and there is concern that the spread of H5N1 to dairy cattle indicates virus adaptation and the possibility that the virus may become easier to spread to humans^{20,24}. On 29 October 2024, H5N1 was reported in a pig for the first time, in Oregon²¹.

The first infected cattle in the US were reported on 25 March 2024 and involved cattle in two dairy farms in Kansas and one in Texas²⁵. Since then, infected cattle have been reported from 17/50 states²⁰. California has the highest number of affected dairy cattle with over 700 confirmed cases as of 26 March 2025²⁰. Colorado is the second most affected state, with over 60 herds affected as of 13 August 2024²⁰. Within the last 30 days, only California, Idaho, Nevada, and Arizona have reported new cases of infected cattle²⁰. Infected cattle develop a low appetite, reduced milk production, and produce thickened, discoloured milk²⁶. Genetic sequencing so far has confirmed infection with 2.3.4.4b (Eurasian lineage

goose/Guangdong clade)²⁶. The virus has spread between cattle in the same herd, but mortality rates have been recorded as low as 2%²⁶. This is less than the high mortality associated with infected birds²⁶.

On 20 December 2024, the Los Angeles County Department of Public Health issued an animal health alert due to an increase in cases of H5 in domestic cats that had consumed raw cat food or milk²⁷. In addition, Oregon also confirmed the death of a domestic cat due to H5N1 after the cat ate infected raw pet food²⁸. The supplier of this pet food, which caters to 12 US states, has recalled this food²⁸. Twenty wild cats at the Wild Felid Advocacy Center of Washington also became ill with H5N1, including one tiger, four cougars, one caracal, and 14 other types of wild cats²⁷. The rise in cases among domestic cats, while concerning, has not led to any known cat-to-cat or cat-to-human transmission²⁸. Therefore, the CDC maintains that the risk to public health remains low¹⁹. To address the issue of contaminated pet foods, the FDA published a statement on 17 January 2025 alerting pet food manufacturers to the H5N1 hazard²⁹. They stated that evidence suggests H5N1 can be transmitted to domestic pets when consuming undercooked or unpasteurized products from infected cattle or poultry²⁹. Pet food manufacturers are required to reanalyse their food safety plans²⁹.

On 31 January 2025, the USDA Animal and Plant Health Inspection Service (APHIS) National Veterinary Services Laboratory (NVSL) reported a new H5N1 genotype (D1.1) in cattle in Nevada^{30,31}. This genotype was identified as part of the USDA's National Milk Testing Strategy (NMTS), which 38 states are enrolled in^{30,31}. On 13 February, USDA announced the detection of the D1.1 genotype in cattle in Arizona and suggests this indicates increased spillover events from wild birds to dairy cattle³². The D1.1 genotype has been found in wild birds, mammals, and poultry in the US³⁰. However, this is the first time it has been detected in cattle^{30,31}. Prior genotypes identified in cattle relate to B3.13³⁰. The D1.1 genotype has been detected in two severe H5N1 human illnesses in North America³³.

Infected humans

Infection with HPAI A (H5N1) in humans is rare, and only sporadic infections have been reported in the US due to close contact with infected animals¹⁴. Between 1 January 2024 and as of 14 April 2025, 70 human cases of H5 (some of which have been confirmed as H5N1, however it is likely all are H5N1) have been reported from Colorado (n=10), Michigan (n=2), Missouri (n=1), Texas (n=1), Washington (n=11), Oregon (n=1), Ohio (n=1), Iowa (n=1), Louisiana (n=1), Wisconsin (n=1), Nevada (n=1), Wyoming (n=1), and California (n=38)¹⁹. Due to low viral RNA levels, the US has not been able to determine the neuraminidase subtype as N1 for all cases³⁴. Most cases developed eye redness and conjunctivitis, but some reported mild respiratory symptoms³⁵. All cases except for three had known contact with infected or sick animals^{19,36}. On 22 November 2024, the CDC reported a confirmed HPAI A (H5N1) case in a child in California³⁷. This was the first child affected in the US³⁷. Household members reported having symptoms however, they tested negative for H5N1 and positive for other common respiratory viruses³⁷. The CDC maintains that this is not indicative of person-to-person transmission³⁷. A second child affected by H5N1 was reported from California on 10 January 2025. Both children developed a mild illness^{37,38}.

Before 2024, only one human case of HPAI A (H5N1) infection occurred in 2022 after exposure to infected poultry³⁹. There has not been any case of human-to-human transmission yet, although a recent study suggests that the virus can be transmitted to the upper respiratory tract of humans, which could facilitate human transmission^{19,40}. Another study demonstrated that H5N1 from an infected human was able to transmit through air to ferrets⁴¹. While there is evidence that consumption of untreated raw milk from infected cattle could transmit the disease to other animals and pose a risk to humans, the US Food and Drug Administration (FDA) maintains that the commercial milk supply is safe^{42,43}. To gain a better understanding of the prevalence of H5N1 in raw cow's milk, a double-blind study for gathering purposes only will sample Grade "A" raw cow's milk from dairy processing facilities for detection of H5N1⁴². A serosurvey study of workers exposed to infected dairy cattle when milking cows or cleaning milk parlours,

found that 8/115 had evidence of recent infection⁴⁴. Only four recall having had any symptoms, mainly conjunctivitis^{44,45}. This evidence highlights the need for strong, active monitoring of exposed workers⁴⁴.

On 13 November, Canada reported its first domestically acquired human case of H5N1⁴⁶. This was confirmed in a teenager in British Columbia⁴⁶. Genomic sequencing showed the virus is related to the H5N1 virus that currently affects poultry in British Columbia: clade 2.3.4.4b, genotype D1.1⁴⁶. At the time, this was different from the genotype circulating in cattle in the US⁴⁶. The previously healthy teenager was hospitalised and in critical condition⁴⁶. Investigations were unable to determine how this individual became exposed to the virus^{46,47}. No other cases have been reported so far, and the Canadian government advises the risk to public health remains low⁴⁶. The virus affecting this teenager has shown some mutations suggesting adaptation to humans, which has raised some concerns and may explain the severity of the illness⁴⁸. However, there remains no evidence that the virus can be transmitted from human to human⁴⁸.

Most cases in the US have developed mild symptoms so far, and the identification of asymptomatic cases has raised concerns that the virus could be spreading undetected^{49,50}. In a serosurvey of 150 veterinarians, three had tested positive for recent exposure to H5N1⁵⁰. The veterinarians had unknowingly been infected with the virus and did not have any symptoms⁵⁰. Two veterinarians stated they had no exposure to animals with known or suspected H5N1 infections⁵⁰. While most cases have been mild, there have been four cases in the US so far that required hospitalisation⁵¹. On 6 January 2025, one H5N1 case in Louisiana died⁵². This is the first death from H5N1 in the US. The individual was 65 years old with underlying medical conditions and was exposed to sick and dead birds suspected of having H5N1^{52,53}. Genomic analysis reveals that genetic sequences in the specimen collected from the individual affected in Louisiana differ from those found in cattle and poultry⁵⁴. The analysis found mutations that had likely emerged during the individual's illness^{54,55}. These mutations may enable greater transmission of the virus and upper airway infection⁵⁵. In addition, one of the changes identified was also found in the infected teenager from British Columbia^{54,55}. This suggests that viral changes have occurred during illness in individuals who suffered severe illnesses⁵⁵. The CDC states that while these changes are concerning, they would be more concerning had they been found in animal hosts or occurred in the early stages of infection⁵⁴. There has been no known onward transmission of H5N1 from the Louisiana case⁵⁴.

Public Health Response and Risk Assessments

Risk Assessments

While the spread of H5N1 to cattle and between cattle has caused some concern about the transmissibility of the virus, the US CDC states that as of 28 February 2025, the risk of H5N1 spread to the public is low⁵⁶. However, the risk to populations in contact with potentially infected animals or contaminated surfaces is moderate to high⁵⁶. This is in line with the Food and Agriculture Organization (FAO), the World Health Organization (WHO), and the World Organisation for Animal Health (WOAH) which also state the risk to the public is low however, the risk to persons exposed is low to moderate depending on the nature of the exposure⁵⁷.

Surveillance

An NIH-funded study by Lin et al. found that one mutation of the virus, called Q226L, could lead to increased human-to-human transmissibility and a pandemic. The US CDC continues to monitor the situation closely to identify any genetic changes that could suggest increased transmissibility, increased disease severity, and reduced susceptibility to antivirals⁵⁸. They are also conducting wastewater surveillance to complement influenza surveillance systems however this cannot distinguish the subtype or source of influenza A viruses³⁹. Even with a strong surveillance system, there are several barriers to detecting H5N1 in humans and the likely number of infections may be higher than what is reported⁵⁹. Barriers to detection include asymptomatic infection, limited access to rural farm workers who may be

hesitant to seek medical care (especially without health insurance or with concerns about immigration status), and a lack of incentive to report infections in cattle⁵⁹.

H5N1 vaccination and protection

As part of a CDC initiative, over 100,000 seasonal influenza vaccine doses have been administered to individuals from 12 states with infected dairy cattle⁶⁰. The vaccine does not protect against H5N1 however, it could reduce illness severity⁶⁰. Further, with a reduction in seasonal influenza, HPAI (H5) cases may be better detected⁶⁰. In addition, the USDA has approved two vaccine candidates for research trials to develop vaccines that protect cattle from H5N1²¹. On 19 February 2025, Canada announced that it had purchased 500,000 doses of GSK's vaccine Arepanrix™ H5N1 A/American wigeon clade 2.3.4.4b, currently listed by the WHO as a candidate vaccine virus^{61,62}. In addition to vaccination of cattle, a recent study, published on 17 April 2025, demonstrated that dairy cows develop protective immunity against H5N1 (clade 2,3,4,4b; genotype B1.13) after primary infection⁶³.

CDC Recommendations

A recent survey study of dairy farmworkers in Colorado found that very few used respiratory personal protective equipment (PPE) when working with confirmed infected cattle⁶⁴. Less than half of workers report using eye protection⁶⁴. Considering recent evidence, the CDC has expanded recommended testing to all individuals (including asymptomatic) who have been exposed to infected animals, particularly if PPE was not worn⁴⁵. In addition, the CDC now recommends offering Oseltamivir (Tamiflu) to all exposed individuals regardless of symptoms⁴⁵. However, one study demonstrated that H5N1 extracted from an infected human was less sensitive to oseltamivir and more sensitive to favipiravir, baloxavir marboxil, and zanamivir⁴¹. A more recent study by the CDC found that H5N1 clade 2.3.4.4b remains susceptible to the current antivirals available and does not support making any changes to the current recommendations for antiviral treatment of human cases^{65,66}.

USDA Strategy to Address Avian Flu

On 26 February 2025, the US Secretary of Agriculture announced a five-pronged strategy plan to tackle H5N1, protect poultry, and lower egg prices⁶⁷. This plan includes⁶⁷:

- A \$500 million investment in biosecurity measures for US poultry producers and expanding Wildlife Biosecurity Assessments
- A \$400 million investment to aid farmers and accelerate repopulation of poultry
- The removal of unnecessary regulatory burdens to reduce the cost of eggs
- A \$100 million investment in vaccines, therapeutics, and other strategies for protecting chickens and reducing depopulation.
- Considering a temporary increase in egg importations

The USDA also announced on 10 April 2025, that it is awarding over \$15.3 million to enhance prevention, preparedness, early detection, and response⁶⁸.

Useful Resources

- Pandemic PACT has a dedicated [H5N1 page](#) in the Outbreak section of the website which provides information and analyses of active mpox research and funding globally since 2020.
- The most up-to-date information and guidance can be found on the US CDC's [webpage](#) dedicated to H5 Bird Flu.
- The US Department of Health and Human Services has published '[U.S. Highly Pathogenic Avian Influenza a\(H5N1\) Research Priorities: October 2024](#)'.

- The US CDC published a [‘Public Health Science Agenda for Highly Pathogenic Avian Influenza A\(H5N1\)’](#) with strategic priorities to guide research and surveillance activities.
- NIAID published a [‘Research Agenda for 2024 H5N1 Influenza – May 2024’](#).
- The WHO published a [‘Summary status of development and availability of A\(H5N1\) candidate vaccine viruses and potency testing reagents’](#) in February 2024.
- PAHO launched an [interactive dashboard](#) for H5N1 in the Americas.
- ANRS publishes a [monthly scientific review](#) on H5N1 highlighting relevant research, guidelines, and news updates.

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