



RISK PROFILES OF FOOD-BORNE PATHOGENS AVIAN INFLUENZA A VIRUS

A recent outbreak of highly pathogenic avian influenza (HPAI) in dairy cows has created public health concerns about the potential of consumers being exposed to live virus from commercial dairy products. Generally, the transmission of the pathogen via infected food, primarily eggs and milk, cannot be ruled out. However, infections of humans with the bird flu virus are rare, and direct and close contact with infected birds or other animal species appears to be the main transmission route to humans. The consumption of pasteurized milk from cattle possibly infected with the bird flu virus is not considered to have any adverse health effects, as the virus - like other pathogenic microorganisms - is efficiently inactivated by heating. Based on current limited evidence, the possibility that avian influenza A viruses could be transmitted to humans via consumption of raw milk or raw-milk products (e.g., cheese) from infected cows cannot be entirely excluded.



Hazard Identification

Background: Since 2021, highly pathogenic avian influenza (HPAI) A(H5N1) has spread globally among wild birds and poultry, causing millions of avian deaths and repeated spillover infections to mammals, particularly predators. In March 2024, the virus was unexpectedly detected in dairy cattle in the United States—a species generally regarded as resistant to influenza A viruses [1, 29].

HPAI H5N1 (clade 2.3.4.4b) has been shown to cause mastitis-like illness in dairy cows. In February 2024, an outbreak in Texas was attributed to H5N1 genotype B3.13. Affected cattle exhibited fever, anorexia, reduced milk production, and abnormal milk consistency. Viral replication occurred predominantly in the mammary glands, with infectious titers exceeding 10^8 focus-forming units (FFU)/mL in milk. Transmission to other species, including cats, mice, and poultry, was documented [2].

Subsequently, a separate introduction of genotype D1.1 was identified in U.S. cattle and has been linked to severe human infections, including a fatal pediatric case in Mexico. The exceptionally high viral loads detected in milk underscore significant public health concerns regarding the consumption of unpasteurized dairy products [2].

Types and Strains: Influenza A Virus (IAV) subtype nomenclature uses the haemagglutinin (H) and neuraminidase (N) surface proteins because of their major importance to the pathogenicity of the virus. 18 HA subtypes (H1-H18) and 11 NA subtypes (N1-N11) are known. [16]

H5N1 influenza viruses are further classified into lineages and clades based on genetic differences, reflecting the virus's evolution and spread across different regions and ecosystems. An influenza clade or group is a further subdivision of influenza viruses (beyond subtypes or lineages) based on the similarity of their HA gene sequences [16].

Table 1: Characteristics of the virus

Characteristics of the virus H5N1	
Family	Orthomyxoviridae
Genus	Alphainfluzavirus
Species	Influenza A Virus (IAV)
Subtype	H5N1
Clade	Highly pathogenic avian influenza viruses of subtype H5N1 (clade 2.3.4.4b) genotype B3.13 and D1.1
Envelopment	enveloped
Genome	Single-stranded negative-sense segmented RNA (ssRNA(-))
Size	14 kb
Morphology	Spherical (80-120nm) or Filamentous (up to 20µm)
Replication	Respiratory tract (mainly) Systemic (HPAI)

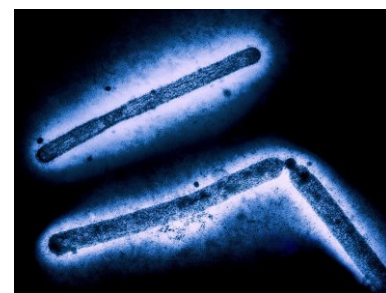


Figure 1: Three influenza A (H5N1/bird flu) virus particles (filamentous) Credit: CDC and NIAID.

Stability and inactivation: IAV virions are very labile, but several studies showed maintenance of infectivity for months in cold water and over a week in 22°C water. pH 7.0 - 8.5 and low ammonia concentrations support the viral tenacity. In aerosolized droplets, infectivity remains up to 1-24hr [2- 5].

Thermization can inactivate H5N1 in milk, but mild and/or short treatments are insufficient. Heating at 50 °C for 10 min or 30 min only slightly reduces viral titers (0.83–2.42 log EID₅₀¹) [2,3]

Pasteurization can effectively inactivate H5N1, as well as H1, H3, H7, H9, and H10 viruses in raw milk. H3 shows the highest thermal stability, while H5N1 clade 2.3.4.4b is moderately stable [9]. Pasteurization at 63 °C for 30 min or 72 °C for 15s achieves complete (>6 log) or near-complete reduction of H5N1 [3,10]. Thus, thermally pasteurized milk poses no influenza virus risk to consumers [2,8 -10, 28].

Viruses remained stable at pH 6–10, were partially inactivated at pH 5, and fully inactivated at pH 4 [2]. Milk acidification to pH 4.1–4.2 inactivated LPAI H6N2 and HPAI H5N1 within 6 hours [12, 28].

UVC, including far-UVC, is suitable for the inactivation of influenza viruses in UVC-transparent liquids and aerosols, including H5N1. Since only very small irradiation doses are required for 90% inactivation, reductions of several orders of magnitude can be achieved within seconds or minutes [21].

Persistence on surfaces: H5N1 and H1N1 viruses can remain infectious on milking equipment for several hours, highlighting the risk of transmission from contaminated surfaces during milking [22].

Persistence in milk: H5N1 influenza viruses can remain infectious in bovine milk for several weeks, indicating that contaminated milk may pose a transmission risk [6].

Table 2: Inactivation and Stability of IAV H5N1

Stability and Inactivation	
Thermal stability	<p>Thermization</p> <ul style="list-style-type: none"> 50 °C for 10 min or 30 min only slightly reduces viral titers <p>Pasteurization</p> <ul style="list-style-type: none"> 72°C, 15 sec reduces infectious H5N1 HPAI titers in bovine milk significantly [8,9] 63°C for 30 min led to complete inactivation (>6 log) of H5N1 clade 2.3.4.4b.[3,10]
D-value	<p>$D_{4°C} = 10.7$ days</p> <p>$D_{50°C} = 7.19$ min</p> <p>$D_{52°C} = 4.74$ min</p> <p>$D_{54°C} = 2.04$ min</p> <p>$D_{60°C} = (\text{approx.}) 1.04$ s</p> <p>$z = 9.93°C$ to $10.33°C$ [all data from 3]</p>

¹ Measures infectivity of the virus: 1 EID₅₀ is needed to infect 50% of inoculated embryonated chicken eggs..

Salt	?			
pH	<ul style="list-style-type: none"> stable at pH 6–10 partially inactivated at pH 5, fully inactivated at pH 4 [2]. <p>Milk acidification to pH 4.1–4.2 inactivated LPAI² H6N2 and HPAI¹ H5N1 within 6 hours [12].</p>			
UV	Median dosage, for reduction of H5N1 by 1 log in UVC-transparent liquids in the UV range 251–270 nm is 3.60 mJ/cm ² [21].			
Persistence on surfaces		Temp. (°C)	Rel. H.* (%)	Half Life (Days)*
	PP ¹⁾	4	80	1.4
		22	65	0.11
	Steel ²⁾	4	80	1.2
		22	65	0.14
	Rubber	4	80	0.51
22		65	0.14	
*Half-life values represent the time for a 50% reduction in infectious virus titer. * Relative Humidity ¹⁾ Polypropylen ; ²⁾ Stainless Steel [6, 22].				
Persistence in milk	H5N1 influenza viruses remain infectious in bovine milk for 4 weeks at 4 °C. [2,3,8].			



Hazard Characterisation

H5 bird flu is widespread in wild birds worldwide and is causing outbreaks in poultry and U.S. dairy cows with several recent human cases in U.S. dairy and poultry [13] workers. In the United States, most reported human cases of avian influenza A(H5) virus infection have been mild and occurred in individuals with known exposure to sick or infected animals. Illness severity ranged from mild to fatal (one case). Clinical manifestations varied, with conjunctivitis being the predominant symptom in recent U.S. cases, alongside respiratory symptoms and fever [13].

In Switzerland, the FOPH is continuously monitoring developments and risks [20].

Symptoms range from mild flu-like illness or eye inflammation to severe respiratory disease and death, depending on the virus and host factors [16]. Disease severity will depend upon the virus causing the infection and the characteristics of the infected individual [16]. Eye redness has been the predominant symptom among recent U.S. cases of avian influenza A(H5) virus infection. Avian influenza usually lasts a few days to less than two weeks, but how long symptoms last can vary by person. People who are severely ill (for example, intubated for severe pneumonia and respiratory failure) may be sick for several weeks.

² LPAI: Low Pathogenic Avian Influenza Virus; HPAI: High Pathogenic Avian Influenza Virus

People are thought to be most contagious during the first few days of their illness [13]

People with severe disease (e.g., pneumonia) requiring hospitalization may have high levels of virus in the lower respiratory tract and may be contagious for several weeks [15].

Table 3: Disease Characteristics

Disease Characteristics	
Incubation Period	2 to 7 days eye symptoms such as redness and irritation can occur one to two days after exposure [15].
Mode of actions	Most human infections have happened after exposure to infected animals [20]. Very rare, limited person to person spread has occurred [15].
Symptoms	Mild symptoms may include: <ul style="list-style-type: none"> eye redness/irritation (conjunctivitis), mild fever (≥ 37.8 °C), feeling feverish cough, sore throat, runny or stuffy nose, muscle aches, headache, and fatigue [15,16]. Moderate to severe symptoms may include: <ul style="list-style-type: none"> high fever, shortness of breath, difficulty breathing, altered consciousness, or seizures [15,16].
Types of viruses	Five subtypes of avian influenza A viruses are known to have infected people. A/H5, A/H6, A/H7, A/H9, and A/H10 viruses. Among these, A/H5, A/H7 and A/H9 viruses have caused the most human infections [15].
Progression	<ul style="list-style-type: none"> Avian influenza typically lasts a few days to under two weeks. Duration varies by individual; severe cases may persist for several weeks [15].
Infectious period	<ul style="list-style-type: none"> People are most contagious in the first few days of illness [13]. Severe cases may remain contagious for several weeks [15].
Shedders	A case study reported a subclinical H5N1 infection in a human who did not develop symptoms, yet viral shedding was observed [25]. Some people who have had bird flu in the United States have reported no symptoms [15].
Vulnerable populations	Factors influencing the risk of severe illness from avian influenza include <ul style="list-style-type: none"> advanced age, delayed initiation of medical treatment,

	<ul style="list-style-type: none"> pre-existing medical conditions [15].
Prophylaxis (Food)	As the virus is sensitive to high temperatures, no adverse health effects are to be expected if the food has been well cooked [23].

Occurrence: To date, there has been no laboratory-confirmed case of H5N1 in humans in Switzerland.

Table 4: Epidemiological Situation in Switzerland

Epidemiological Situation in Switzerland	
Reported cases (Influenza A and B Virus)	See: Federal Office of Public Health (FOPH) Infectious Disease Dashboard for latest data and trends of Influenza type A.
Mandatory reportable disease	Yes



Exposure Assessment

Transmission: The high genetic diversity of the H5N1 influenza viruses in Texas cattle suggests that the bovine B3.13 outbreak originated in Texas and rapidly spread to other states [18]. The virus is likely to have spread by transport of infected cattle or equipment [18]. Large numbers of infectious particles are generated when milk is expressed manually from the udder [18]. Milk from clinically affected cows appears visibly abnormal, typically presenting as thickened and yellowish. [26].

Contaminated milking equipment is thought to be an important mode of H5N1 transmission between cattle from the same farm [18, 29].

Spillover from cattle to domestic barn cats probably occurs through ingestion of contaminated, unpasteurized milk. However, scavenging dead birds is also a way for cats to become infected. The detection of HPAI A(H5N1) clade 2.3.4.4b in U.S. dairy cattle marked a significant expansion of the virus's host range [18].

Influenza A viruses, particularly A(H5N1), can replicate in mammalian gastrointestinal tissues. Studies indicate that ingestion of virus-containing material may serve as a non-respiratory infection route, with Influenza A virus detectable in intestinal tissues following multiple exposure pathways [23].

Food: H5N1 viruses were completely inactivated when incubated with yoghurt at pH 4.2. Incubation of the avian low pathogenic H5N1 virus with soft and semi-hard cheese at pH 5.0–5.3 reduced infectious titers by 5.1 and 3.9 log₁₀, respectively. In contrast, the infectivity of highly pathogenic bovine H5N1 was only minimally reduced following incubation with semi-hard cheese [2]. In a nationwide survey of 167 retail dairy products (cheese, butter, ice cream, and fluid milk), in the US, 17.4% (29/167) tested positive

for viral RNA by qRT-PCR, but none contained infectious virus in embryonated egg assays, indicating that the absence of reproducible virus. Sequencing of the hemagglutinin gene from fragmented viral RNA showed that all RNA-positive samples closely matched previously reported HPAI dairy cow isolates [7].

Based on current limited evidence, the possibility that avian influenza A viruses could be transmitted to humans via consumption of raw milk or raw-milk products (e.g., cheese) from infected cows cannot be excluded [15, 23,28]. Experiments by Nooruzzaman et al. [28] showed that ferrets fed H5N1-contaminated raw milk became infected, unlike those given raw-milk cheese or cheese suspension.

So far, there is no evidence suggesting that humans can be infected by raw eggs or raw sausage products containing poultry meat from infected animals [23]. However, it has been proven that eggs of infected animals can contain the virus both on the shell and also in the egg white and yolk [23].

Safe handling of raw meat and other raw food ingredients, thorough cooking and good kitchen hygiene can prevent or reduce the risks posed by contaminated food in general as well as for Avian Influenza [14, 23].

Table 5: Main Sources and Transmission Routes of highly pathogenic Influenza A viruses

Main Sources and Transmission Routes	
Main Reservoir	Wild aquatic birds (such as ducks, geese and swans) are the natural reservoir hosts for H5N1 [18].
Main source of infection	Mainly two ways [14]: <ul style="list-style-type: none"> • from direct contact with infected animals • from contaminated environments
Transmission via food	To date, there is no convincing evidence that Avian Influenza can be transmitted to humans through the consumption of contaminated food [11]
Transmission via Pet-Food to households	Los Angeles County reported HPAI A(H5N1) in an indoor cat after eating raw pet food [27].
Transmission via asymptomatic cows	It cannot be ruled out that asymptomatic cows are infected with H5N1 [26].
High risk food items	<ul style="list-style-type: none"> • Raw milk and raw milk products • Freeze-drying³ of powdered milk products is likely to inactivate infectious virus, although some uncertainty remains [19]. • Raw Eggs • Raw sausage products containing poultry meat
Secondary spread	Very rare, limited person to person spread has occurred [15]
Populations at elevated risk for infection	People with close or prolonged contact with infected birds or other infected animals or contaminated environments are at greater risk. [15]
Highly pathogenic avian influenza virus detection in Europe	see: EFSA Dashboard [17]
Major Outbreaks	Ongoing outbreak in the USA: H5N1 Bird Flu, Human Cases in U.S. (CDC) [13].

RESOURCES

- Website of the Federal Food Safety and Veterinary Office: [HPAI – Situation in Europe](#)

CONTACTS

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³ Freeze drying is complex and expensive and involves slowly freezing the milk at -50°C to -80°C. Milk is then subjected to low heat and low pressures in a partial vacuum, which helps a process called sublimation turning ice from solid state to

gas. The gas is then condensed and collected, leaving behind a dry powder [19]

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