

Consequence of Avian Influenza Transmission to Dairy Cattle and Associated Risk of Human Infection Through Virus Contaminated Milk: A Brief Report

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Abstract

Recently in March 2024 scientists have observed that dairy cattle from the USA have been infected with avian influenza virus. The live virus particle was detected in the milk sample and nasal washing of the affected cow. How the infection has gone to the cow is unknown and can't be confirmed. The role of wild migratory birds in virus spreading has been predicted. Presence of live virus particles in milk highlights the public health risk. The infected cow did not show any specific symptoms except reduced feed intake, abrupt drop in milk yield. Milk of the affected cow was colostrum like a thickened creamy yellow. Infection was recorded in older cows mostly during middle or late lactation. Most of the animals recovered. Virus infection in two dairy farm workers has confirmed the transmissibility of the virus to human through direct and close exposure to raw milk and secretions from the infected dairy cows. The course of disease in those affected farm workers was mild and symptoms subsided early with oseltamivir taken orally for five days. As per experts' opinion pasteurization is safe for virus-containing milk for human consumption. However, milk from cattle is the source of infection so we must remain vigilant for early detection.

Keywords: Milk; Cow; Infection; Pasteurization

Introduction

From Ancient Information to Present Confirmation

In the present information-driven world, people ranging from layman in remote village to highly educated professor of a college is fully aware of bird flu. The term 'flu' commonly refers to the influenza group of viruses. Avian influenza, commonly referred to as bird flu, had been observed among avian species for an extended period. The earliest report of isolation and identification of influenza virus with laboratory

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confirmation is known only in 1932 [1]. However, avian influenza was scientifically confirmed in 1955 by the German researcher Werner Schäfer. Schäfer conducted critical experiments on the avian influenza virus in animal subjects at the Kaiser Wilhelm Institute for Biochemistry located in Tübingen, Germany [2]. The influenza viruses, are grouped under family Orthomyxoviridae, characterized by eight segmented, negative-strand RNA genomes [3]. Until 1997, the infectivity of avian influenza in the human population had not been recognized [4]. The bird flu virus currently circulating among avian species is categorized as High-Pathogenic Avian Influenza Type A (HPAI) H5N1. The H stands for Hemagglutinin (HA) and N represents Neuraminidase (NA). These two proteins are highly immunogenic in character expressed in the form of spike like projections on viral envelop. Due to genetic reassortment a large number of combinatorial forms of "H" and "N" proteins are designed, therefore HA and NA protein

combinations display antigenic diversity among virus strains. This ongoing reassortment of genomic RNA in nature has led to the global appearance of highly diverse avian influenza A(H5N1) strains [5]. There are several types of influenza viruses affecting animals and human population, those are influenza A, B, C and D, out of these type A influenza virus affects birds. The first recognized human case of influenza due to the Avian Influenza A(H5N1) virus was recorded in Hong Kong in May 1997, where a 3-year-old child was infected and ultimately succumbed to respiratory failure [4]. Although avian influenza viruses predominantly infect bird species, they are highly competent at crossing species barriers. A single nucleotide substitution in the viral RNA genome can be sufficient to alter host specificity and enable cross-species transmission. Consequently, nearly one thousand human infections were reported by 2013, with an observed case fatality rate of approximately 40%. Through the accumulation of adaptive mutations, the virus has acquired the capacity to infect human and murine cells without compromising its replication efficiency in avian hosts [6].

Cross-Species Transmission of Virus

Based on this information, it might be assumed that strict vegetarian or vegan groups who consume dairy products but avoid poultry meat would remain safe from avian influenza. However, the outbreak of avian influenza virus in dairy cattle herds in the United States in March 2024 challenges this assumption, demonstrating that exposure risk is not limited to direct contact with poultry or poultry products [7]. The emergence of avian influenza virus infections in dairy herds has raised global concerns regarding the safety of dairy products. However, the precise mechanisms by which the avian influenza virus crossed the species barrier to infect cattle have not yet been fully elucidated [7]. The predicted way how the avian influenza has crossed the species barrier to infect cattle can be elucidated by graphical representation however this may not be the absolute (Fig. 1).

The avian influenza A (H5N1) viruses affecting wild birds in North America are closely related to a strain found in infected cattle in the U.S. While ostriches are usually considered less susceptible to H5N1 infection an outbreak at Universal Ostrich Farms in British Columbia in 2024 resulted in the deaths of 69 ostriches, with the virus belonging to the same lineage that has severely impacted domestic and wild poultry population over last five years [8]. For the first time the spillover of H5 influenza viruses to vampire bats at the marine-terrestrial interface has been reported [9]. Scientists failed to find exact clue how the virus of birds crossed the species barrier [7]. Simultaneously, the researchers believe that this H5N1 virus has entered through migratory birds crossing Trans-Atlantic flyway from Europe in late 2021 [10]. Obviously, question may arise how does a cow get infected by a bird flu virus? In a recent manuscript Yoshihiro Kawaoka, an eminent influenza virus specialist has mentioned that last year outbreak of bird flu in cattle is due to single introduction of high pathogenic avian influenza virus into this new host, however the exact events that resulted in the introduction of high pathogenic avian influenza virus into cattle are not known and may never be known [11]. Nevertheless, the exact answer is not in hand yet it has been predicted that to a certain extent both birds and cows have mixing of habitat and sharing of common water trough is major source of virus transmission [12].

It has been predicted that in late 2021 the H5N1 virus entered US soil from Europe through migratory birds [10]. According to Yoshihiro Kawaoka, the exact events by which the HPA(H5/N1) virus has infected American dairy herds are not known and may never be known [11]. Sharing of common water trough is major source of virus transmission from birds to cow is justifiable [12]. This can be depicted by a representative figure prepared by Google Gemini (Fig. 2).

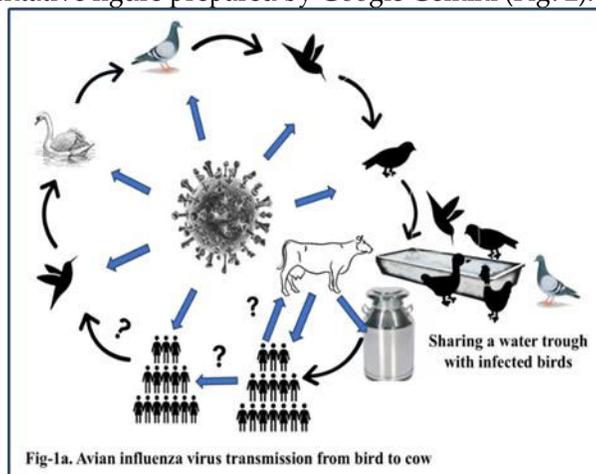


Figure 1: The species barrier to infect cattle can be elucidated by graphical representation.

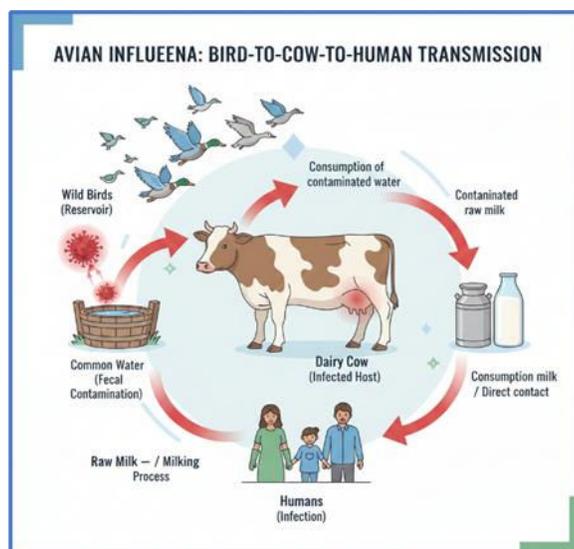


Figure 2: Source of virus transmission from birds to cow.

When large number of cattle without any specific symptom became sick with reduced milk yield, initially scientist failed to understand the situation as influenza virus infections in cows have been rarely observed and never recorded earlier. The affected cows were off-fed, reduced milk yield and sometimes the milk was thick yellow-hued. Due to lack of specific symptoms in affected cows it remains undetected for a considerable period. Subsequently a large number of cases spreading over 16 states of USA dairy herds was recorded updated till 17th January 2025 [13]. High-pathogenic avian influenza subtype H5N1 is presently found throughout the United States and possibly beyond. The rise in cattle infections heightens the risk of the virus acquiring the ability to transmit between humans, potentially leading to severe fatality rates. According to a recent report in December 2023 a single transmission event from a wild bird to dairy cattle has resulted in further transmissions to poultry, peridomestic birds and other mammals. The movement of asymptomatic dairy cattle has facilitated the spread of H5N1 from Texas across the nation. Genetic analysis through deep sequencing has revealed low-frequency variants associated with mammalian adaptation and increased transmission efficiency [14]. The US government was in cross road to give right kind of advice to their citizens; whether they should consume or avoid cow milk as bird flu viral RNAs have already been detected in milk samples collected from consumer market.

Virus Detection and Human Transmission

Detection of high pathogenic avian influenza type A (H5N1, clade 2.3.4.4b) viruses in unpasteurized milk samples from multiple states of the United States of America is a matter of human health concern blowing an alarming signal of food-borne zoonosis. Presence of live virus particles from pooled milk samples of affected cows were estimated which ranged from 10^4 to 10^5 TCID 50 per milliliter [15]. Simultaneously, viral load was significantly high $10^{7.3}$ to $10^{7.8}$ TCID 50 per milliliter in the mammary gland tissues (udder tissues) of the affected cows. Frequency of virus shedding was more in milk samples than the nasal secretion of affected cows. Virus shedding was initially high but beyond 6 days till 31 days of investigation the shedding of virus was negative in PCR. The above finding has shown efficient transmission of avian influenza virus to cattle with high viral tropism towards mammary gland tissues that may be the rich source of infection to human population [15]. Reviewing the data published by Caserta and his group, Max Kozlov, a prominent science journalist of Nature, suggested that the milking process might have provided the substantial evidence needed to link it to viral transmission across cattle, other animal species and humans [15,16]. One of the recent studies have identified key avian influenza receptors within the mammary glands, providing a biological niche where the virus can flourish making the milking process a significant risk for transmission [17]. As scientific information available to the public, informed citizens may find themselves questioning the safety of pasteurized milk for human consumption. The scientific community considers this matter to be a significant public health concern, necessitating careful examination and discussion [18]. In March 2024, a significant development occurred when a dairy farm worker in Texas tested positive for the bird flu virus. This case is notable because it represents the first documented instance of the avian influenza virus being transmitted from a mammalian species to a human [19]. Historically, bird flu has primarily been known to spread from birds to humans, highlighting the emerging risks associated with zoonotic diseases. This incident raises important questions about animal health, biosecurity on farms and the potential for further transmission between species [4]. The subsequent case

was identified in Michigan on May 22, 2024 [20]. This was followed by an additional case reported by the U.S. Centers for Disease Control and Prevention (CDC) in Atlanta on May 30, 2024. The symptoms observed in affected individuals were akin to those of common cold and flu-like illnesses [20]. Notably, there were reports of eye discomfort accompanied by watery discharge, as well as coughing; however, these cases did not present with fever [20]. According to a recent publication, a total of 70 human infections with bovine-origin avian influenza A(H5N1) had been reported in the United States as of 10th November 2025 [9]. The detection of the virus in the Michigan patient was confirmed through PCR testing. Notably, the patient's symptoms alleviated within 24 hours following the administration of medication [20]. On December 13, 2024, the Centers for Disease Control and Prevention (CDC) confirmed the first severe human case of an illness in a patient admitted to a hospital in Louisiana, United States. The patient unfortunately succumbed to the illness on January 6, 2025, as reported by CDC [21]. Fragments of RNA from the highly pathogenic avian influenza virus have been identified in milk samples collected from 10 states across the United States. Nevertheless, the U.S. government has assessed that there is no associated risk to human health, likely due to the inactivation of the virus during the pasteurization process [22]. A comprehensive analysis of raw milk samples collected from four infected cows indicated that the infectious virus could be detected for a duration of up to 22 weeks when stored at a temperature of 4°C [23]. This report may hold academic value, but it highlights the prolonged viability of this virus in raw milk stored at low temperatures. However, it does not address the viability of virus in pasteurized milk that is available in the consumer market. In a similar vein, the detection of Hemagglutinin (HA)-binding antibodies in specific milk samples from states experiencing recent or ongoing outbreaks has been verified. These antibodies present in the milk have demonstrated the ability to neutralize the replicating virus that expresses hemagglutinin and Neuraminidase (NA) found in dairy cattle [24]. Additionally, U.S. agricultural authorities have begun screening dairy cows near infected poultry flocks for the avian influenza virus. Several states have instituted a mandatory requirement for the testing of lactating cows for avian influenza prior to their participation in animal fairs or transportation to other states within the United States.

Criteria for Grey Area

The question of whether the virus will become a permanent presence and whether we must learn to live with this virus is yet to be answered by scientific advisors. However, it is important to note that the virus seldom results in severe or lasting disease in cattle [24]. Scientific advisors from the USDA and CDC have noted that while the virus was initially viewed as an "outbreak," its continued detection throughout 2024 and 2025 suggests it may be settling into a long-term cycle within the dairy industry. Similarly, it is uncertain whether the virus could burn out and eliminated by itself with time or more cows are vulnerable to re-infection is unknown. The transmission of H5N1 among herds demonstrates that the virus can spread from one bovine to another. The movement of animals is widely recognized as a significant risk factor for disease transmission. Furthermore, evidence suggests that the virus may also transfer from dairy cattle operations to adjacent poultry facilities. Elimination of virus through vaccination may be a wise decision but its practical implementation needs much precession in decision. World Health Organization (WHO) has cautioned that the risk for cows in other countries getting infection though migratory birds cannot be ruled out. Indirectly it has given a message that other countries may get this infection in their dairy industries so to be remain vigilant. Additionally at present time the spread of virus is in flight mode so with shortest possible time the infection may spread from one country to another.

Conclusion

In our own country federal law never prohibit distribution and sales of raw milk (unpasteurized), so chance of getting infection is sufficiently high enough once the bird flu hits the cattle population in our soil. Pasteurization is highly effective at killing the H5N1 virus. Raw milk lacks this "kill step," meaning any viable virus present at the time of milking remains active in the final product. There is a remote chance to receive viable avian influenza virus through dairy products imported from USA, yet while international trade standards generally require heat treatment (pasteurization or drying) for dairy products, the import of raw milk cheeses or specialized dairy components requires rigorous certification. With several uncertainties we cannot rule out the possibility of landing of virus in our own country therefore preparedness is highly demanding. As international trade standards usually require heat treatment for most dairy products, the risk of getting avian influenza virus in our country through dairy products imported from the USA seems to be low. Nevertheless, importing raw milk, cheeses or specialized dairy components should involve strict certification. With several inherent uncertainty we cannot rule out the possibility of receiving viruses in our own soil therefore preparedness is highly demanding to minimize the spread of infection in our dairy cattle.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Data Availability Statement

Not applicable.

Ethical Statement

The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations and therefore, was exempt.

Informed Consent Statement

Informed consent was taken for this study.

Authors' Contributions

All authors contributed equally to this paper.

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