UNIVERSITY OF CALGARY
CUMMING SCHOOL OF MEDICINE

UNIVERSITY OF CALGARY
O'Brien Institute for Public Health
Health Technology Assessment Unit

Potential for Transmission of Avian Influenza Virus to Humans Associated with Handling, Preparing, and Consuming Contaminated Meat, Organs, Eggs, Milk, and Other Dairy Products from Infected Animals: A Rapid Evidence Synthesis.

Health Technology Assessment Unit,

University of Calgary

1 Executive summary

1.1 Purpose

This rapid evidence synthesis reviews the evidence on the potential for transmission of avian influenza virus (AIV) to humans associated with handling, preparing, and/or consuming contaminated meat, organs, eggs, milk, and other dairy products.

1.2 Research question

What is the risk to humans associated with handling, preparing and/or consuming foods, including meat, organs, eggs, milk, and other dairy products, from animals infected with AIV?

1.3 Approach

A systematic review following the Cochrane Handbook[1] was completed and was reported in accordance with the PRISMA reporting guidelines [2]. A PRESS-reviewed[3] search strategy was used to search published literature databases from 2014 to July 23, with a final updated search completed on September 5, 2024, (Medline, Embase, CINHAL, CAB Abstracts, Web of Science). A grey literature search was also completed.

Eligibility criteria:

Population: AIV-contaminated foods or all population groups that report data on AIV-infection in humans potentially exposed to foods for human consumption that are contaminated by AIV, including hunters/trappers who may handle, prepare, or consume infected wild game meat.

Exposure: AIV

Comparator: None required

Outcomes: Laboratory/test measurements of food contamination with AIV or confirmed infection in humans associated with consuming, handling, or preparing AIV-contaminated food.

Study design: Any study design including laboratory studies

Other criteria: Reported in English or French

Study selection and data extraction: After calibration, abstract and full-text reviews were conducted by two independent reviewers in duplicate. Data were extracted by single reviewers and checked for accuracy by a second reviewer. All disagreements were resolved through discussion and consensus.
Critical appraisal: Due to the study designs (case studies and laboratory-based studies), no critical appraisal was done.

1.4 Summary of findings

Twenty-five[1] studies met the inclusion criteria and were included in the final synthesis. Five studies reported on human outcomes after ingestion or exposure to food contaminated with AIV, nine studies reported on testing food product samples that were naturally contaminated with AIV, while twelve studies reported on outcomes on experimentally contaminated AIV food samples.

1.4.1 Findings

- There are no studies where index human AIV infection can be conclusively linked to ingestion or consumption. In all studies, the index cases that were assumed to have consumed contaminated food were also exposed to sick live birds (n=3). The possibility of secondary human-to-human transmission of AIV was reported in 3 studies. Two studies reported no cases in close contact with the index case. The third study identified other cases that were likely unrelated epidemiologically to the index case but noted that limited transmission between humans in close quarters without personal protective equipment could not be ruled out.

- AIV was detected in raw poultry meat, eggs, unpasteurized milk, and tissue samples from affected cows, indicating that AIV is in raw food sources (n=8). Three studies indicate that unpasteurized cow milk (n=2) and raw chicken (n=1) were contaminated with AIV and might have potentially transmitted the infection when consumed by other mammals.

- Retail samples of pasteurized milk appear to be safe for consumption, with no infectious virus detected in any tested samples (n=1). Further in experimental studies, pasteurization effectively

[1] One study reported outcomes on both natural and experimental contamination.

inactivated AIV in cow milk (n=6). In addition, cooking to recommended target endpoint temperatures effectively inactivated AIV in contaminated ground beef (n=1).

2 Table of Contents

2.1 Table of Figures

2.2 Table of Tables

2.3 Abbreviations

AIV	Avian influenza virus
cDNA	Complementary DNA
Ct/Cq values	Threshold cycle values
EID_{50}	50% Embryo Infectious Dose
FDA	Food and Drug Administration
HPAI	Highly pathogenic avian influenza
HTST	High temperature short time
IAV	Influenza A virus
LPAI	Low pathogenic avian influenza
PBS	Phosphate-buffered saline
PCR	Polymerase chain reaction
PPE	Personal protective equipment
qrRT-PCR	Quantitative real-time reverse-transcription PCR
RNA	Ribonucleic acid
RT-PCR	Real-time reverse transcriptase-polymerase chain reaction
$TCID_{50}$	50% tissue-culture infectious dose

3 Background and Rationale

Highly pathogenic avian influenza (HPAI) A(H5N1) is a viral infection that primarily infects birds, affecting both wild birds and domestic poultry [4]. The virus can lead to severe illness in most birds and spreads rapidly among susceptible avian species, often resulting in high mortality rates [4]. Although most influenza viruses found in birds do not transmit to humans, certain strains such as the currently circulating A(H5N1), can infect susceptible mammals, including humans, thereby posing a potentially significant public health risk [4]. The A(H5N1) clade 2.3.4.4b virus, which emerged in 2020, has spread globally, resulting in widespread bird fatalities [4]. It was first detected in Canada in December 2021 and has since been found in various mammalian species, likely due to contact with infected wild birds [4].

The ongoing global outbreaks of avian influenza, particularly the recent emergence of avian influenza A(H5N1) in dairy cattle in the United States, have raised significant public health concerns. With four human cases linked to the dairy cattle outbreaks in the United States, and the potential for the virus to spread to Canada, there is an urgent need to understand the potential for foodborne transmission of avian influenza virus (AIV) to humans.

3.1 Purpose Statement

This review aims to synthesize the current evidence on the potential for transmission of AIV to humans associated with handling, preparing, and/or consuming contaminated meat, organs, eggs, milk, and other dairy products.

4 Research Question and Objective

4.1 Primary Question

i. What is the risk to humans associated with handling, preparing and/or consuming foods, including meat, organs, eggs, milk, and other dairy products, from animals infected with avian influenza viruses (AIV)?

5 Methods

The design and eligibility criteria for the systematic review were based on *a priori* written unregistered protocol. There were no deviations from the protocol. The protocol and systematic review followed the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions [1] and was reported in accordance with the PRISMA reporting guidelines [2]. The PRISMA Checklist is presented in Appendix A.

5.1 Literature Search Methods

An experienced medical information specialist developed and tested the search strategies through an iterative process in consultation with the review team. Another senior information specialist peer-reviewed the MEDLINE strategy prior to execution using the PRESS Checklist [3]. Using the multifile option and deduplication tool available on the Ovid platform, we searched Ovid MEDLINE® ALL and Embase. We also searched CINAHL and CAB Abstracts on Ebsco and the Web of Science (core databases). We performed all searches on July 23, with a final updated search completed on September 5, 2024.

The search strategies utilized a combination of controlled vocabulary (e.g., "Influenza A Virus, H5N1 Subtype", "Food Handling", "Occupational Exposure") and keywords (e.g., "bird flu", "food", "farmer"). Vocabulary and syntax were adjusted across the databases. Results were restricted to English and French and the publication years 2014 to the current date. The full search strategy is included Appendix B. Records were downloaded and deduplicated using EndNote version 9.3.3 (Clarivate Analytics) and uploaded to Covidence.

A grey literature search of provincial, territorial, federal, and international organizations was undertaken to identify guidance and other scientific and technical publications. Google Scholar was also searched. Bibliographic searches of relevant systematic reviews and other reports were conducted to identify studies that were not captured in the original searches.

5.2 Study Selection

A calibration exercise was conducted by four independent reviewers on samples of 100 retrieved abstracts. After >95% agreement was reached among reviewers, three independent reviewers screened the remaining abstracts in duplicate. Abstracts proceeded to full-text review if they met the following inclusion criteria: reported on AIV contaminated food for human consumption and/or AIV infection in humans associated with consuming, handling, or preparing AIV contaminated food and reported on outcomes including laboratory confirmed human infection and/or AIV presence in food, Table 1. Abstracts were excluded if they did not meet the inclusion criteria or were published in languages other than English or French. Abstracts selected for inclusion by either reviewer proceeded to full-text review.

Table 1. Eligibility Criteria

Population	• AIV-contaminated foods • All population groups that report data on AIV-infection in humans potentially exposed to foods for human consumption that are contaminated by AIV, including hunters/trappers who may consume, handle, or prepare infected wild game meat
Exposure	• AIV
Comparator	• Not required
Outcomes	• Laboratory/test measurements of food contamination with AIV • Confirmed infection in humans associated with consuming, handling, or preparing AIV-contaminated food
Study design	• Any study design including laboratory studies
Publication types and language	• Preprints, primary studies, conference abstracts, technical reports, guidance documents, alerts, surveillance reports • English & French
Publication date	• 2014 - present

A similar calibration exercise was conducted by all four reviewers on ten samples of the retrieved full-text studies. After 95% agreement was reached among reviewers, full text review was conducted in duplicate by three independent reviewers. All discrepancies between reviewers were resolved through discussion and consensus.

5.3 Data Extraction

For all included studies, year of publication, country, study design, laboratory measurement of AIV presence in food, and confirmed infection in humans associated with consuming, handling, or preparing AIV-contaminated food were extracted by single reviewers using a piloted and standardized data extraction form. A second reviewer verified the extracted data. Discrepancies between reviewers during data extraction were resolved through consensus.

5.4 Data Analysis

A narrative approach to synthesis was adopted, structured into the following categories: studies reporting human outcomes, studies on naturally occurring contaminated meat, organs, and food products from animals with AIV, studies involving experimental interventions (e.g., virus presence in experimentally contaminated milk before and after pasteurization), and other relevant literature that were identified but did not meet the inclusion criteria.

6 Results

Summary of findings

Twenty-five studies were included in the final dataset. One of the studies reported outcomes on both natural and experimental infections.

Human outcomes (n=5)

Five studies reported on human outcomes after consuming or exposure to AIV-contaminated foods. In two of the studies, no confirmed human infection was reported while confirmed human infections were reported in three studies. However, in the studies that reported a confirmed human infection, in addition to consuming and/or exposure to poultry meat, the index cases were also exposed to sick live birds; the source of the human infection could not be confirmed. Furthermore, in two out of the three cases that reported a confirmed infection, no close contacts of the index patients developed symptoms or tested positive for AIV. One study, however, reported limited human-to-human transmission. The cases were unlikely linked epidemiologically but transmission within family clusters could not be ruled out.

Natural infections (n=9)

Nine studies focused on testing food samples naturally contaminated with AIV from infected animals. Across the studies, AIV was detected in raw poultry meat, eggs, and raw milk, and tissue samples from affected cows. In one study, >50% of cats fed raw milk from affected cows became ill and died, illustrating that the virus in unpasteurized milk might potentially transmit infection from cows to other mammals.

Experimental infections (n=12)

Twelve studies reported on experimentally infecting and testing animals or contaminating food samples with AIV. In six studies, pasteurization effectively inactivated the AIV virus in raw milk, and one study found that cooking to recommended target endpoint temperatures eliminated AIV from ground beef patties. Two studies concluded that AIV survived for several days at various temperatures in chicken tissue samples, while two studies detected AIV in chicken tissues and eggs laid by hens infected with AIV. Finally, one study found that AIV in contaminated unpasteurized milk survived for several hours on milking equipment, potentially putting dairy farm workers at risk of infection when PPE is not used.

The database and grey literature searches yielded 1,916 unique citations, 1,875 of which were excluded after abstract review. Fifty-four studies proceeded to full-text review. After excluding 31 studies at the full-text review stage, 25 studies met the inclusion criteria and were included in the final synthesis, Figure 1. Six studies that did not meet inclusion criteria were flagged as relevant and are discussed in the ongoing studies and other relevant literature sections.

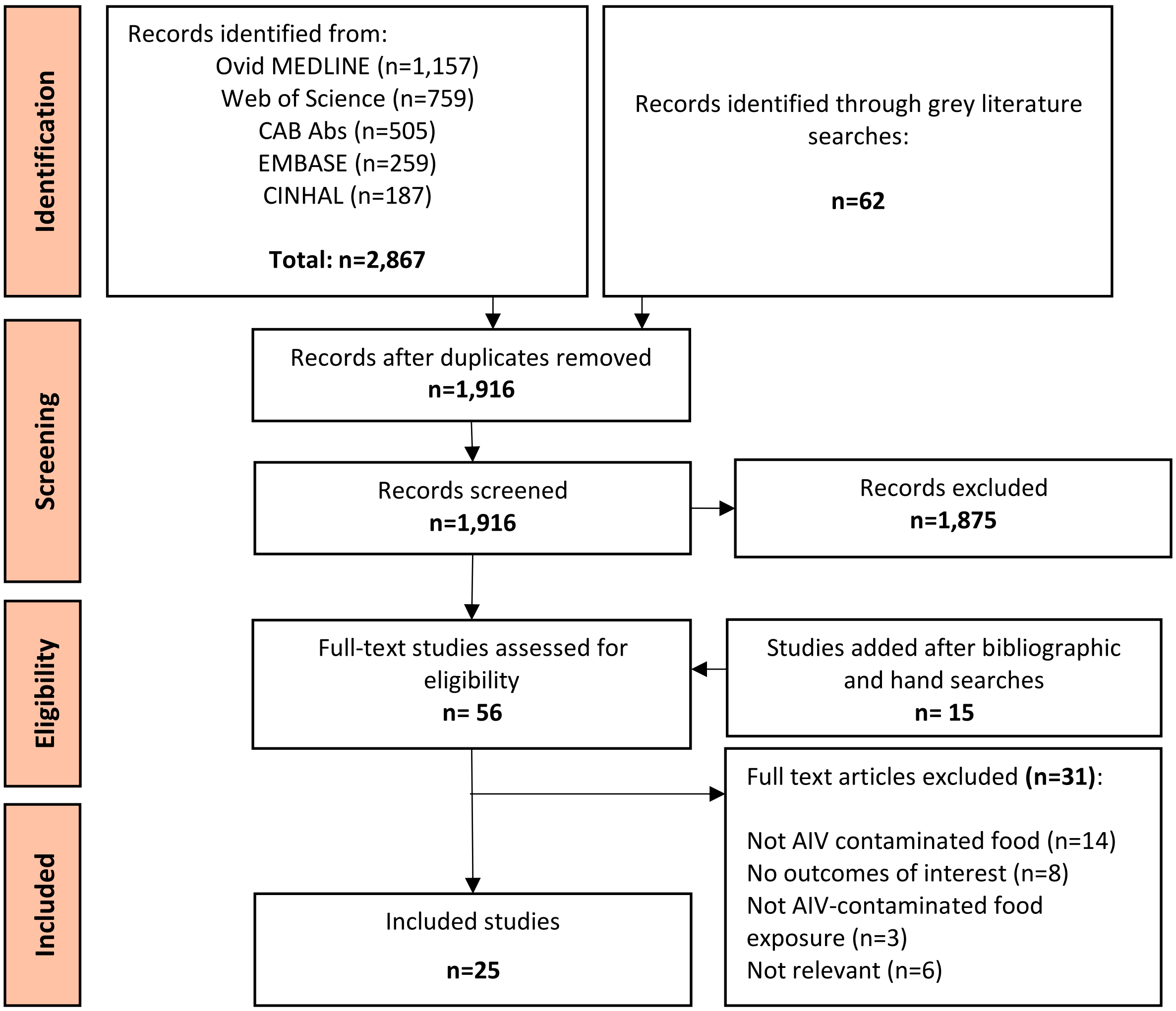

Figure 1: PRISMA Flow Chart of Study Selection

6.1 Study Characteristics

Twenty-five studies [5-30] were included in the final dataset: 5 studies reported human outcomes [5,12,16,17,21], 9 studies examined naturally contaminated meat and animal products with no human outcomes [6,7,10,19,22-25,29], and 12 studies involved experimental interventions [8,9,11,13,15,18,20,26-30]. One study reported on both naturally occurring and experimental contamination of milk samples[29].

Most of the studies (n=13) were conducted in laboratory settings [8,9,11,13,18-20,23,26-30], two in rural village settings [5,12], one in a farm milking equipment setting [15], and another in a poultry retail shop setting [10]. Six studies were conducted across multiple settings [6,7,21,22,24,25], such as laboratories, farms, commercial poultry hatcheries, and airports. The remaining studies did not specify their settings [16,17] (Figure 2, Panel A).

Eight of the included studies were conducted in the US [6,7,11,13,15,18,25,29], four in China [8,9,16,17], four in Japan [23,24,26,28], two in Lao PDR [5,21], two in India [10,27], and one each in Canada[30], Bangladesh [12], the UK [20], Poland [19], and Nepal [22] (Figure 2, Panel B). The studies were published between 2014 and 2024.

Included Studies (n=25)*

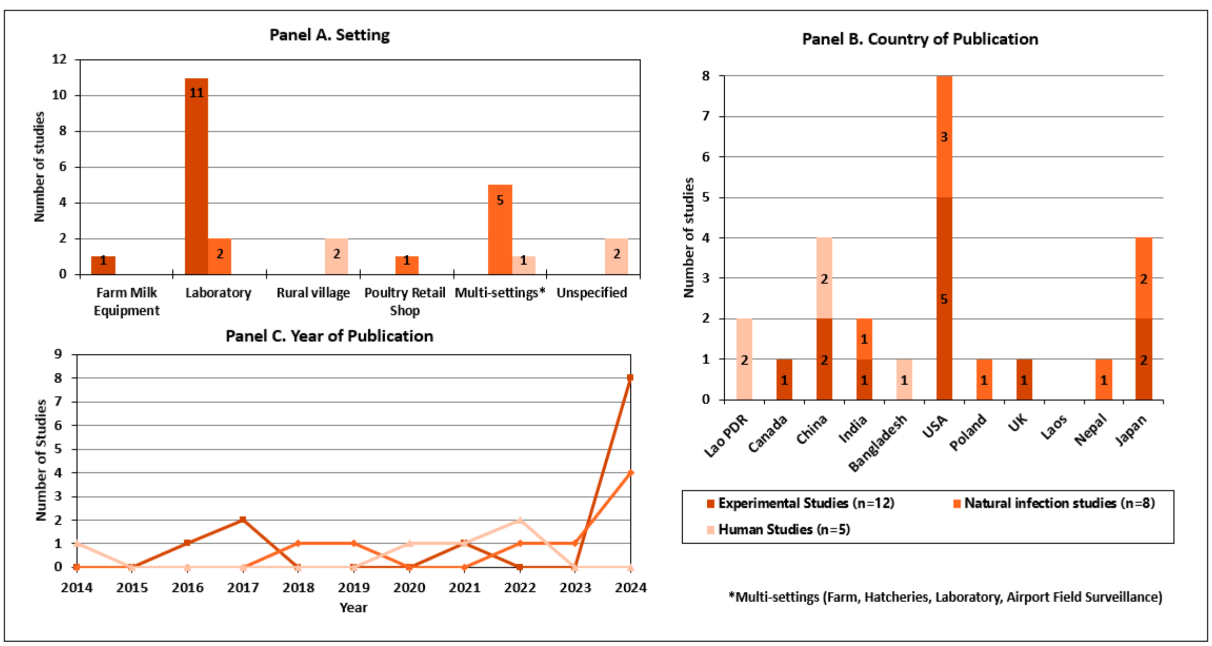

Figure 2. Characteristics of Included Studies

6.2 Studies that report human outcomes

Five studies reported on human outcomes after consuming or exposure to AIV-contaminated foods, Table 2. Three out of the five studies reported on outcomes after ingesting infected poultry [31-33]. The first study concluded that there was no confirmed human infection after ingesting infected birds [31]. The other two studies reported on confirmed human infections; however, in the first study, the index case visited a live poultry market and observed the slaughtering process before he prepared and ate the chicken [32], while in the second study, the child's family slaughtered and consumed the chicken after the child was ill [33]. The remaining two studies reported outcomes after exposure to infected poultry [34,35]. In the first study, human infection was reported after exposure to a freshly slaughtered chicken [35], while in the second study, infected birds scavenged in living areas and were slaughtered without personal protective equipment, but there were no confirmed human infections [34]. The three cases that reported on a confirmed human infection also reported on the possibility of secondary human-to-human transmission [32,33,35]. Two of the studies found that no close contacts of the index patients developed symptoms or tested positive for AIV [33,35]. In the third study, limited transmission within family clusters could not be ruled out [32].

Table 2. Studies that report on human outcomes

First Author **Year** **Country** **Setting**	**Aim of study**	**Virus** **Sample** **Summary of EPI investigation or testing**	**Context**	**Conclusions**
Annand [31] **2020** **Lao PDR** **Rural village**	Summarize the events surrounding the first laboratory-confirmed diagnosis of HPAI in the Sekong Province of Lao PDR and characterize the virus.	**Virus:** A(H5N1), clade 2.3.2.1c **Sample:** Poultry flock **Summary of investigation:** Poultry purchased from a local market was introduced to a household flock. On Day 2, one of the affected birds with clinical symptoms was slaughtered and consumed. 55% of the poultry in the household flock died or showed clinical signs prior to the cull on Day 8.	Many of the affected birds were consumed by locals during the outbreak. Three fresh carcasses and one egg were confirmed as infected with avian influenza A(H5N1) by real time RT-PCR on Day 7. **Preventative measures:** Tier 3 PPE (cotton overalls, goggles, non-P2 surgical mask, gloves, and rubber boots) were used, carcasses were double bagged in plastic, affected	No confirmed human infection after ingesting infected birds.

			premise was decontaminated with lime and bleach when flock were culled.	
Islam [34] 2022 Bangladesh Rural village	Investigate the source of infection and extent of an AIV A(H9N2) outbreak in a rural village between February 2-4, 2017.	**Virus:** H5, H7, H9, and N2 **Sample:** 55 swab samples from poultry, 18 swab samples from humans **Summary of investigation:** Suspected human A/H9 outbreak. Launched an investigation into infection and extent of outbreak, swab samples collected from poultry and humans.	Poultry scavenged inside the kitchen and bedrooms, children were involved in bird-raising activities, and sick poultry was slaughtered without PPE. Soap was rarely used after handling and slaughtering poultry. All human samples were negative. H9N2 prevalence detected by RT-PCR was 16.4% in bird level.	Human and poultry interaction with risky behavioral practices might facilitate transmitting the AIV from poultry to humans, however no human samples were positive.
Li J [35] 2022 China N/A	To report a case of human infection by A(H5N6) virus after exposure to a freshly slaughtered chicken.	**Virus:** A(H5N6), clade 2.3.4.4b **Sample:** Patient (female, aged 51) **Summary of investigation:** Environmental samples were collected from the living space of the patient and nearby poultry market.	Of the 49 samples, 12 samples were positive for A(H5N6), including 35% of the samples from the patient's home. Positive swabs were concentrated in the area linked to the slaughtered chicken.	The risk of exposure to possible viral variants from infected slaughtered poultry or the associated environments should be taken seriously, however none of the close contacts of the index patients developed symptoms or tested positive to A(H5N6) by throat swab sampling.
Li Q [32] 2014 China N/A	Summarize the epidemiologic findings of case investigations and follow-up monitoring of close contacts of persons with confirmed cases of A(H7N9).	**Virus:** A(H7N9) **Sample:** Suspected and confirmed cases of human infection with A(H7N9) **Summary of investigation:** Field investigation for cases of A(H7N9); in one family cluster, the index patient had visited a live poultry market, purchased a chicken, observed the slaughtering process, brought the freshly killed chicken home, and prepared, cooked, and ate the chicken within 2 weeks before the onset of his illness.	RT-PCR confirmed case of A(H7N9) in index patient who was exposed to and consumed a chicken likely contaminated with A(H7N9).	Most confirmed cases were epidemiologically unrelated and were probably infected during visits to live poultry markets, in line with the decline in cases following the closure of live poultry markets. Follow-up investigations of contacts with confirmed A(H7N9) infection suggest that the risk of secondary transmission including to health care personnel is low. In family clusters however, limited, non-sustained human-to-

				human transmission of A(H7N9) virus could not be ruled out.
Sengkeopraseuth[33] 2021 Lao PDR Village, Farm, Laboratory	To trace contacts of the infected child, strengthen surveillance in humans and animals, identify the infection source, and implement control measures to prevent further virus spread.	**Virus:** A(H5N6) clade 2.3.4.4h **Sample:** 1 infected child, contact tracing and surveillance of 71 close contacts of the infected child. **Summary of investigation:** After detecting the virus in a child, a team investigated through contact tracing, surveillance, and data reviews.	A(H5N6) detected through RT-PCR testing of the human specimen yielded a high cycle threshold (>36) for HPAI A(H5). **Preventative measures:** Surveillance	One chicken with clinical symptoms was slaughtered and consumed by the child's family after the child was ill. No human-to-human transmission was identified in tracing of close contacts.
AIV: Avian influenza virus, HPAI: Highly pathogenic avian influenza, PPE: Personal protective equipment, RT-PCR: Real-time reverse transcriptase-polymerase chain reaction.				

6.3 Studies that report on natural contamination of meat and animal products

Nine studies focused on testing food product samples that were naturally contaminated with AIV from infected animals, Table 3 [29,36-43]. Five studies reported on poultry products including chicken and duck [36-40] and four studies reported on beef and dairy products [29,41-43], Table 3.

In the first poultry study, a 9.4% prevalence of AIV primers was found from tissue samples in a poultry retail shop [36]. In the second study, chicken meat purchased fresh for human consumption was eaten by a cat that later became ill, with genetic analysis linking the contaminated poultry meat to the virus from the cat [37]. The remaining two poultry studies focused on testing chicken and duck meat samples illegally taken on board airplanes [39,40]. In both studies, AIV with varying pathogenicity were isolated from chicken and duck meat products [39,40], Table 3.

One study was a surveillance study that found AIV in four out of eleven months of screening eggs from hatcheries [38]. One study focused on beef and milk found infectious viral RNA in cow organs, tissues, and milk [41].

The remaining three studies focused on milk and dairy products [29,42,43]. The first study found A(H5N1) in tissues of affected cows, and over 50% of the cats fed raw milk from affected cows became ill and died, illustrating that the virus in unpasteurized milk might potentially transmit infection from cows to other mammals [42]. The second study tested samples of pasteurized retail milk and dairy products, including cream, cheese, and yogurt, but no infectious virus was detected in any of the samples [43]. The third study tested raw milk samples from bulk storage tanks from farms in the affected US states and found that 57% of the samples were positive for influenza A, but only 24.8% of the PCR positive samples were positive for the infectious virus[29], Table 3.

Table 3. Studies that report on natural contamination of meat and animal products

First Author Year Country Setting	Aim of study	Virus Sample Summary of EPI investigation or testing	Outcomes	Conclusions
POULTRY				
Dixit [36] 2024 India Poultry retail shops	To understand the extent of A(H9N2) virus prevalence and associated risk factors in poultry retail shops and their surrounding environment.	**Virus:** A(H9N2) **Sample:** 500 poultry, 700 environmental (1200 samples in total) **Investigation:** Organ and environmental samples were taken from poultry shops, including trachea, lung, and intestine samples, knife, slaughter slab, and cage swabs, poultry feces, slaughter waste, discarded feed material, and water.	47/500 food samples were positive in RT-PCR test for influenza A and H9 primers; total prevalence of 9.4% in tissue samples, and 9.7% of environmental samples were A(H9N2) positive.	The high level of A(H9N2) positivity in birds with no clinical manifestations provides an opportunity for widespread amplification and circulation with other avian viruses leading to generations of novel reassorted viruses with high zoonotic potential. This may result in infection in other animals that have access to the poultry retail shops and in humans, with those occupationally exposed at higher risk of infection.
Rabalski [37] 2023 Poland Laboratory	To determine whether the HPAI A(H5N1) virus was responsible for the outbreak in domestic cats and to explore potential routes of transmission, including the possibility of infection through contaminated food sources	**Virus:** A(H5N1) **Sample:** Fresh chicken meat purchased for human consumption **Investigation:** Genetic analyses, including whole genome sequencing and phylogenetic analysis, were conducted on viral samples from affected cats and a poultry meat sample	The chicken meat sample, tested positive for HPAI A(H5N1) virus with: Matrix Gene (M) Cq: 20; Haemagglutinin (H5) Cq: 25	A A(H5N1) virus similar to the virus from the sick cat was found in chicken meat consumed by the cat, suggesting a possible route of transmission.
Shibata [40] 2018 Japan Field surveillance at airports and laboratory	To investigate the presence, genetic characteristics, and pathogenicity of A(H7N9) and A(H9N2) isolated from poultry meat products.	**Virus:** A(H7N9) (both HPAI and LPAI) and A(H9N2) AIVs **Sample:** Meat and organ from chicken and Muscovy duck **Investigation:** Isolating viruses from samples, determining their genetic sequences, performing antigenic	Titers of AIVs isolated from the poultry products ≤ 101.5 to 103.8 EID_{50}/g. A(H7N9) viruses showed varying pathogenicity in chickens and ducks, with significant differences in viral titers and clinical outcomes. **Preventative measures:** Continuous border disease	Illegal transportation of poultry products carrying AIVs poses a significant risk to both poultry and public health. Continuous monitoring and border control are essential to mitigate these risks.

		analyses, and conducting pathogenicity experiments in chickens and ducks.	control, including detection and culling of infected poultry and meat products	
Shibata [39] 2019 Japan Laboratory	To isolate, identify, and characterize a new reassortant A(H7N3) HPAI from contaminated duck meat, analyze its genetic properties and its relationship with other AIVs.	**Virus:** A(H7N3), A/duck/Japan/AQ-HE30-1/2018 (Dk/HE30-1) **Sample:** One duck meat product **Investigation:** The duck meat product was homogenized, and the homogenate was inoculated into three embryonated chicken eggs.	The virus isolated from the duck meat product was identified as A(H7N3) HPAI, through haemagglutination and neuraminidase inhibition tests and had a pathogenicity index value of 2.99.	A novel reassortant A(H7N3) HPAI was isolated from raw contaminated duck meat illegally taken onboard by a passenger on a flight from China to Japan.
EGGS				
Sharma [38] 2022 Nepal Commercial poultry hatcheries and laboratory	To assess the presence of major avian pathogens in eggs from hatcheries to improve disease surveillance and bio-security measures.	**Virus:** H5 and H7 **Sample:** 4,343 egg samples from eleven hatcheries **Investigation:** From August 2020 to August 2021, excluding October 2020, eggs from the hatcheries were tested for six avian pathogens using multiplex PCR, involving nucleic acid extraction, cDNA synthesis, and PCR analysis.	At least one avian pathogen was detected in nine out of eleven months (82%) of screening. One or multiple occurrences of other major avian pathogens- IAV (n=4 times) were found **Preventative measures:** Regular screening	Influenza A virus was detected most frequently, and at least one avian pathogen was detected in nine out of the eleven months of screening.
BEEF, MILK, AND DAIRY PRODUCTS				
Burrough [42] 2024 USA Dairy farms/laboratory	Report highly pathogenic avian influenza A(H5N1) clade 2.3.4.4b virus in dairy cattle and cats in the United States.	**Virus:** (HPAI) A(H5N1) clade 2.3.4.4b **Sample:** Milk samples (cases 2-5), and formalin-fixed tissues (cases 1, 3-5) from 8 clinically affected mature dairy cattle. **Investigation:** Vets alerted to syndrome occurring in lactating dairy cattle in northern Texas including feed intake, rumination, abrupt drop in milk production in Feb 2024. In March similar cases were reported in Kansas and New Mexico. Cats on farm	Milk and mammary gland homogenates showed low Ct values: 12.3–16.9 by IAV screening PCR, 17.6–23.1 by H5 subtype PCR, and 14.7–20.0 by H5 2.3.4.4b clade PCR (case 1, cow 1; case 2, cows 1 and 2; case 3, cow 1; and case 4, cow 1). >50% of cats fed with raw milk became ill and died. Post-mortem brain and lung samples from cats were positive for IAV and H5 2.3.4.4b by PCR screening.	Dairy cattle are susceptible to infection with HPAI A(H5N1) virus, can shed virus in milk and might potentially transmit infection to other mammals via unpasteurized milk.

		premises were fed with raw milk from affected cows.		
Caserta [43] **2024** **USA** **9 Dairy farms/laboratory**	Report spillover of HPAI A(H5N1) virus in dairy cattle herds across several states in the US	**Virus:** HPAI-A(H5N1) **Sample:** Milk samples (n=192) and lung, small intestine, supramammary lymph nodes and mammary gland tissues from three affected cows. **Investigation:** Cows from investigated farms showed signs of sickness (decreased feed intake, decreased rumination time, mild respiratory signs, dehydration, diarrhea, and milk with abnormal yellowish colostrum-like colour, abrupt decrease in milk production).	Milk and tissue samples tested by rRT-PCR showed viral RNA loads (milk; 129/192), and the presence of viral RNA in lung, small intestine, supramammary lymph nodes and mammary gland. The highest viral RNA loads were detected in the mammary gland. Virus titers in milk from affected cows ranged from 104.0 to 108.8 50% tissue culture infectious dose ($TCID_{50}$) per ml, and 107.3 to 107.8 $TCID_{50}$.ml-1) were detected in mammary gland tissues.	Infectious virus and viral RNA were consistently detected in milk from affected cows
Spackman [41] **2024** **USA** **Laboratory**	To determine whether viable HPAI could be detected in pasteurized retail milk products from 17 US states collected between April 18 to April 22, 2024.	**Virus:** Clade 2.3.4.4b A(H5N1) HPAI **Sample:** 297 samples of Grade A pasteurized dairy products: milk (whole, 1%, 2%, skim), cream, half and half, cottage cheese, sour cream, and yogurt. **Investigation:** Viral RNA was detected using qrRT-PCR, and the presence of infectious virus was tested by inoculation into embryonating chicken eggs.	60 samples (20.2% of total) were positive for influenza virus with a virus titer of up to 5.4 log_{10} 50% egg infectious doses (EID_{50}) per mL. No infectious virus was detected in any of the qrRT-PCR-positive samples. **Preventative measures:** Pasteurization.	20.2% of all samples were positive for HPAI, but the infectious virus was not detected in any of the samples. This finding indicates that with the current safety measures, infectious viruses in milk are unlikely to enter the food supply chain.
Spackman[29] **2024** **USA** **Laboratory**	To determine the potential quantities of infectious HPAI in raw milk in affected states where herds were confirmed positive by USDA for HPAI, and to confirm that continuous flow pasteurization using the FDA approved 72 °C for 15s conditions for high−temperature short time (HTST)	**Virus:** (HPAI) A(H5N1) clade 2.3.4.4b **Sample:** Raw milk bulk tank samples (n=275) **Experiment:** Samples were screened for influenza A using qrRT-PCR and infectious virus was quantified using embryonated chicken eggs. A pilot scale continuous flow pasteurizer was used to evaluate HPAI	158 (57.5%) were positive, 107 (38.9%) were negative, and 10 (3.6%) were invalid. Of the 158 qrRT-PCR positive samples, one was discarded due to bacterial contamination and 39 (24.8%) were positive for infectious virus with titers from 1.3 to 6.3 log10 EID50/mL and a median of 3.5 log10 EID50/mL.	Only 24.8% of the raw milk from bulk storage tank samples that tested positive were positive for infectious virus by qrRT-PCR. The quantities of infectious virus were generally lower than what was detected by qrRT-PCR with a mean of 3.5 log10 EID50/mL.

	processing, will inactivate the virus.	inactivation in artificially contaminated raw milk samples at 72 °C (161°F) for 15 s.		
AIV: Avian influenza virus, cDNA: complementary DNA, Ct/Cq values: threshold cycle values, EID_{50}: 50 percent Embryo Infectious Dose, HPAI: Highly pathogenic avian influenza, IAV: influenza A virus, LPAI: Low pathogenic avian influenza, PCR: polymerase chain reaction, qrRT-PCR: Quantitative real-time reverse-transcription PCR, RNA: ribonucleic acid, RT-PCR: Real-time reverse transcriptase-polymerase chain reaction, $TCID_{50}$: 50% tissue-culture infectious dose				

6.4 Studies that report on experimental contamination and infections

Twelve studies reported on experimentally infecting and testing animals or food samples with AIV [29,30,44-53], Table 4.

Six studies focused on pasteurization of cow milk [29,30,45,46,51,52], one study examined the effectiveness of cooking ground beef patties at various temperatures to eliminate AIV [50], two studies tested the survival of AIV in raw chicken stored at different temperatures [44,48], two studies tested the detection of AIV in chicken tissues and eggs post-infection [47,53], and one study tested the detection of AIV in unpasteurized milk on milking equipment [49], Table 4.

All six studies that examined the effectiveness of pasteurization in inactivating AIV in cow milk concluded that pasteurization conditions effectively inactivated all tested subtypes of AIV, and that pasteurized milk products are safe for consumption [30,45,46,51,52],[29]. In two of the studies however, the authors noted that heat treatment at 63°C for up to 30mins may be more effective in inactivating AIV in milk samples compared to 72°C for 15 or 20 seconds[30,54]. In one of the studies, a sample of contaminated milk was fed to mice, the mice showed signs of illness and were subsequently euthanized [45]. AIV was found in mice organs suggesting that unpasteurized contaminated milk may pose a risk to mammals [45].

One study found that cooking to recommended target endpoint temperatures inactivated AIV from ground beef patties and concluded that the risk of humans becoming infected with AIV from a cooked beef patty is negligible [50].

The two studies that reported on the survivability of AIV in chicken tissue samples stored at different temperatures found that AIV can potentially survive on raw chicken at various temperatures [44,48]. Furthermore, one of the studies found that cold temperatures had a positive effect on HPAI A(H5N1) viral survival in chicken tissues; the virus persisted for longer in tissue samples stored at colder temperatures (+4°C) than in those kept at +20°C [48].

Two studies reported on the detection of AIV in chicken tissues and eggs [47,53]. The first study found viral antigens in chicken muscle tissues six hours after intranasal inoculation with an A(H5N1) virus [53], while the second concluded that the A(H5N8) virus was transmitted to the internal contents and shells of eggs laid by hens experimentally infected with the virus [47].

The last study examined the persistence of various influenza viruses in unpasteurized milk on milking equipment and concluded that A(H5N1) virus was detectable for up to one hour on milking equipment, posing a potential risk to dairy farm workers [49], Table 4.

Table 4. Studies that report on experimental contamination and infections

First Author **Year** **Country** **Setting**	**Aim of study**	**Virus** **Sample** **Summary of Experiment**	**Outcomes**	**Conclusions**
		PASTEURIZATION		
Alkie[30] **2024** **Canada** **Laboratory**	To examine whether pasteurization could effectively inactivate HPAI A(H5N1) inoculated raw whole milk samples	**Virus:** A(H5N1) virus clade 2.3.4.4b **Sample:** Non-homogenized cow milk **Experiment:** 1 mL samples of non-homogenized cow's milk were heated to attain an internal temperature of 63°C or 72°C and spiked with 6.3 log 33 EID50 of clade 2.3.4.4b A(H5N1) virus.	Complete A(H5N1) virus inactivation was achieved in all milk samples (four replicates) treated at 63°C for 30 minutes; and complete viral inactivation was achieved in 7 out of 8 replicates treated at 72°C for 15 seconds.	Pasteurization of milk is an effective strategy for mitigation of risk of human exposure to milk contaminated with A(H5N1) virus.
Cui [52] **2024** **China** **Laboratory**	Examine the effectiveness of pasteurization against influenza A viruses mixed in raw milk collected from healthy dairy cattle	**Virus:** H3N8, H10N8, H9N2, H3N2 (swine), H5 clade 2.3.4.4b with N1, N6, or N8 gene, H7N9 (human), H1N1 (swine), H3N2 (human) **Sample:** Inoculated milk, three samples **Experiment:** Tested the thermal stability of H5 clade 2.3.4.4b viruses:	All H1, H3, H5, H7, H9, and H10 influenza viruses were completely inactivated at 63°C for 30 minutes or at 72°C for 15 seconds.	Heat treatment can inactivate as much as $10^{7.75}$ EID/ml of H5 virus in raw milk. Pasteurization

		avian H3N8, H10N8, H9N2, H5N1, H5N6, and H5N8, swine H3N2 and H1N1, and human H7N9 and seasonal H3N2		effectively inactivates all tested subtypes of influenza viruses in raw milk, and thermally pasteurized milk products are safe for consumption.
Guan [45] **2024** **USA** **Laboratory**	To test heat inactivation of four HPAI A(H5N1) virus–positive milk samples, and the risk that HPAI A(H5N1) positive milk poses to humans and animals.	**Virus:** HPAI A(H5N1) **Sample:** Virus positive milk samples **Experiment:** Undiluted milk samples were incubated in a PCR thermocycler at 63°C for 5, 10, 20, or 30 minutes or at 72°C for 5, 10, 15, 20, or 30 seconds. Control samples were left untreated. Mice were orally inoculated with sample of infected milk.	Heat treatment at 63°C reduced the virus titers below the detection limit of the $TCID_{50}$ assay (1.5 log10/ml). Milk samples treated at 72°C for 15 or 20 seconds were inoculated into embryonated chicken eggs or Madin–Darby canine kidney cells for virus detection. Heat treatment reduced virus titers by more than 4.5 log units but did not completely inactivate the virus. For the stability of HPAI A(H5N1) virus in cow's milk stored at 4°C, a decline of two log units was detected over 5 weeks. Mice showed signs of illness day 1 after inoculation, euthanized on day 4, A(H5N1) virus found in respiratory and other organs.	HPAI A(H5N1) positive milk poses a risk to mammals when consumed untreated, but heat inactivation under the laboratory conditions reduces HPAI H5 virus titers by more than 4.5 log units.
Kaiser [46] **2024** **USA** **Laboratory**	To measure the stability of HPAI A(H5N1) virus in raw milk at 63°C and 72°C, the temperatures commonly used in commercial pasteurization	**Virus:** HPAI A(H5N1) clade 2.3.4.4b **Sample:** Raw unpasteurized cow milk **Experiment:** Diluted HPAI A(H5N1) virus A/mountain lion/MT/1/2024 (clade 2.3.4.4b) in raw (unpasteurized) cow's milk to 106 50% tissue-culture infectious doses ($TCID_{50}$) per milliliter of medium.	At 63°C, HPAI A(H5N1) virus was inactivated from initial titers of 106 TCID50 per milliliter to undetectable levels within 2 minutes with an estimated half-life of infectious virus to be 4.5 seconds (95% credible interval, 3.5 to 5.8) at 63°C. At 72°C, a decrease in virus titers from approx. 105 to 101 $TCID_{50}$ per milliliter within 5 seconds and then very low titers (<10 $TCID_{50}$ per milliliter, at the boundary of detectability) until the 20-second time	Heat treatment at 63°C would yield a decrease in infectious viral HPAI A(H5N1) titer within 2.5 minutes, so standard bulk pasteurization of 30 minutes at 63°C has a large safety buffer. There is a potential for a relatively small but

			point had been reached; no viable virus was found at later time points.	detectable quantity of virus to remain infectious in milk after 15 seconds at 72°C if the initial titer is sufficiently high.
Schafers [51] 2024 UK Laboratory	To determine if standard pasteurization processes can render milk safe for a panel of different influenza viruses, and in particular the high pathogenicity A(H5N1) avian influenza virus	**Virus:** A(H5N1) HPAI, strain A/chicken/Scotland/054477/2021, H5N3, H5N2, H1N1 **Sample:** Raw milk and processed milk. **Experiment:** Influenza A viruses were mixed into milk samples 1:10 and subjected to pasteurization temperatures (low-temperature long time at 62.5°C for at least 30 minutes; and high-temperature short time at 72°C for at least 15 seconds) to test how quickly inactivation of viruses occurred.	Pasteurisation temperatures (63°C for 30 minutes or 72°C for 15 seconds) rapidly inactivated the infectivity of all tested influenza viruses, including A(H5N1) HPAI. While the viral genetic material (RNA) could still be detected after pasteurisation, the infectivity of the virus was lost before the minimum times required for pasteurisation. In unpasteurised milk, influenza viruses, including A(H5N1) HPAI, remained infectious. **Preventative measures:** Pasteurisation	Industry-standard pasteurization conditions should effectively inactivate A(H5N1) HPAI in cows' milk, but unpasteurized milk could carry infectious influenza viruses.
Spackman[29] 2024 USA Laboratory	To determine the potential quantities of infectious HPAI in raw milk in affected states where herds were confirmed positive by USDA for HPAI, and to confirm that continuous flow pasteurization using the FDA approved 72 °C for 15s conditions for high−temperature short time (HTST) processing, will inactivate the virus.	**Virus:** (HPAI) A(H5N1) clade 2.3.4.4b **Sample:** Raw milk bulk tank samples (n=275), artificially contaminated raw milk samples **Experiment:** Samples were screened for influenza A using qrRT-PCR and infectious virus was quantified using embryonated chicken eggs. A pilot scale continuous flow pasteurizer was used to evaluate HPAI inactivation in artificially contaminated raw milk samples at 72 °C (161°F) for 15 s.	Among all replicates at two flow rates (n = 5 at 0.5 L/min; n = 4 at 1 L/min), no viable virus was detected. A mean reduction of ≥5.8 ± 0.2 log10 EID50/mL occurred during the heating phase where the milk is brought to 72.5 °C before the holding tube.	Estimates from heat-transfer analysis support that standard U.S. continuous flow HTST pasteurization parameters will inactivate >12 log10 EID50/mL of HPAI, which is ~9 log10 EID50/mL greater than the median quantity of infectious virus detected in raw milk from bulk storage tank samples. These findings

				demonstrate that the US milk supply is safe when pasteurized.
		COOKING		
Luchansky [50] **2024** **USA** **Laboratory**	Determine if cooking will eliminate AIV from inoculated ground beef	**Virus:** LPAI A(H5N1), clade 2.3.4.4c, specifically A/rgGyrfalconHAxPR8/2014 A(H5N1) (referred to as strain rgGYR/14) **Sample:** Supermarket ground beef **Experiment:** Two batches of ground beef were inoculated, cooked to target endpoint temperatures of 48.9°C, 62.8°C, or 71.1°C, and sampled; two patties from the same batch were used as replicates	Greater inactivation of AIV was observed for the higher internal temperatures; cooking inoculated ground beef patties to 48.9°C, 62.8°C, or 71.1°C reduced the quantity of infectious virus on average by at least 2.5, 4.8, and 4.8 log10 EID, respectively. When patties were cooked to an internal instantaneous temperature of 62.8°C or 71.1°C, levels of AIV decreased to below the detection limit of 0.8 log_{10} EID per 0.1 g of meat	The current risk for humans becoming infected with AIV from a cooked beef patty is negligible, even when considering that some patties were not properly cooked it is unlikely that such high levels of AIV would occur naturally in retail ground beef.
		VIRUS SURVIVAL IN RAW CHICKEN MEAT STORED AT DIFFERENT TEMPERATURES		
Dai [44] **2021** **China** **Laboratory**	Report on the survivability of HPAI viruses on raw chicken meat in different environmental conditions.	**Virus:** A(H7N9) and A(H5N8) (clade 2.3.4.4b) **Sample:** Raw chicken meat **Experiment:** The virus titre ($TCID_{50}$) of viable A(H7N9) on raw chicken and the virus titre of untreated A(H7N9) in culture medium set at different temperatures, frozen temperature (–20°C), refrigerator temperature (4°C), and room temperature (25°C), was measured. A(H7N9) on the raw chicken or untreated A(H7N9) in culture medium was incubated for 10 days and 9 days respectively then tested for infectivity. Virucidal effects of six standard disinfectants: household bleach, ethanol, hand soap, peracetic acetic acid, lactic acid, and acetic acid—on A(H7N9) and A(H5N8) (clade 2.3.4.4b) on raw chicken	A(H7N9) on raw chicken remained viable at –20°C for 9 days, 4°C for 7 days, and 25°C for 4 days. A(H7N9) and A(H5N8) were not susceptible to 2 min incubation with hand soap or lactic acid. No infectious virus was detected after a 2 min incubation at room temperature with the other disinfectant agents. **Preventative measures:** Cleaning/disinfectants	HPAI viruses can potentially survive for several days on raw chicken at various temperatures (-20°C, 4°C, and 25°C), highlighting the importance of strict inspection and disinfection measures in the supply chain of raw poultry.
Yamamoto [48] **2017**	To investigate the survival of virus in feather, muscle	**Virus:** (HPAI) A(H5N1) **Sample:** Muscle, tissue, and organ samples from six 12-week-old	Maximum periods for viral survival in each tissue stored at +4°C were 240	Cold temperature had a positive

Japan **Laboratory**	and liver tissues collected from six chickens experimentally infected with A(H5N1) virus	chickens **Experiment:** Chickens were experimentally infected (n=6), four were found dead on day 3 after inoculation, the remaining 2 chickens were euthanized for sampling on the same day (day 0)	days in feather tissues, 160 days in muscle, and 20 days in liver. Viral infectivity at +20°C was maintained for a maximum of 30 days in the feather tissues, 20 days in muscle, and 3 days in liver.	effect on HPAI A(H5N1) viral survival in chicken tissues, the virus persisted for longer in the samples stored at +4°C than in those kept at +20°C for all tissue types. Virus contaminated tissues can be potential sources that could allow the virus to spread to humans, animals, and the surrounding environment.
VIRUS DETECTION IN CHICKEN TISSUES AND EGGS				
Uchida [47] **2016** **Japan** **Laboratory**	To demonstrate the transmission of H5N8-subtype HPAI to both the internal contents and shells of eggs laid by white leghorn hens experimentally infected with the virus	**Virus:** A(H5N8); Miya7 **Sample:** 8 pathogen-free, 32-week-old white leg horn hens and the eggs they laid up to four days post infection **Experiment:** Hens evaluated daily from 7 days pre-infection until death. Egg albumen, yolk, eggshell surface was obtained from each egg laid after viral inoculation	Virus was isolated from the eggs of three hens that laid eggs post inoculation. Hen Ea: 4.5 log_{10} EID_{50}/mL on the egg surface, 5.3 log_{10} EID_{50}/mL in the egg albumen, and 4.4 EID_{50}/mL in the egg yolk. Hen Eb: Virus titers of the eggshell swab, albumen, and yolk were 0.5 to 2.7 log_{10} EID_{50}/mL. Hen Ec: Virus titers of the egg samples collected on 3 dpi were 2.5 to 5.5 log_{10} EID_{50}/mL	A(H5N8) was transmitted to the internal contents and shells of eggs laid by infected hens
Vasudevan [53] **2017** **India** **Laboratory**	To investigate the amount and duration of virus detection in skeletal muscle of chickens infected with different doses of HPAI A(H5N1) virus and assess the potential risk to human health through poultry meat.	**Virus:** HPAI A(H5N1) virus strain A/Chicken/India/59001/07/H5N **Sample:** 120 chickens **Experiment:** Intranasal inoculation of chickens with the virus, followed by regular sampling and analysis of muscle tissues for virus detection and recovery	Viral antigen could be detected as early as 6 hours after infection and live virus was recovered from 48 hours after infection **Preventative measures:** Surveillance	There is a potential risk of human exposure to A(H5N1) virus through meat from clinically healthy chickens infected with a low dose of the virus. Proper monitoring systems to

				regularly screen poultry meat are essential to limit the global spread of A(H5N1) viruses.
VIRUS DETECTION IN UNPASTEURIZED MILK ON MILKING EQUIPMENT				
Le Sage [49] 2024 USA Farm milking equipment	Examine the persistence of HPAI A(H5N1) in unpasteurized milk on milking equipment	**Virus:** Influenza A(H5N1) strain A/dairy cattle/TX/8749001/2024 or a surrogate influenza A(H1N1)pdm09 pandemic influenza virus strain, A/California/07/2009 **Sample:** Virus samples in milk **Experiment:** Virus samples placed onto stainless steel or rubber inflation liner coupons inside an environmental chamber were collected immediately (time 0), and after 1, 3, or 5 hours to detect infectious virus; samples were compared to samples in raw milk and PBS.	A(H5N1) cattle virus remained infectious in unpasteurized milk on stainless steel and rubber after 1 hour, whereas infectious virus in PBS fell below limit of detection after 1 hour	A(H5N1) virus was still detectable after 1 hour and H1N1 was still detectable for at least 3 hours. Dairy farm workers are at risk for infection with A(H5N1) virus from surfaces contaminated during the milking process. PPE should be used during milking and liners should be sanitized after milking each cow.
AIV: Avian influenza virus, EID_{50}: 50 percent Embryo Infectious Dose, HPAI: Highly pathogenic avian influenza, HTST: High temperature short time, LPAI: Low pathogenic avian influenza virus, PBS: phosphate-buffered saline, PCR: polymerase chain reaction, PPE: personal protective equipment, RNA: ribonucleic acid, $TCID_{50}$: 50% tissue-culture infectious dose, qrRT-PCR: Quantitative real-time reverse-transcription PCR.				

7 Ongoing Studies

Two Canadian projects were highlighted as ongoing. The first study was conducted on behalf of the Pan-Canadian Milk Study Network, a group formed in April 2024 with the objective of testing retail milk samples for HPAI [55]. Every two weeks, samples of pasteurized whole (3.25%) milk are obtained from local stores. Samples are then screened using RT-PCR for the presence of influenza A viruses (IAV); any subsequent positive samples are screened for the H5 subtype of the haemagglutinin gene [55].

As of July 5, 2024, 92 milk samples from every Canadian province have been tested [55]. All samples tested negative for AIV [55].

The second project, conducted by the Canadian Food Inspection Agency, has monitored Canadian dairy cows and milk for HPAI [56]. Pasteurized commercial milk sold at retail facilities and raw, unpasteurized milk at processing plants have been periodically tested across Canada. As of September 5, 2024, 1,211 retail milk samples have been tested. All have tested negative for HPAI. As of September 20, 2024, 272 samples of raw milk at processing plants have been tested. All have tested negative for HPAI [56].

Additionally, the US Food and Drug Administration (FDA) provides regular updates on HPAI across the US, including work on the Federal-State Milk Safety System [57]. To date, two surveys on retail dairy products have been completed. In May 2024, retail milk samples were collected from 17 states. No samples were positive for viable A(H5N1). On August 13, 2024, the FDA announced the results of the second survey of retail dairy products. Samples were taken from retail dairy products, including raw milk cheese, pasteurized milk, cream cheese, butter, and ice cream; samples were taken from 31 states. All 167 samples were negative for viable A(H5N1) virus [57].

8 Other relevant literature identified

Three international reports were identified through our search that did not meet inclusion criteria but were still relevant. One report was from the US [57,58], one was from France [59], and one was from the UK [60].

One report from the US was an update on A(H5N1) beef safety studies from the US Department of Agriculture's Food Safety and Inspection Service [58] and included three studies. The first sampled beef muscle from culled dairy cows at slaughter facilities. Nearly all (108/109) of the samples that were collected tested negative for viral particles. Viral particles were detected in one diaphragm muscle from one cow. No meat from any of the dairy cattle tested entered the food supply. The second study sampled ground beef obtained from grocery stores in A(H5N1)-affected states. No virus particles were identified in any of the samples. The last study inoculated a very high level of A(H5N1) into 300 grams of ground beef and cooked the beef at three different temperatures (120°, 145°, and 160° Fahrenheit). There was no virus present in the patties cooked to 145° or 160° and the virus was substantially inactivated in the patties cooked to 120° [58].

The report from France was an opinion from the French Agency for Food, Environmental and Occupational Health and Safety (ANSES) published in 2015 on the risk of avian influenza [59]. In November 2015, a strain of HPAI A(H5N1) was identified in a backyard flock of hens and chickens. Several questions were referred to ANSES, including about the risk of exposure to humans by ingestion, mainly by consumption of raw and cooked foods. An expert appraisal was conducted. It was concluded by ANSES that, at that point, there had been no confirmed cases of HPAI A(H5N1) via consumption of food. The risk to humans via the consumption of poultry infected with HPAI A(H5N1) was evaluated as being nil to negligible [59].

The report from the UK was a risk assessment with the goal of determining the risk to UK consumers of becoming ill with AIV via food consumption, specifically commercial chicken and turkey, farmed duck and geese, and hen eggs [60]. A systematic review was conducted to identify evidence to support the risk assessment. The authors concluded that the frequency of occurrence for the UK population of acquiring AIV from the handling and consuming of commercial chicken and turkey is negligible (so rare that it does not merit to be considered) with low uncertainty. The frequency of occurrence for the UK population of acquiring AIV from the handling and consuming of duck and geese is very low (very rare but cannot be excluded) with medium uncertainty. The frequency of occurrence for the UK population of acquiring AIV from the handling and consuming of hen table eggs is very low (very rare but cannot be excluded) with low uncertainty. The severity of detriment from AIV infection in humans is high (severe illness: causing life-threatening or substantial sequelae or illness of long duration) with medium uncertainty [60].

9 Conclusions

There are no studies where human infection can be conclusively linked to ingestion or consumption of AIV-contaminated food products. In the very few studies that reported human infection, the index case that reported consuming food that may have been contaminated with AIV was also exposed to infected and symptomatic live birds.

AIV was detected in raw poultry meat, eggs, unpasteurized milk, and tissue samples from affected cows indicating that AIV is in raw food sources. Three studies indicate unpasteurized cow milk (n=2), and raw chicken (n=1) contaminated with AIV might potentially transmit infection when consumed by other mammals.

Pasteurization and cooking standards are precautionary measures that effectively inactivate AIV from milk, dairy products, and ground beef patties. Retail samples of pasteurized milk are safe for consumption, with no infectious virus detected in any tested samples.

10 Acknowledgements

This report is authored by Nkiruka Eze, Ally Memedovich, Benedicta Asante, Becky Skidmore, and Dr. Fiona Clement on behalf of the HTA Unit at the University of Calgary, and in collaboration with a network of evidence-support units supported by a secretariat housed at the McMaster Health Forum. The authors declare no conflict of interest.

We acknowledge Kaitryn Campbell, MLIS, MSc for peer review of the MEDLINE search strategy.

Suggested citation: Eze N, Memedovich A, Asante B, Skidmore B, Clement F. *Potential for Transmission of Avian Influenza Virus to Humans Associated with Handling, Preparing, and Consuming Contaminated Meat, Organs, Eggs, Milk, and Other Dairy Products from Infected Animals: A Rapid Evidence Synthesis.* Health Technology Assessment Unit, University of Calgary, October 2024.

Funding

This living evidence synthesis was commissioned and funded by the Office of the Chief Science Officer, Public Health Agency of Canada. Subject matter expertise was provided from The Public Health Agency of Canada, Health Canada and the Canadian Food Inspection Agency. The opinions, results, and conclusions are those of the team that prepared the evidence synthesis, and independent of the Government of Canada and the Public Health Agency of Canada. No endorsement by the Government of Canada or the Public Health Agency of Canada is intended or should be inferred.

11 References

1. Higgins J, Thomas J, Chandler J, et al. *Cochrane Handbook for Systematic Reviews of Interventions*. 2nd ed. 2022. www.training.cochrane.org/handbook

2. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Rev Esp Cardiol (Engl Ed)*. Sep 2021;74(9):790-799. Declaracion PRISMA 2020: una guia actualizada para la publicacion de revisiones sistematicas. doi:10.1016/j.rec.2021.07.010

3. McGowan J, Sampson M, Salzwedel DM, Cogo E, Foerster V, Lefebvre C. PRESS Peer Review of Electronic Search Strategies: 2015 Guideline Statement. *J Clin Epidemiol*. Jul 2016;75:40-6. doi:10.1016/j.jclinepi.2016.01.021

4. Ontario). OAfHPaPPH. Rapid review: survivability of influenza A (H5N1) in milk. 2024;

5. Annand EJ, High H, Wong FYK, et al. Detection of highly pathogenic avian influenza in Sekong Province Lao PDR 2018-Potential for improved surveillance and management in endemic regions. *Transbound Emerg Dis*. Jan 2021;68(1):168-182. doi:10.1111/tbed.13673

6. Burrough ER, Magstadt, D. R., Petersen, B., Timmermans, S. J., Gauger, P. C., Zhang, J....Main, R. Highly Pathogenic Avian Influenza A(H5N1) Clade 2.3.4.4b Virus Infection in Domestic Dairy Cattle and Cats, United States. *Emerging Infectious Diseases*. 2024;30(7):1335-1343. doi: https://doi.org/10.3201/eid3007.240508.

7. Caserta LC, Frye EA, Butt SL, et al. Spillover of highly pathogenic avian influenza H5N1 virus to dairy cattle. *Nature*. Jul 25 2024;doi:10.1038/s41586-024-07849-4

8. Cui P, Zhuang Y, Zhang Y, et al. Does pasteurization inactivate bird flu virus in milk? *Emerg Microbes Infect*. Dec 2024;13(1):2364732. doi:10.1080/22221751.2024.2364732

9. Dai M, Yan N, Huang Y, Zhao L, Liao M. Survivability of highly pathogenic avian influenza virus on raw chicken meat in different environmental conditions. *Lancet Microbe*. Feb 2022;3(2):e92. doi:10.1016/S2666-5247(21)00333-5

10. Dixit B, Murugkar HV, Nagarajan S, et al. Prevalence and risk factor for H9N2 avian influenza virus in poultry retail shops of Madhya Pradesh. *Virusdisease*. Jun 2024;35(2):321-328. doi:10.1007/s13337-024-00865-y

11. Guan L, Eisfeld, A. J., Pattinson, D., Gu, C., Biswas, A., Maemura, T., Trifkovic, S., Babujee, L., Presler, R., Dahn, R., Halfmann, P. J., Barnhardt, T., Neumann, G., Thompson, A., Swinford, A. K., Dimitrov, K. M., Poulsen, K., & Kawaoka, Y. . Cow's Milk Containing Avian Influenza A(H5N1) Virus — Heat Inactivation and Infectivity in Mice. *New England Journal of Medicine*. 2024;391(1): 87–90. doi:https://doi.org/10.1056/nejmc2405495

12. Islam A. Qayum MO, Hossain M. E., Islam S., Islam K., Alam H. M. S., Chakraborty P., Shakil A.A., Hassan M.M., Alamgir A., Shirin T., Rahman M.Z., Flora M.S. . EPIDEMIOLOGICAL INVESTIGATION OF H9N2 VIRUS CIRCULATION IN BACKYARD POULTRY FARMS AND HUMANS IN A RURAL COMMUNITY, BANGLADESH. *International Journal of Infectious Diseases*. 2022;130:S71-S72. doi:https://doi.org/10.1016/j.ijid.2023.04.179

13. Kaiser F, Morris, D. H., Wickenhagen, A., Mukesh, R., Gallogly, S., Yinda, K. C., De Wit, E., Lloyd-Smith, J. O., & Munster, V. J. . Inactivation of Avian Influenza A(H5N1) Virus in Raw Milk at 63°C and 72°C. *New England Journal of Medicine* Jul 4 2024;391(1):90–92. doi:https://doi.org/10.1056/nejmc2405488

14. Kintz E, Trzaska WJ, Pegg E, et al. The risk of acquiring avian influenza from commercial poultry products and hen eggs: A qualitative assessment. *Microbial Risk Analysis*. 2024;27-28doi:10.1016/j.mran.2024.100317

15. Le Sage V, Campbell AJ, Reed DS, Duprex WP, Lakdawala SS. Persistence of Influenza H5N1 and H1N1 Viruses in Unpasteurized Milk on Milking Unit Surfaces. *Emerg Infect Dis*. Aug 2024;30(8):1721-1723. doi:10.3201/eid3008.240775
16. Li J, Fang Y, Qiu X, et al. Human infection with avian-origin H5N6 influenza a virus after exposure to slaughtered poultry. *Emerg Microbes Infect*. Dec 2022;11(1):807-810. doi:10.1080/22221751.2022.2048971
17. Li Q, Zhou L, Zhou M, et al. Epidemiology of human infections with avian influenza A(H7N9) virus in China. *N Engl J Med*. Feb 6 2014;370(6):520-32. doi:10.1056/NEJMoa1304617
18. Luchansky JB, Porto-Fett ACS, Suarez DL, Spackman E. Inactivation of Avian Influenza Virus Inoculated into Ground Beef Patties Cooked on a Commercial Open-Flame Gas Grill. *J Food Prot*. Aug 2024;87(8):100325. doi:10.1016/j.jfp.2024.100325
19. Rabalski L, Milewska A, Pohlmann A, et al. Emergence and potential transmission route of avian influenza A (H5N1) virus in domestic cats in Poland, June 2023. *Euro Surveill*. Aug 2023;28(31)doi:10.2807/1560-7917.ES.2023.28.31.2300390
20. Schafers J, Warren CJ, Yang J, et al. Pasteurisation temperatures effectively inactivate influenza A viruses in milk. 2024;doi:10.1101/2024.05.30.24308212
21. Sengkeopraseuth B, Co KC, Leuangvilay P, et al. First human infection of avian influenza A(H5N6) virus reported in Lao People's Democratic Republic, February-March 2021. *Influenza Other Respir Viruses*. Mar 2022;16(2):181-185. doi:10.1111/irv.12934
22. Sharma S, Dhital K, Puri D, et al. Screening Avian Pathogens in Eggs from Commercial Hatcheries in Nepal- an Effective Poultry Disease Surveillance Tool. 2022;doi:10.1101/2022.08.11.503567
23. Shibata A, Harada R, Okamatsu M, et al. Characterization of a novel reassortant H7N3 highly pathogenic avian influenza virus isolated from a poultry meat product taken on a passenger flight to Japan. *J Vet Med Sci*. Mar 20 2019;81(3):444-448. doi:10.1292/jvms.18-0628
24. Shibata A, Okamatsu M, Sumiyoshi R, et al. Repeated detection of H7N9 avian influenza viruses in raw poultry meat illegally brought to Japan by international flight passengers. *Virology*. Nov 2018;524:10-17. doi:10.1016/j.virol.2018.08.001
25. Spackman E, Jones, D. R., McCoig, A. M., Colonius, T. J., Goraichuk, I. V., & Suarez, D. L. . Characterization of highly pathogenic avian influenza virus in retail dairy products in the US. *Journal of virology*. 2024;98(7):e0088124. doi:. https://doi.org/10.1128/jvi.00881-24
26. Uchida Y, Takemae N, Tanikawa T, Kanehira K, Saito T. Transmission of an H5N8-Subtype Highly Pathogenic Avian Influenza Virus from Infected Hens to Laid Eggs. *Avian Dis*. Jun 2016;60(2):450-3. doi:10.1637/11312-110315-Reg
27. Vasudevan G, Vanamayya PR, Nagarajan S, et al. Infectious dose-dependent accumulation of live highly pathogenic avian influenza H5N1 virus in chicken skeletal muscle-implications for public health. *Zoonoses Public Health*. Feb 2018;65(1):e243-e247. doi:10.1111/zph.12406
28. Yamamoto Y NK, Mase M. . Survival of highly pathogenic avian influenza H5N1 virus in tissues derived from experimentally infected chickens. . *Appl Environ Microbiol* 2017:83:e00604-17. doi:https://doi.org/10 .1128/AEM.00604-17.
29. Spackman E, Anderson N, Walker S, et al. Inactivation of Highly Pathogenic Avian Influenza Virus with High-temperature Short Time Continuous Flow Pasteurization and Virus Detection in Bulk Milk Tanks. *J Food Prot*. Oct 2024;87(10):100349. doi:10.1016/j.jfp.2024.100349
30. Alkie TN, Nasheri N, Romero-Barrios P, et al. Effectiveness of pasteurization for the inactivation of H5N1 influenza virus in raw whole milk. *Food Microbiology*. 2025/01/01/ 2025;125:104653. doi:https://doi.org/10.1016/j.fm.2024.104653

31. Annand E, High H, Wong F, et al. Highly pathogenic avian influenza in Sekong province Lao PDR 2018 - Potential for improved surveillance and management. *International Journal of Infectious Diseases*. 2020;101(Supplement 1):381-382. doi:https://dx.doi.org/10.1016/j.ijid.2020.09.1001
32. Li Q, Zhou L, Zhou M, et al. Epidemiology of human infections with avian influenza A(H7N9) virus in China. *The New England journal of medicine*. 2014;370(6):520-32. doi:https://dx.doi.org/10.1056/NEJMoa1304617
33. Sengkeopraseuth B, Co KC, Leuangvilay P, et al. First human infection of avian influenza A(H5N6) virus reported in Lao People's Democratic Republic, February-March 2021. *Influenza and other respiratory viruses*. 2022;16(2):181-185. doi:https://dx.doi.org/10.1111/irv.12934
34. Islam A, Qayum MO, Hossain ME, et al. EPIDEMIOLOGICAL INVESTIGATION OF H9N2 VIRUS CIRCULATION IN BACKYARD POULTRY FARMS AND HUMANS IN A RURAL COMMUNITY, BANGLADESH. *International Journal of Infectious Diseases*. 2023;130(Supplement 2):S72. doi:https://dx.doi.org/10.1016/j.ijid.2023.04.179
35. Li J, Fang Y, Qiu X, et al. Human infection with avian-origin H5N6 influenza a virus after exposure to slaughtered poultry. *Emerging microbes & infections*. 2022;11(1):807-810. doi:https://dx.doi.org/10.1080/22221751.2022.2048971
36. Dixit B, Murugkar HV, Nagarajan S, et al. Prevalence and risk factor for H9N2 avian influenza virus in poultry retail shops of Madhya Pradesh. *VirusDisease*. 2024;doi:https://dx.doi.org/10.1007/s13337-024-00865-y
37. Rabalski L, Milewska A, Pohlmann A, et al. Emergence and potential transmission route of avian influenza A (H5N1) virus in domestic cats in Poland, June 2023. *Eurosurveillance*. 2023;28(31)doi:https://dx.doi.org/10.2807/1560-7917.ES.2023.28.31.2300390
38. Sharma S, Dhital K, Puri D, et al. Screening Avian Pathogens in Eggs from Commercial Hatcheries in Nepal- an Effective Poultry Disease Surveillance Tool. *bioRxiv*. 2022;doi:https://dx.doi.org/10.1101/2022.08.11.503567
39. Shibata A, Harada R, Okamatsu M, et al. Characterization of a novel reassortant H7N3 highly pathogenic avian influenza virus isolated from a poultry meat product taken on a passenger flight to Japan. *J Vet Med Sci*. 2019;81(3):444-448. doi:10.1292/jvms.18-0628
40. Shibata A, Okamatsu M, Sumiyoshi R, et al. Repeated detection of H7N9 avian influenza viruses in raw poultry meat illegally brought to Japan by international flight passengers. *Virology*. 2018;524:10-17. doi:https://dx.doi.org/10.1016/j.virol.2018.08.001
41. Spackman E, Jones DR, McCoig AM, Colonius TJ, Goraichuk IV, Suarez DL. Characterization of highly pathogenic avian influenza virus in retail dairy products in the US. *Journal of virology*. 2024:e0088124. doi:https://dx.doi.org/10.1128/jvi.00881-24
42. Burrough ER, Magstadt DR, Petersen B, et al. Highly pathogenic avian influenza A (H5N1) clade 2.3. 4.4 b virus infection in domestic dairy cattle and cats, United States, 2024. *Emerging infectious diseases*. 2024;30(7):1335.
43. Caserta LC, Frye EA, Butt SL, et al. Spillover of highly pathogenic avian influenza H5N1 virus to dairy cattle. *Nature*. 2024:1-3.
44. Dai M, Yan N, Huang Y, Zhao L, Liao M. Survivability of highly pathogenic avian influenza virus on raw chicken meat in different environmental conditions. *The Lancet Microbe*. 2022;3(2):e92.
45. Guan L, Eisfeld AJ, Pattinson D, et al. Cow's Milk Containing Avian Influenza A (H5N1) Virus—Heat Inactivation and Infectivity in Mice. *New England Journal of Medicine*. 2024;
46. Kaiser F, Morris DH, Wickenhagen A, et al. Inactivation of Avian Influenza A (H5N1) Virus in Raw Milk at 63° C and 72° C. *New England Journal of Medicine*. 2024;

47. Uchida Y, Takemae N, Tanikawa T, Kanehira K, Saito T. Transmission of an H5N8-subtype highly pathogenic avian influenza virus from infected hens to laid eggs. *Avian Diseases*. 2016;60(2):450-453.
48. Yamamoto Y, Nakamura K, Mase M. Survival of highly pathogenic avian influenza H5N1 virus in tissues derived from experimentally infected chickens. *Applied and Environmental Microbiology*. 2017;83(16):e00604-17.
49. Le Sage V, Campbell AJ, Reed DS, Duprex WP, Lakdawala SS. Persistence of Influenza H5N1 and H1N1 Viruses in Unpasteurized Milk on Milking Unit Surfaces. *Emerging infectious diseases*. 2024;30(8)doi:https://dx.doi.org/10.3201/eid3008.240775
50. Luchansky JB, Porto-Fett ACS, Suarez DL, Spackman E. Inactivation of Avian Influenza Virus Inoculated into Ground Beef Patties Cooked on a Commercial Open-Flame Gas Grill. *Journal of food protection*. 2024;87(8):100325. doi:https://dx.doi.org/10.1016/j.jfp.2024.100325
51. Schafers J, Warren CJ, Yang J, et al. Pasteurisation temperatures effectively inactivate influenza A viruses in milk. *medRxiv*. 2024;doi:https://dx.doi.org/10.1101/2024.05.30.24308212
52. Cui P, Zhuang Y, Zhang Y, et al. Does pasteurization inactivate bird flu virus in milk? *Emerging microbes & infections*. 2024;13(1):2364732. doi:https://dx.doi.org/10.1080/22221751.2024.2364732
53. Vasudevan G, Vanamayya PR, Nagarajan S, et al. Infectious dose-dependent accumulation of live highly pathogenic avian influenza H5N1 virus in chicken skeletal muscle-implications for public health. *Zoonoses and public health*. 2018;65(1):e243-e247. doi:https://dx.doi.org/10.1111/zph.12406
54. Guan L, Eisfeld AJ, Pattinson D, et al. Cow's Milk Containing Avian Influenza A(H5N1) Virus — Heat Inactivation and Infectivity in Mice. *New England Journal of Medicine*. 2024;391(1):87-90. doi:doi:10.1056/NEJMc2405495
55. Wallace HL, Wight J, Dowding B, et al. Longitudinal Influenza A Virus Screening of Retail Milk from Canadian Provinces (Rolling Updates). *medRxiv*. 2024;doi:https://doi.org/10.1101/2024.05.28.24308052
56. Canadian Food Inspection Agency. Milk sampling and testing for highly pathogenic avian influenza (HPAI) in Canada. https://inspection.canada.ca/en/animal-health/terrestrial-animals/diseases/reportable/avian-influenza/latest-bird-flu-situation/hpai-livestock/milk-sampling-and-testing?utm_campaign=cfia-acia-hpaimilktesting-24-25&utm_medium=eml&utm_source=ogd&utm_content=results3-en-240716
57. US Food and Drug Administration. Updates on Highly Pathogenic Avian Influenza (HPAI). https://www.fda.gov/food/alerts-advisories-safety-information/updates-highly-pathogenic-avian-influenza-hpai
58. US Department of Agriculture. *Updates on H5N1 Beef Safety Studies*. 2024. https://www.usda.gov/media/press-releases/2024/05/24/updates-h5n1-beef-safety-studies
59. French Agency for Food EaOHS. *OPINION of the French Agency for Food, Environmental and Occupational Health & Safety concerning the risk of avian influenza (Request No 2015-SA-0241)*. 2015. https://www.anses.fr/en/system/files/SANT2015sa0241EN.pdf
60. Kintz E, Trzaska WJ, Pegg E, et al. The risk of acquiring avian influenza from commercial poultry products and hen eggs: A qualitative assessment. *Microbial Risk Analysis*. 2024;27-28:100317. doi:https://dx.doi.org/10.1016/j.mran.2024.100317

Appendices

11.1 Appendix A. PRISMA Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	10
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	10
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	8
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	8, 9
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	11, 12
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	10
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Appx B
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	10, 11
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	10,11
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	11
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	11
Study risk of bias	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used	N/A

Section and Topic	Item #	Checklist item	Location where item is reported
assessment		in the process.	
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	N/A
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	11
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	11,12
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	11,12
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	11, 12
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	N/A
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	N/A
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	N/A
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Fig 1., 14
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	N/A
Study characteristics	17	Cite each included study and present its characteristics.	Fig. 2, Tables 2-4; 15-22
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	N/A
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Tables 2-4; 15-29

Section and Topic	Item #	Checklist item	Location where item is reported
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	15-29
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	N/A
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	N/A
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	15-29
	23b	Discuss any limitations of the evidence included in the review.	N/A
	23c	Discuss any limitations of the review processes used.	N/A
	23d	Discuss implications of the results for practice, policy, and future research.	30
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	10
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	N/A
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	31
Competing interests	26	Declare any competing interests of review authors.	31
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Table 2-4; 15-22

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

11.2 Appendix B. Search Strategy

Ovid Multifile

Database: Embase <1974 to 2024 July 22>, Ovid MEDLINE(R) ALL <1946 to July 22, 2024>
Search Strategy:
----
1 Influenza in Birds/ (14439)
2 Influenza A Virus, H5N1 Subtype/ (8858)
3 (H5N1 or HPAI).tw,kw,kf. (18343)
4 ((avian or bird?) adj3 (flu or flus or influenza*)).tw,kw,kf. (30604)
5 (fowl? adj3 plague?).tw,kw,kf. (849)
6 "clade 2.3.4.4b".tw,kw,kf. (636)
7 (AIV and avian).tw,kw,kf. (4419)
8 or/1-7 [AVIAN FLU/VIRUS] (40537)
9 Food/ (122050)
10 (food or foods).tw,kw,kf. (1431224)
11 exp Dairy Products/ (242901)
12 (butter* or cheese* or cream* or curd* or dairy* or egg or eggs or ghee or kefir* or koumiss* or margarine* or milk* or yoghurt* or yogurt*).tw,kw,kf. (818826)
13 exp Food, Preserved/ (5525)
14 Food, Processed/ (2247)
15 exp Foods, Specialized/ (1341863)
16 exp Meat/ (150495)
17 (meat or meats or beef* or lamb* or mutton or pork* or veal).tw,kw,kf. (428096)
18 Food Contamination/ (97242)
19 Food Microbiology/ (62310)
20 exp Food Handling/ (237148)
21 exp Eating/ (125693)
22 (ate or consum* or drink* or eat or eaten or eats or eating or feed* or ingest* or intake*).tw,kw,kf. (3779522)
23 Cooking/ (36518)
24 cook*.tw,kw,kf. (94517)
25 or/9-24 [FOOD, ETC.] (6232522)
26 8 and 25 [AVIAN FLU/VIRUS - FOOD] (6358)
27 Humans/ (42486868)
28 (human or humans or people or person? or people or child* or boy or boys or girl or girls or man or men or wom#n).tw,kw,kf. (17252829)
29 Farmers/ (33921)
30 ((agricultur* or dairy* or farm*) adj3 (employee? or force or forces or individual? or labo?r* or people or personnel or person? or staff or worker? or workforce?)).tw,kw,kf. (21528)
31 (dairyfarmer? or dairyworker? or farmer? or farmworker?).tw,kw,kf. (71035)

32 ((egg or eggs or beef? or food? or meat? or meatpack* or meatprocess* or lamb? or milk or milking or pork or sheep or slaughter* or veal) adj3 (employee? or force or forces or handler? or labo?r* or people or personnel or person? or staff or worker? or workforce?)).tw,kw,kf. (20737)
33 (hunter? or trapper?).tw,kw,kf. (22971)
34 Dietary Exposure/ (4388)
35 Environmental Exposure/ (213145)
36 Occupational Exposure/ (154398)
37 Prenatal Exposure Delayed Effects/ (35185)
38 (contact* or expos*).tw,kw,kf. (4454738)
39 or/27-38 [HUMAN EXPOSURE] (49358878)
40 26 and 39 [AVIAN FLU/VIRUS - FOOD - HUMAN EXPOSURE] (3776)
41 limit 40 to yr="2014-current" [DATE LIMIT APPLIED] (1859)
42 limit 41 to english (1821)
43 limit 41 to french (6)
44 42 or 43 [LANGUAGE LIMITS APPLIED] (1822)
45 44 use medall [MEDLINE RECORDS] (1137)
46 exp avian influenza/ (18801)
47 exp "influenza A(H5N1)"/ (3281)
48 (H5N1 or HPAI).tw,kw,kf. (18343)
49 ((avian or bird?) adj3 (flu or flus or influenza*)).tw,kw,kf. (30604)
50 (fowl? adj3 plague?).tw,kw,kf. (849)
51 "clade 2.3.4.4b".tw,kw,kf. (636)
52 (AIV and avian).tw,kw,kf. (4419)
53 or/46-52 [AVIAN FLU/VIRUS] (41437)
54 food/ (122050)
55 (food or foods).tw,kw,kf. (1431224)
56 exp dairy product/ (242901)
57 (butter* or cheese* or cream* or curd* or dairy* or egg or eggs or ghee or kefir* or koumiss* or margarine* or milk* or yoghurt* or yogurt*).tw,kw,kf. (818826)
58 exp preserved food/ (5525)
59 exp processed food/ (8087)
60 exp animal product/ (315443)
61 exp Meat/ (150495)
62 (meat or meats or beef* or lamb* or mutton or pork* or veal).tw,kw,kf. (428096)
63 food contamination/ (97242)
64 exp food control/ (106781)
65 exp food handling/ (237148)
66 exp food intake/ (515427)
67 (ate or consum* or drink* or eat or eaten or eats or eating or feed* or ingest* or intake*).tw,kw,kf. (3779522)
68 exp cooking/ (40748)
69 cook*.tw,kw,kf. (94517)
70 or/54-69 [FOOD, ETC.] (5884465)
71 53 and 70 [AVIAN FLU/VIRUS - FOOD] (6346)
72 exp human/ (48995426)

73 (human or humans or people or person? or people or child* or boy or boys or girl or girls or man or men or wom#n).tw,kw,kf. (17252829)
74 agricultural worker/ (33921)
75 ((agricultur* or dairy* or farm*) adj3 (employee? or force or forces or individual? or labo?r* or people or personnel or person? or staff or worker? or workforce?)).tw,kw,kf. (21528)
76 (dairyfarmer? or dairyworker? or farmer? or farmworker?).tw,kw,kf. (71035)
77 ((egg or eggs or beef? or food? or meat? or meatpack* or meatprocess* or lamb? or milk or milking or pork or sheep or slaughter* or veal) adj3 (employee? or force or forces or handler? or labo?r* or people or personnel or person? or staff or worker? or workforce?)).tw,kw,kf. (20737)
78 (hunter? or trapper?).tw,kw,kf. (22971)
79 exposure/ (185716)
80 dietary exposure/ (4388)
81 environmental exposure/ (213145)
82 intermittent exposure/ (132)
83 lactational exposure/ (155)
84 long term exposure/ (38095)
85 maternal exposure/ (16417)
86 occupational exposure/ (154398)
87 paternal exposure/ (1792)
88 perinatal exposure/ (904)
89 prenatal exposure/ (66513)
90 short term exposure/ (3341)
91 (contact* or expos*).tw,kw,kf. (4454738)
92 or/72-91 [HUMAN EXPOSURE] (53422918)
93 71 and 92 [AVIAN FLU/VIRUS - FOOD - HUMAN EXPOSURE] (3814)
94 limit 93 to yr="2014-current" [DATE LIMIT APPLIED] (1854)
95 limit 94 to english (1816)
96 limit 94 to french (6)
97 95 or 96 [LANGUAGE LIMITS APPLIED] (1817)
98 97 use oemezd [EMBASE RECORDS] (685)
99 45 or 98 [BOTH DATABASES] (1822)
100 remove duplicates from 99 (1376) [TOTAL UNIQUE RECORDS]
101 100 use medall [MEDLINE UNIQUE RECORDS] (1134)
102 100 use oemezd [EMBASE UNIQUE RECORDS] (242)

****

CINAHL

#	Query	Limiters/Expanders	Last Run Via	Results
S48	S45 AND S46	Limiters - Publication Date: 20140101-20241231 Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search	187

			Screen - Advanced Search Database - CINAHL Plus with Full Text	
S47	S45 AND S46	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	357
S46	LA English OR LA French	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	8,776,849
S45	S29 AND S44	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	359
S44	S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41 OR S42 OR S43	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases	3,706,475

			Search Screen - Advanced Search Database - CINAHL Plus with Full Text	
S43	TI (contact* or expos*) OR AB (contact* or expos*)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	292,540
S42	(MH "Prenatal Exposure Delayed Effects")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	6,767
S41	(MH "Paternal Exposure")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	227
S40	(MH "Maternal Exposure")	Search modes - Find all my search terms	Interface - EBSCOhost Research	2,741

			Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	
S39	(MH "Occupational Exposure")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	21,607
S38	(MH "Environmental Exposure")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	20,382
S37	(MH "Dietary Exposure")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	143
S36	TI (hunter# or trapper#) OR AB (hunter# or trapper#)	Search modes - Find all my search terms	Interface - EBSCOhost	1,390

			Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	
S35	TI ((egg or eggs or beef# or food# or meat# or meatpack* or meatprocess* or lamb# or milk or milking or pork or sheep or slaughter* or veal) N3 (employee# or force or forces or handler# or labo#r* or people or personnel or person# or staff or worker# or workforce#)) OR AB ((egg or eggs or beef# or food# or meat# or meatpack* or meatprocess* or lamb# or milk or milking or pork or sheep or slaughter* or veal) N3 (employee# or force or forces or handler# or labo#r* or people or personnel or person# or staff or worker# or workforce#))	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	3,147
S34	TI (dairyfarmer# or dairyworker# or farmer# or farmworker#) OR AB (dairyfarmer# or dairyworker# or farmer# or farmworker#)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	4,504
S33	TI ((agricultur* or dairy* or farm*) N3 (employee# or force or forces or individual# or labo#r* or people or personnel or person# or staff or worker# or workforce#)) OR AB ((agricultur* or dairy* or farm*) N3 (employee# or force or forces or individual# or labo#r* or people or personnel or person# or staff or worker# or workforce#))	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	2,114

S32	(MH "Farmworkers")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	4,082
S31	TI (human or humans or people or person# or people or child* or boy or boys or girl or girls or man or men or wom?n) OR AB (human or humans or people or person# or people or child* or boy or boys or girl or girls or man or men or wom?n)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	1,781,501
S30	(MH "Human")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	2,815,989
S29	S8 AND S28	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database -	667

			CINAHL Plus with Full Text	
S28	S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	501,611
S27	TI cook* OR AB cook*	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	9,719
S26	(MH "Cooking")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	8,264
S25	TI (ate or consum* or drink* or eat or eaten or eats or eating or feed* or ingest* or intake*) OR AB (ate or consum* or drink* or eat or eaten or eats or eating or feed* or ingest* or intake*)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search	372,053

			Database - CINAHL Plus with Full Text	
S24	(MH "Eating")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	7,599
S23	(MH "Food Intake+")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	24,849
S22	(MH "Food Handling+")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	25,755
S21	(MH "Food Microbiology")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced	1,512

			Search Database - CINAHL Plus with Full Text	
S20	(MH "Food Contamination")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	3,827
S19	TI (meat or meats or beef* or lamb* or mutton or pork* or veal) OR AB (meat or meats or beef* or lamb* or mutton or pork* or veal)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	14,228
S18	(MH "Meat+")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	9,867
S17	(MH "Food Preservatives")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen -	256

			Advanced Search Database - CINAHL Plus with Full Text	
S16	(MH "Food Preservation+")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	880
S15	TI (butter* or cheese* or cream* or curd* or dairy* or egg or eggs or ghee or kefir* or koumiss* or margarine* or milk* or yoghurt* or yogurt*) OR AB (butter* or cheese* or cream* or curd* or dairy* or egg or eggs or ghee or kefir* or koumiss* or margarine* or milk* or yoghurt* or yogurt*)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	40,967
S14	(MH "Cheese")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	1,095
S13	(MH "Eggs")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search	2,486

			Screen - Advanced Search Database - CINAHL Plus with Full Text	
S12	(MH "Butter") OR (MH "Margarine")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	607
S11	(MH "Dairy Products+")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	11,686
S10	TI (food or foods) OR AB (food or foods)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	131,446
S9	(MH "Food")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases	15,282

			Search Screen - Advanced Search Database - CINAHL Plus with Full Text	
S8	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	2,816
S7	TI (AIV and avian) OR AB (AIV and avian)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	48
S6	TI "clade 2.3.4.4b" OR AB "clade 2.3.4.4b"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	33
S5	TI fowl# N3 plague# OR AB fowl# N3 plague#	Search modes - Find all my search terms	Interface - EBSCOhost Research	0

			Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	
S4	TI ((avian or bird#) N3 (flu or flus or influenza*)) OR AB ((avian or bird#) N3 (flu or flus or influenza*))	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	1,942
S3	TI (H5N1 or HPAI) OR AB (H5N1 or HPAI)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	810
S2	(MH "Influenza A H5N1") OR (MH "Influenza A Virus, H5N1 Subtype")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	741
S1	(MH "Influenza, Avian")	Search modes - Find all my search terms	Interface - EBSCOhost	1,290

			Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text	

CAB Abstracts

#	Query	Limiters/Expanders	Last Run Via	Results
S45	S42 AND S43	Limiters - Publication Year: 20140101-20241231 Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	483
S44	S42 AND S43	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	1,021
S43	LA English OR LA French	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	9,756,462

S42	S30 AND S41	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	1,183
S41	S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	2,987,484
S40	TI (contact* or expos*) OR AB (contact* or expos*)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	647,343
S39	DE "exposure"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	63,904
S38	TI (hunter# or trapper#) OR AB (hunter# or trapper#)	Search modes - Find all my search terms	Interface - EBSCOhost Research	8,210

			Databases Search Screen - Advanced Search Database - CAB Abstracts	
S37	TI ((egg or eggs or beef# or food# or meat# or meatpack* or meatprocess* or lamb# or milk or milking or pork or sheep or slaughter* or veal) N3 (employee# or force or forces or handler# or labo#r* or people or personnel or person# or staff or worker# or workforce#)) OR AB ((egg or eggs or beef# or food# or meat# or meatpack* or meatprocess* or lamb# or milk or milking or pork or sheep or slaughter* or veal) N3 (employee# or force or forces or handler# or labo#r* or people or personnel or person# or staff or worker# or workforce#))	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	25,053
S36	DE "food handlers"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	1,494
S35	TI (dairyfarmer# or dairyworker# or farmer# or farmworker#) OR AB (dairyfarmer# or dairyworker# or farmer# or farmworker#)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	243,000
S34	TI ((agricultur* or dairy* or farm*) N3 (employee# or force or forces or individual# or labo#r* or people or personnel or person# or staff or worker# or workforce#)) OR AB (	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases	49,763

	(agricultur* or dairy* or farm*) N3 (employee# or force or forces or individual# or labo#r* or people or personnel or person# or staff or worker# or workforce#))		Search Screen - Advanced Search Database - CAB Abstracts	
S33	DE "farm families" OR DE "farmers"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	54,448
S32	TI (human or humans or people or person# or people or child* or boy or boys or girl or girls or man or men or wom?n) OR AB (human or humans or people or person# or people or child* or boy or boys or girl or girls or man or men or wom?n)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	1,510,204
S31	DE "man"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	1,697,816
S30	S6 AND S29	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced	2,670

			Search Database - CAB Abstracts	
S29	S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	2,780,291
S28	TI cook* OR AB cook*	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	72,011
S27	DE "cooking" OR DE "outdoor cooking"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	19,994
S26	TI (ate or consum* or drink* or eat or eaten or eats or eating or feed* or ingest* or intake*) OR AB (ate or consum* or drink* or eat or eaten or eats or eating or feed* or ingest* or intake*)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	1,492,464

S25	DE "eating"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	4,852
S24	DE "food intake" OR DE "food consumption"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	83,049
S23	DE "food handling"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	2,247
S22	DE "food microbiology"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	12,489
S21	DE "food contamination" OR DE "foodborne diseases" OR DE "milkborne diseases"	Search modes - Find all my search terms	Interface - EBSCOhost Research	104,110

			Databases Search Screen - Advanced Search Database - CAB Abstracts	
S20	TI (meat or meats or beef* or lamb* or mutton or pork* or veal) OR AB (meat or meats or beef* or lamb* or mutton or pork* or veal)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	305,059
S19	DE "meat" OR DE "beef" OR DE "buffalo meat" OR DE "camel meat" OR DE "crab meat" OR DE "donkey meat" OR DE "game meat" OR DE "goat meat" OR DE "horse meat" OR DE "ostrich meat" OR DE "pigmeat" OR DE "poultry meat" OR DE "rabbit meat" OR DE "seal meat" OR DE "sheepmeat" OR DE "turtle meat" OR DE "variety meats" OR DE "veal" OR DE "whale meat" OR DE "canned meat" OR DE "dried meat" OR DE "frozen meat" OR DE "meat products" OR DE "beefburgers" OR DE "canned meat" OR DE "cured meats" OR DE "dried meat" OR DE "frozen meat" OR DE "hamburgers" OR DE "luncheon meats" OR DE "meat extracts" OR DE "meat pastes" OR DE "mechanically deboned meat" OR DE "patties" OR DE "salami" OR DE "sausages" OR DE "smoked meats" OR DE "surimi"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	128,015
S18	DE "food preservatives"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search	7,913

			Database - CAB Abstracts	
S17	DE "food preservation" OR DE "brining" OR DE "drying" OR DE "home food preservation" OR DE "milk preservation" OR DE "pickling" OR DE "salting" OR DE "smoking"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	57,840
S16	TI (butter* or cheese* or cream* or curd* or dairy* or egg or eggs or ghee or kefir* or koumiss* or margarine* or milk* or yoghurt* or yogurt*) OR AB (butter* or cheese* or cream* or curd* or dairy* or egg or eggs or ghee or kefir* or koumiss* or margarine* or milk* or yoghurt* or yogurt*)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	786,718
S15	DE "yoghurt" OR DE "frozen yoghurt"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	16,726
S14	DE "koumiss"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	359

S13	DE "kefir"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	2,320
S12	DE "butter" OR DE "ghee" OR DE "whey butter"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	10,678
S11	DE "eggs" OR DE "duck eggs" OR DE "goose eggs" OR DE "turkey eggs"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	43,255
S10	DE "margarine"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	2,208
S9	DE "milk products" OR DE "butter" OR DE "butter oil" OR DE "buttermilk" OR DE "cheese milk" OR DE "cheese slurry" OR DE "cheeses"	Search modes - Find all my search terms	Interface - EBSCOhost Research	250,927

	OR DE "chhana" OR DE "cream" OR DE "cultured milks" OR DE "curd" OR DE "custard" OR DE "dried milk products" OR DE "dulce de leche" OR DE "ice cream" OR DE "jellified milks" OR DE "khoa" OR DE "lactic beverages" OR DE "milk" OR DE "paneer" OR DE "quarg" OR DE "recombined milk" OR DE "toned milk" OR DE "whey"		Databases Search Screen - Advanced Search Database - CAB Abstracts	
S8	TI (food or foods) OR AB (food or foods)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	836,335
S7	DE "food" OR DE "food products" OR DE "foods"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	226,268
S6	S1 OR S2 OR S3 OR S4 OR S5	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	15,699
S5	TI (AIV and avian) OR AB (AIV and avian)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search	2,886

			Screen - Advanced Search Database - CAB Abstracts	
S4	TI "clade 2.3.4.4b" OR AB "clade 2.3.4.4b"	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	220
S3	TI fowl# N3 plague# OR AB fowl# N3 plague#	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	241
S2	TI ((avian or bird#) N3 (flu or flus or influenza*)) OR AB ((avian or bird#) N3 (flu or flus or influenza*))	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CAB Abstracts	14,580
S1	TI (H5N1 or HPAI) OR AB (H5N1 or HPAI)	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search	6,257

			Database - CAB Abstracts	

Web of Science (Core Collection)

Set #	Search Query	Results
1	H5N1 or HPAI (Topic) OR (avian or bird or birds) NEAR/3 (flu or flus or influenza*) (Topic) OR (fowl or fowls) NEAR/3 plague* (Topic) OR "clade 2.3.4.4b" (Topic) OR AIV and avian (Topic)	22543
2	food or foods (Topic) OR butter* or cheese* or cream* or curd* or dairy* or egg or eggs or ghee or kefir* or koumiss* or margarine* or milk* or yoghurt* or yogurt*i (Topic) OR meat or meats or beef* or lamb* or mutton or pork* or veal (Topic) OR ate or consum* or drink* or eat or eaten or eats or eating or feed* or ingest* or intake* (Topic) OR cook* (Topic)	5774244
3	human or humans or people or person or persons or people or child* or boy or boys or girl or girls or man or men or woman or women (Topic) OR (agricultur* or dairy* or farm*) NEAR/3 (employee* or force or forces or individual* or labor* or labour* or people or personnel or person or persons or staff or worker* or workforce*) (Topic) OR dairyfarmer* or dairyworker* or farmer* or farmworker* (Topic)	11099704
4	(egg or eggs or beef or beefs or food or foods or meat or meats or meatpack* or meatprocess* or lamb or lambs or milk or milking or pork or sheep or slaughter* or veal) NEAR/3 (employee* or force or forces or handler* or labor* or labour* or people or personnel or person or persons or staff or worker* or workforce*) (Topic) OR hunter* or trapper* (Topic)	56826
5	contact* or expos* (Topic)	3338640
6	#5 OR #4 OR #3	13624589
7	#1 AND #2 AND #6	1280
8	#1 AND #2 AND #6 and 2024 or 2023 or 2022 or 2021 or 2020 or 2019 or 2018 or 2017 or 2016 or 2015 or 2014 (Publication Years)	707

9	#1 AND #2 AND #6 and 2024 or 2023 or 2022 or 2021 or 2020 or 2019 or 2018 or 2017 or 2016 or 2015 or 2014 (Publication Years) and English or French (Languages)	697