

Perspectives on vaccination as an approach for control of highly pathogenic avian influenza viruses: challenges and opportunities

**Shayan Sharif
Ontario Veterinary College
University of Guelph
Canada**

2022-2024 H5N1 outbreaks in poultry and wild birds in the US

More Spotlights



Wild Birds

Wild Birds Detected

8,753

as of 2/08/2024 | [Full Report >](#)



Poultry

Poultry Affected

81,801,527

as of 2/08/2024 | [Full Report >](#)



Humans

Reported Human Cases in the U.S.

1

as of 04/28/2022 | [Full Report >](#)

Jurisdictions with Bird Flu in Wild Birds

50

States with Poultry Outbreaks

47

States with Reported Case(s)

1



This webpage will be updated weekly on Wednesdays to reflect any new data. Data on wild birds have been collected since January 20, 2022. Data on poultry have been collected since February 8, 2022.

Protective Actions for People



[Protective actions around wild birds](#)



[If you have contact with infected birds and become](#)

2022-2024 H5N1 outbreaks in poultry in Canada

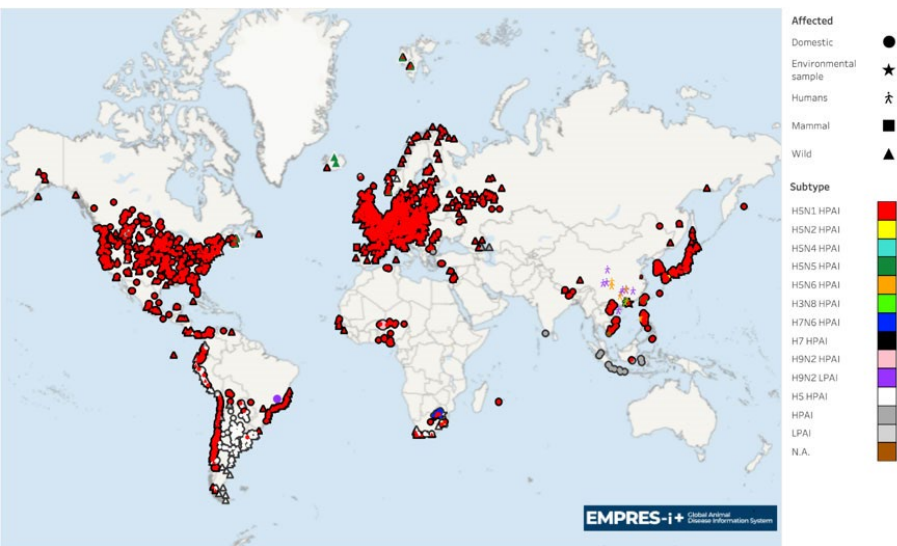
Flocks in Canada where HPAI has been detected

▼
[Estimated number of birds in infected flocks](#)

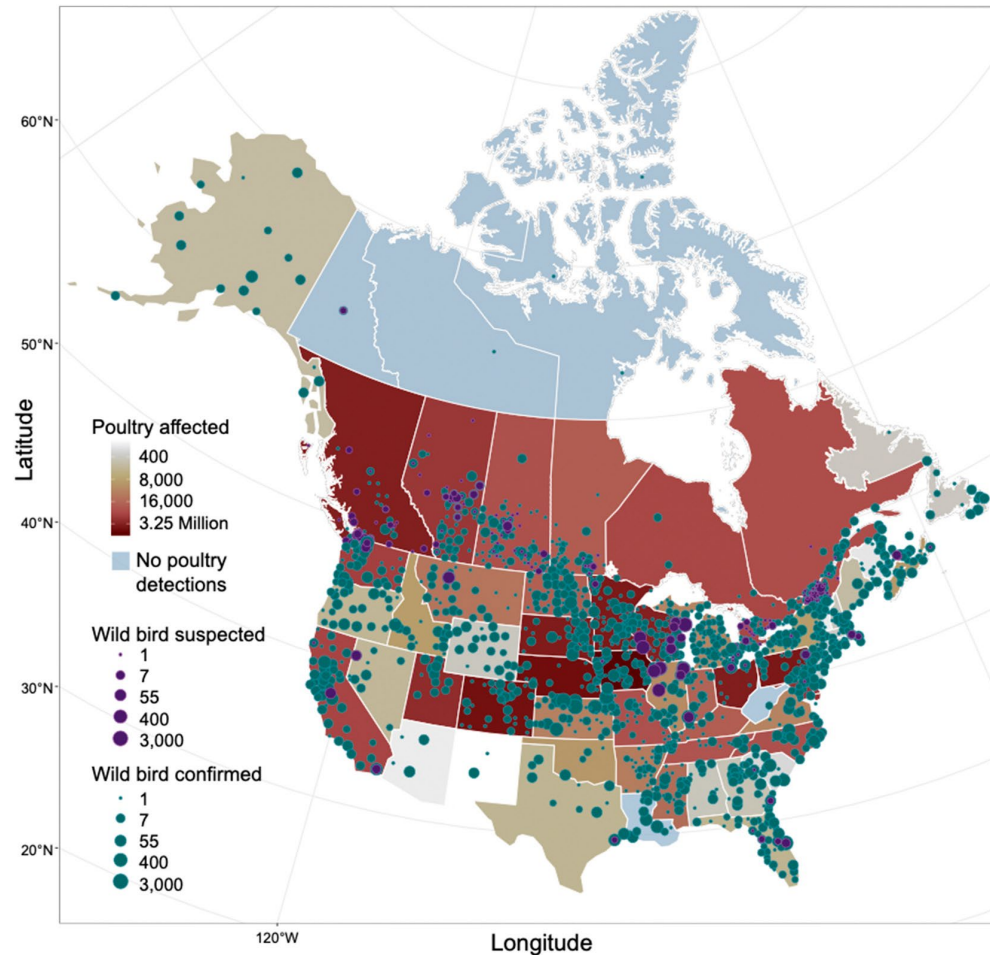
This table lists the estimated number of birds in flocks impacted by highly pathogenic avian influenza by province.

Province	Number of infected premises (current IPs)	Number of previously infected premises (released IPs)	Estimated number of birds impacted (as of 2024-02-09)
Alberta	4	77	1,858,000
British Columbia	18	140	6,004,000
Manitoba	0	23	400,000
New Brunswick	0	2	Under 100
Newfoundland and Labrador	0	2	400
Nova Scotia	2	6	12,000
Ontario	1	48	899,000
Quebec	1	51	1,111,000
Saskatchewan	2	42	742,000
Total	28	391	11,026,500

Highly pathogenic avian influenza H5N1 outbreaks

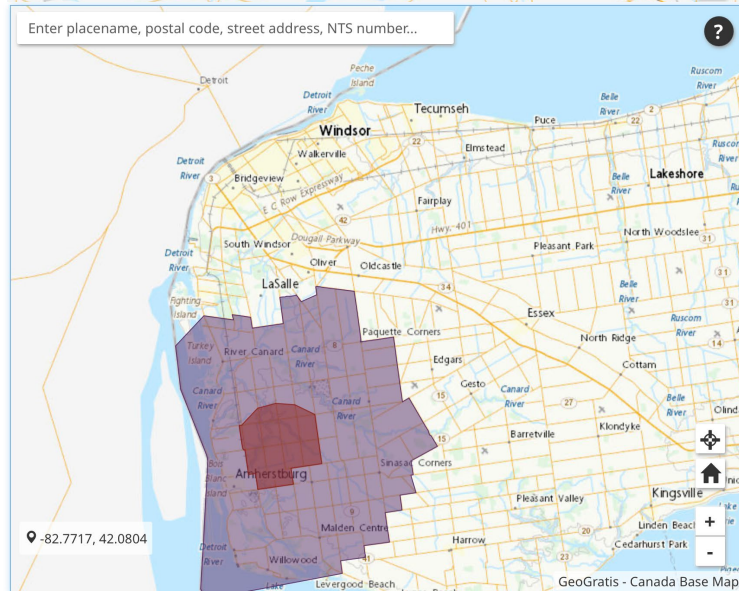
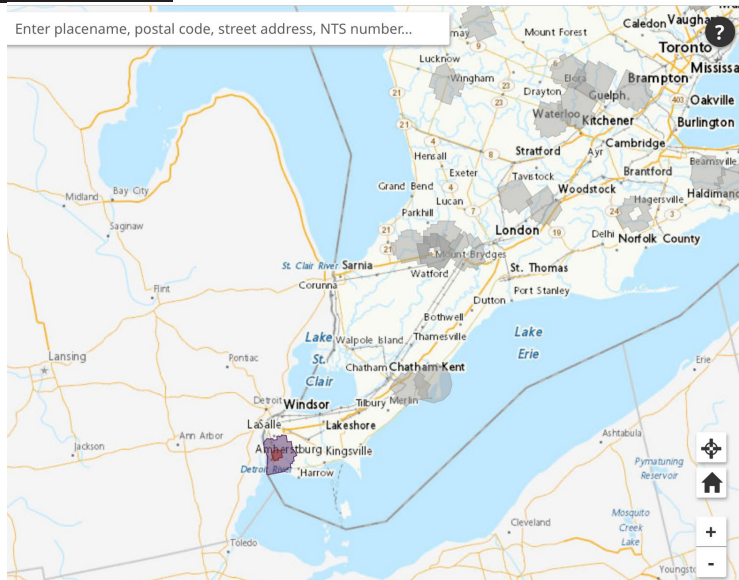


AIV with zoonotic potential, 2022 to 2023



Poultry affected by HPAIV H5N1 from December 2021 to March 2023
([Canadian Food Inspection Agency Government of Canada, 2023b](#); [USDA APHIS, 2023b](#))

Control of HPAI in Canada



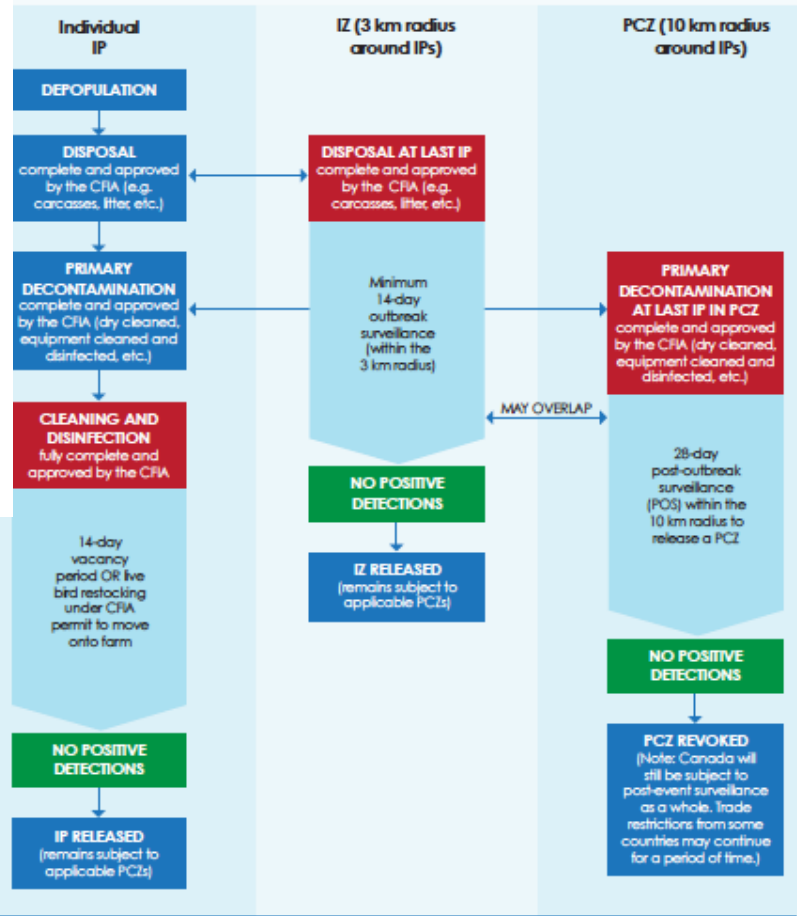
- ☒ Commercial - Infected zone
- ☒ Commercial - Restricted zone
- ☒ Commercial - Security zone
- ☒ Non-commercial - Infected zone
- ☒ Non-commercial - Restricted zone
- ☒ Non-commercial - Security Zone
- ☒ Revoked zone

- ☒ Commercial - Infected zone
- ☒ Commercial - Restricted zone
- ☒ Commercial - Security zone
- ☒ Non-commercial - Infected zone
- ☒ Non-commercial - Restricted zone
- ☒ Non-commercial - Security Zone
- ☒ Revoked zone

The path to revoking a primary control zone

The process leading to revoking a primary control zone (PCZ) begins when the last infected premises (IP) in a PCZ has completed primary decontamination. Certain steps are tied to the size of the premises and the type of action required. As a result, the number of days required to complete the revocation process may vary.

The following outlines key trigger points for specific timelines related to an IP, an infected zone (IZ) within a PCZ, and a PCZ.



Avian influenza is a federally reportable disease – anyone suspecting avian influenza is required to report to the CRA

inspection.canada.ca/flock-protection

Source: CFIA

HPAI live and dead bird testing and surveillance in Canada



CANADIAN
WILDLIFE HEALTH
COOPERATIVE

REPORT & SUBMIT

SURVEILLANCE & RE-
SPONSE

REPORTS

PUBLICATIONS

ABOUT US

REGIONS

WHIP



CANADIAN
WILDLIFE HEALTH
COOPERATIVE

REPORT & SUBMIT

SURVEILLANCE & RE-
SPONSE

REPORTS

PUBLICATIONS

ABOUT US

REGIONS

WHIP

CONTACT US

LEGAL & DISCLAIMER

LIVE BIRD SURVEY - 2023

Region	Tested	Matrix Positive*	H5 Positive	H7 Positive	HPAI **
British Columbia	53	5	0	0	0
Alberta	0	0	0	0	0
Saskatchewan	45	0	0	0	0
Manitoba	0	0	0	0	0
Ontario	737	0	2	0	0
Quebec	944	1	1	0	1
New Brunswick	406	63	0	0	0
Nova Scotia	249	28	3	0	0
Prince Edward Island	378	5	0	0	0
Newfoundland and Labrador	550	92	2	0	1
Yukon	0	0	0	0	0
Northwest Territories	406	0	0	0	0
Nunavut	220	0	0	0	0
TOTAL	3988	194	8	0	1

** The CFIA has confirmed the presence of High Pathogenic Avian Influenza (HPAI), subtype H5N1. Numbers correct as of October 3, 2023

DEAD BIRD SURVEY - 2023

Region	September 26 - October 23, 2023		Year To Date				HPAI **
	Tested	Matrix Positive*	Tested	Matrix Positive*	H5 Positive	H7 Positive	
British Columbia	0	0	0	0	0	0	15
Alberta	51	14	418	37	36	0	8
Saskatchewan	28	4	338	18	14	0	0
Manitoba	11	0	189	1	1	0	3
Ontario	51	2	765	147	148	0	103
Québec	19	0	362	36	35	0	15
New Brunswick	2	0	155	10	7	0	1
Nova Scotia	0	0	233	47	47	0	40
Prince Edward Island	9	0	119	57	56	0	45
Newfoundland and Labrador	0	0	63	20	19	0	10
Yukon	1	0	20	1	1	0	0
Northwest Territories	0	0	5	0	0	0	0
Nunavut	0	0	8	1	1	0	1
TOTAL	172	20	2675	375	365	0	241

** The CFIA has confirmed the presence of High Pathogenic Avian Influenza (HPAI), subtype H5N1.

Digital surveillance of HPAI

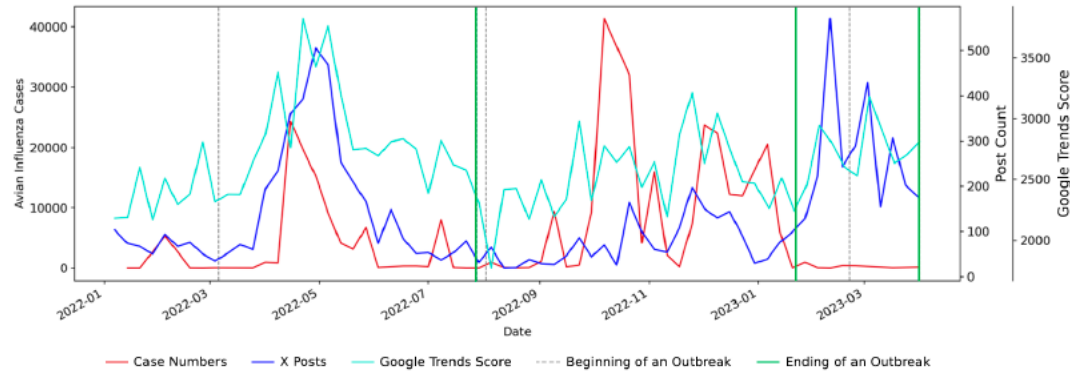


Fig. 7: Weekly Trend of Post Count, Google Trends Score, and Avian Influenza Cases in Canada. Depicted outbreak waves were reported by the Canadian Food Inspection Agency (CFIA). The gray dashed line represents 3 weeks prior to the outbreak start date, and the green line shows the end of the wave.

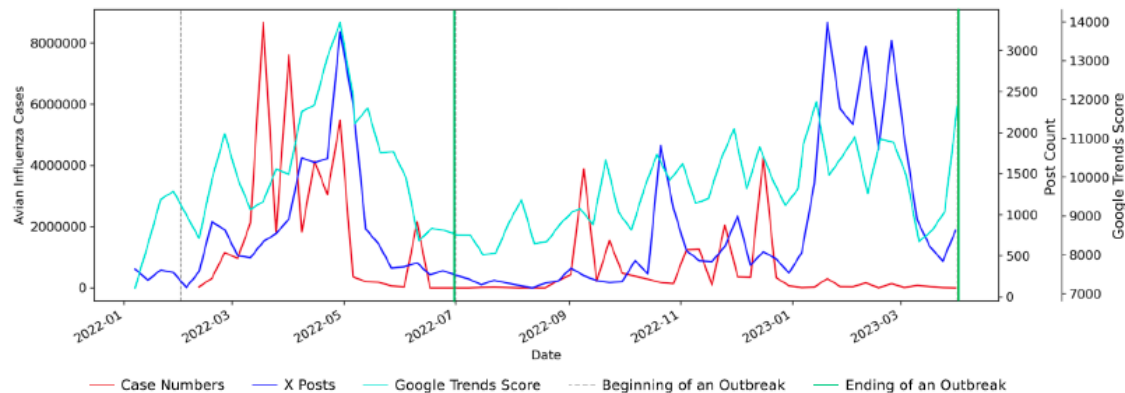


Fig. 8: Weekly Trend of Post Count, Google Trends Score, and Avian Influenza Cases in the USA. Depicted outbreak waves were reported by the USDA. The gray dashed line represents 3 weeks prior to the outbreak start date, and the green line shows the end of the wave.

Will H5N1 jump to mammals and eventually to humans?

Popular Latest Newsletters

The Atlantic

My Account

Eagles Are Falling, Bears Are Going Blind

Bird flu is already a tragedy.

By Katherine J. Wu



Sea lion die-off in Peru

H5N1 and transmission to mammals

nature

[Explore content](#) ▾ [About the journal](#) ▾ [Publish with us](#) ▾ [Subscribe](#)

[nature](#) > [research highlights](#) > [article](#)

RESEARCH HIGHLIGHT | 17 March 2023

Bird-flu virus makes itself at home in Canada's foxes and skunks

The virulent H5N1 strain now sweeping across the world is adapting to its mammalian hosts in northern North America.



Pet dog dies from bird flu in Ontario — but experts tell owners to 'relax'

Experts warn pet owners to keep animals away from wildlife after dog dies in Oshawa, Ont. after chewing on a diseased gopher



Kayla Kuefler · Shopping & Lifestyle Editor

April 5, 2023 · 3 min read



TRENDING

1. Nordstrom T-shirt dress
2. I just flew: essentials
3. Reviewers 'magic' — a
4. Amazon C:

Wyoming reports high-path avian flu in cat

News brief | April 7, 2023

Lisa Schnirring

Topics: Avian Influenza (Bird Flu)



SHARE

The Wyoming State Veterinary Lab (WSVL) said it has diagnosed highly pathogenic avian influenza in a barn cat, the state's first detection of the virus in a domestic cat.

In a brief **statement** on its website, the WSVL said the cat is located near Thermopolis, in the central part of the state. It said that the cat probably contracted the virus from eating meat from wild waterfowl. In recent months, the lab has also detected the virus in other carnivores, including mountain lions and a red fox.

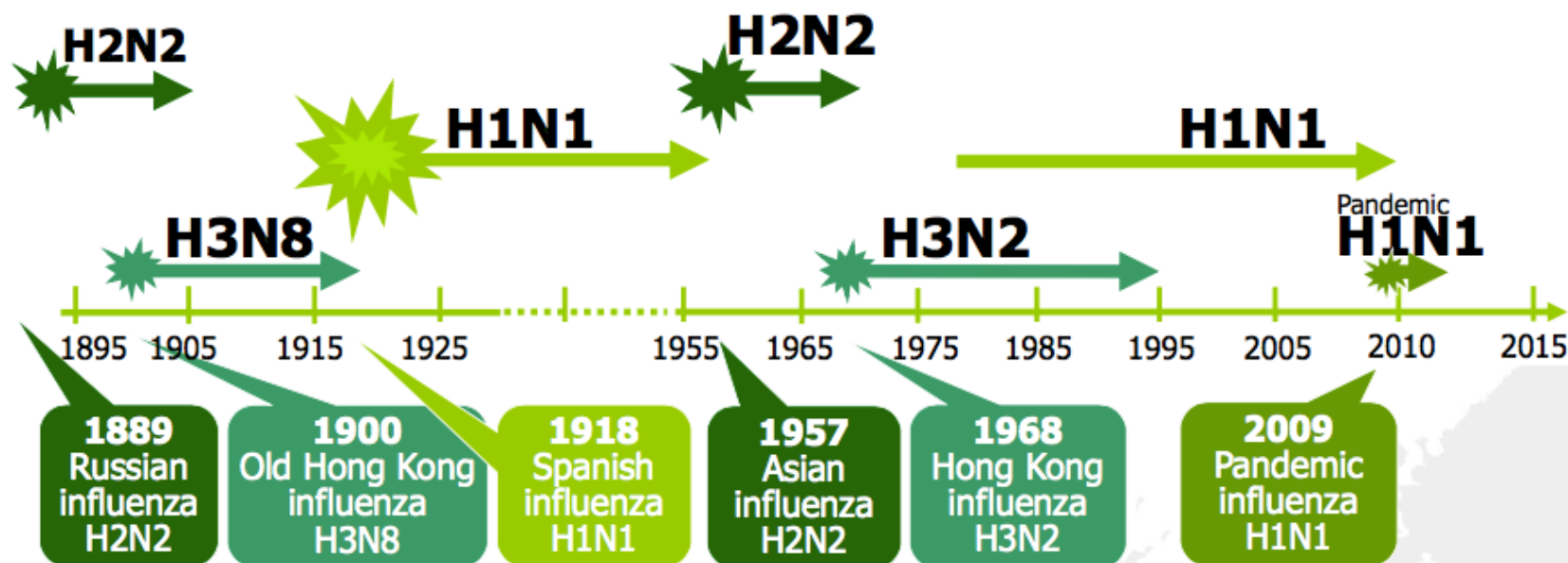
The WSVL said clinical symptoms of avian flu infection in mammals can include neurologic signs that resemble rabies, and it urged people to use gloves and masks when handling sick and dead mammals.

The detection of avian flu in a domestic cat follows a similar report earlier this week of a **domestic dog** that tested positive for H5N1 in Canada. In **earlier H5N1 outbreaks** in Asia

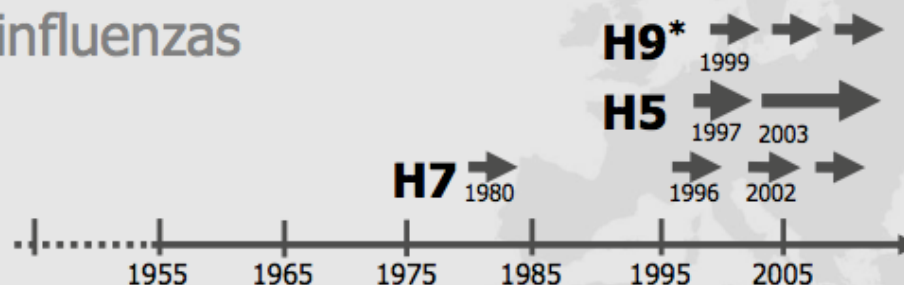


Pandemics of influenza

Recorded human pandemic influenza
(early sub-types inferred)



Recorded new avian influenzas

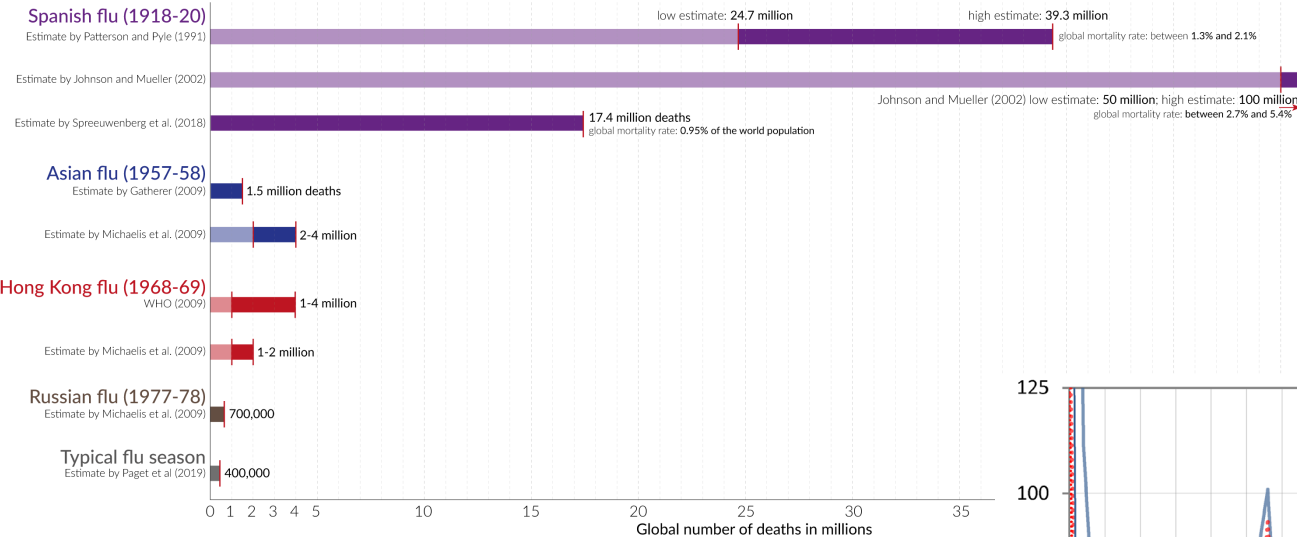


Influenza pandemic mortality

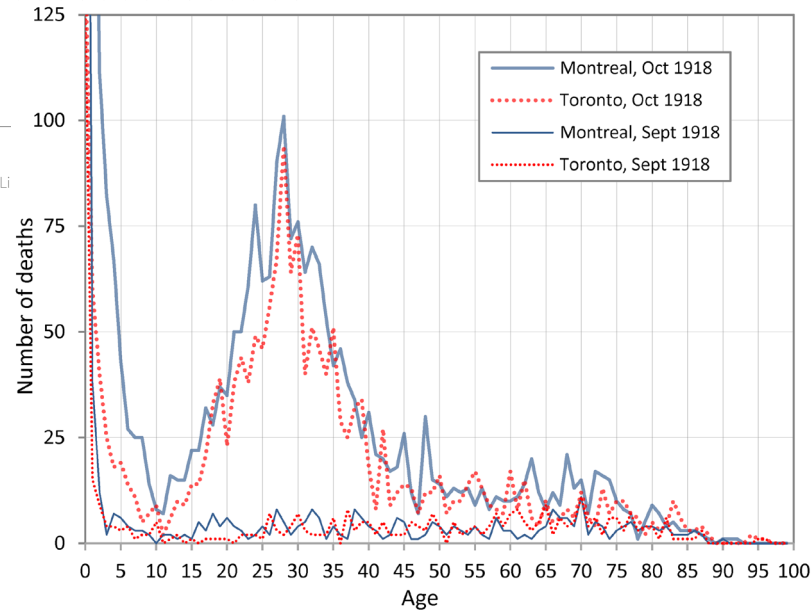
Global number of deaths from influenza pandemics

Estimates from different research publications for 4 pandemics.

Our World
in Data



OurWorldinData.org - Research and data to make progress against the world's largest problems.



Gagnon et al. 2013

● Council of the EU
 Press release
 24 May 2022
 10:50

Council approves conclusions on a strategic approach for the development of vaccination as a complementary tool for the prevention and control of highly pathogenic avian influenza (HPAI)

April 4, 2022
 8:41 PM EDT
 Last Updated 6 months ago

United States

U.S. considers vaccines to protect poultry from deadly bird flu

By Tom Polansek

2 minute read



INFECTIOUS DISEASE

Wrestling with bird flu, Europe considers once-taboo vaccines

To lessen the toll of culling, some countries launch vaccine trials despite trade implications and public health risks

What types of vaccines and vaccine platforms do we need?

- Reduce virus transmission
- Generate long-lasting immunity
- Thermostable
- Rapid development and approval
- Rapid and efficient deployment
- Differentiate between vaccinated and infected

Desired property	Current situation
Inexpensive	Current cost for inactivated AI vaccine: US\$0.05–0.10 per dose plus cost of administration (US\$0.05–0.07 per dose for individual handling and injection) [342]
Use in multiple avian species	Most used in meat, layer, and breeder chickens, but large quantity also used in ducks; minor amounts in turkeys, geese, quail, etc. [336]
Single dose protection	Most situations require a minimum of two doses; prime-boost scenario is optimal, with additional boost in long-lived birds at 6- to 12-month intervals [338]
Mass application	95.5% is inactivated vaccine administered by handling and injecting individual birds, with 4.5% as vectored vaccine given by mass spray vaccination (rNDV vector) [299, 332]
Identify infected birds in vaccinated population	Serological differentiation tests are available, but have only minor use. Most vaccine is applied without using a DIVA strategy [338]
Overcome maternal antibody block	Maternal antibody to AIV hemagglutinin or virus vector inhibits primary immune response. Initial vaccination must be timed for declining maternal antibody titers to allow optimal primary immune response [332], and also a decline in active immunity is needed before giving booster vaccinations [213]
Given at 1 day of age in hatchery or <i>in ovo</i>	Inactivated vaccine provides poor protection if given at 1 day of age. Vectored vaccines can be given at 1 day of age, but generally require a field boost with inactivated vaccine 10 days or more later
Antigenically close to field virus	The majority of inactivated whole AI vaccine uses reverse-genetic-generated vaccine seed strains to antigenically match field viruses [324]

To vaccinate or not to vaccinate?

- Emergency or preventive vaccines?
- Vaccinating target populations, species or regions
- Aim: reducing disease or infection or both?
- Leaky and mismatched vaccines
- Trade issues
- Can we vaccinate wild birds?

AVIAN PATHOLOGY
2022, VOL. 51, NO. 3, 211–235
<https://doi.org/10.1080/03079457.2022.2054309>

 Taylor & Francis
Taylor & Francis Group

 Check for updates

REVIEW ARTICLE

Strategies for enhancing immunity against avian influenza virus in chickens: a review

Nadiyah Alqazlan^{a*}, Jake Astill^{b*}, Sugandha Raj^{a*} and Shayan Sharif^a

^aDepartment of Pathobiology, Ontario Veterinary College, University of Guelph, Guelph, Canada; ^bArtemis Technologies Inc., Guelph, Canada

ABSTRACT

Poultry infection with avian influenza viruses (AIV) is a continuous source of concern for poultry production and human health. Uncontrolled infection and transmission of AIV in poultry increase the potential for viral mutation and reassortment, possibly resulting in the emergence of zoonotic viruses. To this end, implementing strategies to disrupt the transmission of AIV in poultry, including a wide array of traditional and novel methods, is much needed. Vaccination of poultry is a targeted approach to reduce clinical signs and shedding in infected birds. Strategies aimed at enhancing the effectiveness of AIV vaccines are multi-pronged and include methods directed towards eliciting immune responses in poultry. Strategies include producing vaccines of greater immunogenicity via vaccine type and adjuvant application, and increasing bird responsiveness to vaccines by modification of the gastrointestinal tract (GIT) microbiome and dietary interventions. This review provides an in-depth discussion of recent findings surrounding novel AIV vaccines for poultry, including reverse genetics vaccines, vectors, protein vaccines and virus-like particles, highlighting their experimental efficacy among other factors such as safety and potential for use in the field. In addition to the type of vaccine employed, vaccine adjuvants also provide an effective way to enhance AIV vaccine efficacy; therefore, research on different types of vaccine adjuvants and vaccine adjuvant delivery strategies is discussed. Finally, the poultry gastrointestinal microbiome is emerging as an important factor in the effectiveness of prophylactic treatments. In this regard, current findings on the effects of the chicken GIT microbiome on AIV vaccine efficacy are summarized here.

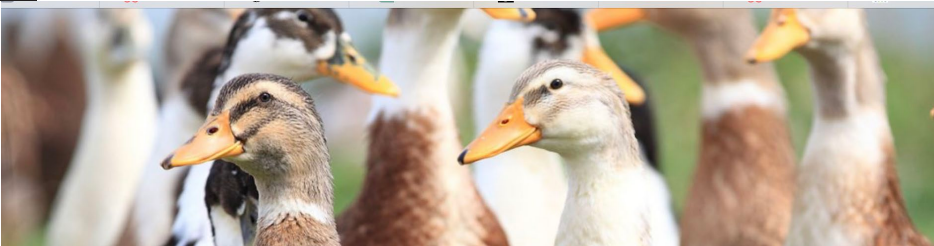
ARTICLE HISTORY

Received 3 November 2021
Accepted 11 March 2022

KEYWORDS

Vaccine; influenza; H9N2;
adjuvants; microbiome;
prebiotics; probiotics;
immune response

French experience with vaccines



06/04/2023 — Expert assessment ⌚ 4 min

VETERINARY MEDICINE - ANMV

Avian influenza: three vaccination scenarios for poultry

Health crises caused by avian influenza have been recurring and growing in scale, which means that preventive measures on French poultry farms need to be reinforced. The vaccination of poultry is a possible option that is being considered to supplement the biosecurity measures already in place on these farms. To help the public authorities establish a vaccination strategy that could be implemented as early as autumn 2023, ANSES

They aim to protect & determining the type priority, depending o

REUTERS® World Business Markets Sustainability Legal Breakingviews Technology Inves

Europe

France detects bird flu on vaccinated ducks farm

Reuters

January 4, 2024 9:53 AM EST · Updated 2 months ago



REUTERS® World Business Markets Sustainability Legal Breakingviews Technology Inves

Europe

France kicks off bird flu vaccination despite trade backlash risk

By Sybille De La Hamaide

October 2, 2023 10:26 AM EDT · Updated 5 months ago



[1/2] A person holds a test tube labelled "Bird Flu", in this picture illustration, January 14, 2023. REUTERS/Dado Ruvic/Illustration/File Photo [Purchase Licensing Rights](#) (?)

What are we doing in Canada?

Highly Pathogenic Avian Influenza Vaccination Task Force

The Highly Pathogenic Avian Influenza (HPAI) Vaccination Task Force is dedicated to studying the challenges and opportunities for the development and implementation of an HPAI vaccination program.

This task force serves as a forum for discussion and consensus building that brings together insights from veterinarians, experts from academia, industry representatives and government representatives on issues relating to the potential use of vaccination against HPAI in Canada.

Background

The recent outbreak of H5N1 HPAI has resulted in the deaths of hundreds of millions of domestic and wild birds throughout the globe. HPAI has occurred in areas of the world where it had never occurred previously, such as countries in Central and South America. In Canada, millions of birds have been impacted since December 2021.

Canada has historically maintained a stamping out policy for HPAI with the goal of achieving disease eradication in poultry and a return to disease-free status. However, the scale and duration of this outbreak, along with international movements towards exploring the use of vaccination as an additional tool to fight against HPAI, has prompted Canada to take action.

Topics of discussion

The task force will explore whether Canada would benefit from a vaccination program. Topics of discussion will include and are not limited to:

- availability of effective vaccines
 - what vaccines are available, for which species
- implementation considerations
 - logistics
 - roles and responsibilities of government, industry and veterinarians in a roll-out
- approaches for surveillance
 - requirements for differentiating infected from vaccinated animals (DIVA) methodology
 - how to meet surveillance requirements set by key trading partners
- trade implications
 - identifying priority export markets, reviewing their requirements for imports, including their own intentions in relation to vaccinating domestic flocks
- identifying cost and benefits
 - cost of vaccines per dose
 - administration of vaccine
 - surveillance
 - assessment of economic costs and benefits to industry and government
 - cost and responsibility sharing

Source: CFIA

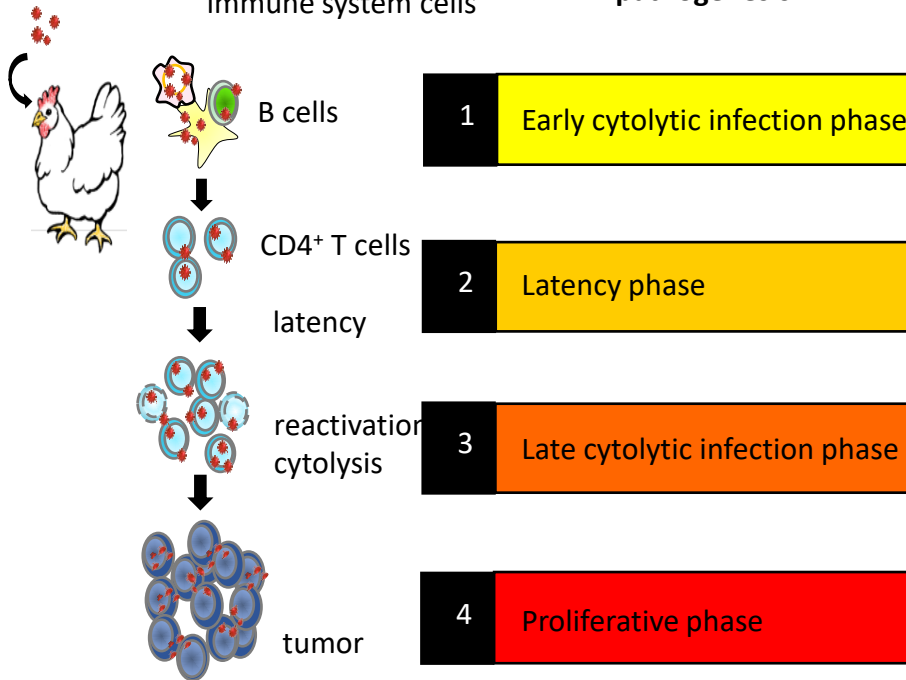
Genetic resistance to Marek's disease: A success story!



Cell-free MDV

immune system cells

MDV pathogenesis



MDV is cell-associated and replicates intracellularly in lymphocytes.

MDV is preferentially reactivated in CD4⁺ T cells.

Infected CD4⁺ T cells transform into neoplastic cells and then form tumors.

Challenges ahead!

- Could vaccination/genetic resistance lead to virus evolution?
- Could HPAI viruses evade vaccines and genetic resistance?
- Could resistant/vaccinated animals spread HPAI even more efficiently?
- What tests will we use for surveillance?
- What are the international trade implications?
- Can vaccination and genetic resistance be combined as a strategy?

 **frontiers**
in Veterinary Science

REVIEW
published: 30 October 2018
doi: 10.3389/fvets.2018.00263



Detecting and Predicting Emerging Disease in Poultry With the Implementation of New Technologies and Big Data: A Focus on Avian Influenza Virus

Jake Astill¹, Rozita A. Dara², Evan D. G. Fraser³ and Shayan Sharif^{1*}

OPEN ACCESS

scientific reports

 Check for updates

OPEN

A decision support framework for prediction of avian influenza

Samira Yousefinaghani¹, Rozita A. Dara^{1,2}, Zvonimir Poljak³ & Shayan Sharif¹

Thank you