



# **Potential for an avian influenza pandemic: Time for NZ to ramp up preparedness**

15 May 2024

Michael Baker, John D. Potter, Nigel French, Jemma L. Geoghegan, Nick Wilson, Oz Mansoor, Sue Huang, Richard Webby

# Summary

Influenza A(H5N1) virus, a major cause of highly pathogenic avian influenza (HPAI) or 'bird flu', is causing concern as it continues to evolve and infect new hosts, notably cattle for the first time. Although this virus is still not adapted for human-to-human transmission, its spread is a warning for Aotearoa New Zealand (NZ) to review and enhance our pandemic preparedness.

At a minimum, we need to immediately update our pandemic plan to incorporate lessons from past pandemic responses, notably the effective use of public health and social measures (PHSM) to delay entry and circulation of serious pandemic infections. We need to review systems to ensure timely supply of A(H5N1) testing, vaccine, antivirals, and infection prevention and control (IPC) equipment. And strengthen One Health approaches to reduce the risk of influenza emergence and spread in poultry, livestock, wildlife, and humans, along with effective surveillance and early detection and response systems covering these populations.

---

The continuing global spread of influenza A(H5N1) is causing international concern. A(H5N1) virus causes highly pathogenic avian influenza (HPAI) with high death rates in chickens and other birds.<sup>1</sup> This is the largest influenza panzootic (a pandemic in animals) of HPAI virus ever documented. An increasing number of mammals, most recently cattle, appear to be susceptible hosts for the virus. And a dairy farm worker was infected, the first known case of this virus jumping to humans from another mammal.<sup>2 3</sup>

This Briefing provides a high-level risk assessment of the current A(H5N1) panzootic and comments on needed risk-management measures.

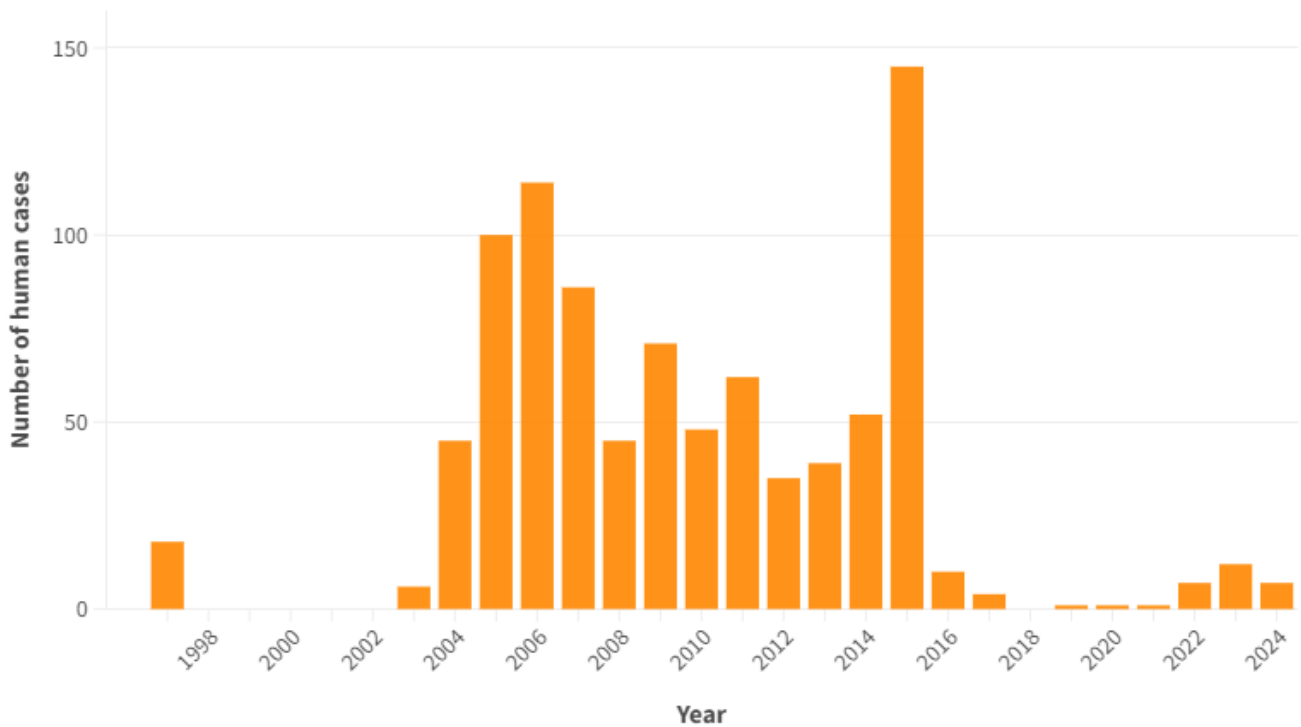
## **Risk assessment of influenza A(H5N1)**

Influenza is considered [the world's most likely pandemic threat](#), for good reason (see [Appendix for background](#)).

General principles of pandemic risk assessment are based on key attributes of the emerging threat, notably its infectiousness, severity, controllability, and the certainty of knowledge and stability of the threat in question.<sup>4</sup>

A(H5N1) viruses are not currently being transmitted between people. It is still in the category of an uncommon 'spillover' infection, where people in close contact with infected birds and mammals become infected.<sup>5</sup> (see Figure). Severity varies, but the overall case fatality risk is high.<sup>6</sup>

## Past Reported Global Human Cases with Highly Pathogenic Avian Influenza A(H5N1), 1997-2024



Source: Centers for Disease Control and Prevention, National Center for Immunization and Respiratory Diseases (NCIRD)  
Note: Case numbers for 2024 are based on Jan-Apr.

phcc

A(H5N1) virus infection in birds is relatively well characterised, based on more than two decades of research. However, it is uncertain how it may evolve and adapt to other hosts, including humans.<sup>7</sup> Preliminary genomic evidence from the ongoing dairy cattle infections in the United States supports a single bird-to-dairy cattle transmission event with subsequent spread between cattle.<sup>8</sup> Despite potentially widespread transmission between dairy cows, the virus currently retains characteristics that are more avian virus-like than mammalian virus-like.<sup>7</sup> The virus isolated from the dairy worker did, however, have one mutation that has been associated with mammalian adaptation of A(H5N1) viruses.<sup>2</sup> There is potential that cows, like pigs, could become influenza 'mixing vessels' and/or promote the selection of mammalian virus traits enhancing zoonotic A(H5N1) virus transmission to people.<sup>9 10</sup>

NZ has systems to reduce the risk of importing A(H5N1) from animal populations overseas, including border biosecurity. However, the virus could be introduced by wild birds as NZ is on the migratory path of multiple species.<sup>11</sup> If the virus evolves to transmit in humans, we can expect rapid spread across the globe as with previous influenza pandemics, unless NZ and other countries applied vigorous control measures – see “risk management” below.

### Risk management and upgrading our pandemic preparedness

There are international calls to strengthen preparedness for avian influenza.<sup>12</sup>

Effective surveillance for emerging infectious diseases is critically important. For zoonotic infections such surveillance needs to support early detection of A(H5N1) in wildlife, poultry, and livestock. Biosecurity New Zealand leads surveillance initiatives in this area. Members of the public have an important role in reporting sick or dead wild birds, poultry and sea mammals (see [Biosecurity NZ](#) for details).

Similarly, the [human disease surveillance system](#) has been extended to A(H5N1). HPAI is a separate notifiable disease (in addition to non-seasonal influenza). If the risk of importing A(H5N1) rises, NZ clinicians will need to be particularly vigilant, including considering the diagnosis in occupational groups who work with poultry, livestock, and wildlife and in arriving travellers.

Public health authorities in NZ need to update the national pandemic plan to cover the full range of A(H5N1) scenarios. The publicly available version is still the pre-Covid influenza plan from 2017.<sup>13</sup> The revised plan needs to fully support public health and social measures (PHSM): border management to exclude cases; case isolation, contact tracing and quarantine; ventilation upgrades; and masking and physical distancing.<sup>14</sup>

As was demonstrated during the Covid-19 pandemic, these measures were sufficient to interrupt disease transmission in multiple jurisdictions and to protect a sizeable proportion of the world's population from infection prior to arrival of a new vaccine.<sup>15</sup> Equity needs to be at the heart of pandemic responses.<sup>16</sup> NZ also has a responsibility to support measures to protect Pacific Island populations from pandemic diseases.<sup>17</sup> Enhanced pandemic planning will also help prepare NZ for other emerging threats such as bioengineered pandemics.<sup>18</sup>

One positive feature of A(H5N1) is that there is already production technology that can deliver effective vaccines.<sup>19</sup> The candidate vaccine viruses are a good match with circulating A(H5N1).<sup>2</sup> However, it would still take many months or longer to meet global demand.<sup>20</sup> There are small stocks of A(H5N1) vaccine available in NZ (though the [online policy document](#) has not been updated to describe the present situation).

The threat of A(H5N1) is a further opportunity for NZ to strengthen and exercise its pandemic preparedness and response capacity.<sup>21</sup> The work of the [NZ Royal Commission COVID-19 Lessons Learned](#) is particularly important given its forward-looking focus on increasing NZ's preparedness for future pandemics. NZ should also consider use of simulation exercises to test national pandemic preparedness plans, as it has done in the past.<sup>22</sup> In addition, specific mitigation measures such as mask use could be implemented and evaluated for managing seasonal epidemics of respiratory infections.<sup>23</sup>

The One Health paradigm is useful for managing pandemic threats across the human, agricultural, and ecological domains.<sup>24</sup> Relevant organisations need to coordinate their work and consider a full range of scenarios including a sustained epizootic in poultry and dairy cattle. A New Zealand CDC-type organisation looks increasingly important to support the integration of science workforces and systems across these fields.<sup>25</sup>

This situation is a further impetus to strengthen collaborative international disease surveillance and control measures with the World Health Organization, including finalising revisions to the International Health Regulations (IHR) and Pandemic Accord. Strengthening cooperation with Australia (which is building new vaccine facilities) and capacity building in the Pacific will increase regional resilience.

## What this Briefing adds

- Influenza has been a cause of human pandemics for centuries and is still the primary focus for pandemic preparedness (although there is growing concern about the threat of bioengineered pandemics).
- Influenza A(H5N1) has caused a global panzootic (a pandemic in birds and other animals) since 1997, with occasional and frequently fatal infections of humans but as yet no sustained human-to-human transmission.
- This virus is now infecting a wider range of birds and mammals, increasing exposure of humans to this infection and creating opportunities for mutations that could allow sustained human spread and trigger a pandemic.

## Implications for policy and practice

- NZ needs to increase preparedness for a global influenza A(H5N1) pandemic, including: an updated plan that incorporates lessons from past pandemics (including the option of exclusion/elimination for a severe pandemic) and arrangements for supply of A(H5N1) testing, vaccine, antivirals, and appropriate protective equipment (notably respirator-grade masks).
- NZ needs to strengthen response capacities including One Health approaches to reduce the risk of influenza emergence and spread in poultry, livestock, wildlife, and humans, along with effective surveillance and early response systems.
- NZ should more actively support international approaches to reduce the risks of pandemics and improve their management, including an updated International Health Regulation and Pandemic Accord and capacity building in the Pacific region.

### Author details

[Prof Michael Baker](#), Department of Public Health, University of Otago Wellington, and Public Health Communication Centre

[Prof John D. Potter](#), Research Centre for Hauora and Health, Massey University

[Prof Nigel French](#), Distinguished Professor of Infectious Disease Epidemiology and Public



Health at Massey University

[Prof Jemma Geoghegan](#), Webster Family Chair of Viral Pathogenesis, Department of Microbiology and Immunology, University of Otago.

[Prof Nick Wilson](#), Department of Public Health, University of Otago Wellington, and Public Health Communication Centre

[Dr Oz Mansoor](#), Medical Officer of Health, Tairāwhiti (on sabbatical with Public Health Communication Centre)

[Prof Sue Huang](#), Director, WHO National Influenza Centre, Institute of Environmental Science and Research Ltd (ESR)

[Prof Richard Webby](#), St. Jude Children's Research Hospital, and Director, World Health Organization Collaborating Centre for Studies on the Ecology of Influenza in Animals and Birds

## **Appendix: Background to the global rise in A(H5N1) influenza**

### **History of influenza pandemics**

Despite public sentiment, we have not yet seen the end of the Covid-19 pandemic.<sup>26</sup> It is therefore alarming to have to contemplate another pandemic threat, this time from influenza.

It is very likely that influenza pandemics have occurred regularly since humans settled into agricultural and then urban communities (eg, 5<sup>th</sup> century Greece, European Middle Ages).<sup>27</sup> <sup>28</sup> However, identifying, with certainty, that specific respiratory-disease outbreaks were influenza (eg, as opposed to coronaviruses or other pathogens) became possible only in the 20<sup>th</sup> century, when there were 3 pandemics: in 1918-19, 1957, and 1968.<sup>28</sup>

The influenza virus was discovered in 1933<sup>29</sup> and the first vaccine developed by 1945.<sup>30</sup>

Each of the 20<sup>th</sup> century pandemics was caused by a different influenza A subtype (respectively A(H1N1); A(H2N2); A(H3N2)).<sup>28</sup> The A(H1N1) virus responsible for the 1918-19 pandemic ("Spanish flu") was an avian influenza virus that became fully adapted to humans, possibly through adaptation in other mammalian hosts.<sup>31-33</sup> The two later pandemics were the result of reassortment (swapping) of glycoprotein genes among viral strains with origins in wild birds—a common feature of avian influenza viruses.<sup>34 35</sup> The first influenza pandemic of the 21<sup>st</sup> Century was caused by the A(H1N1)pdm09 virus in 2009, which was a swine origin virus derived from reassortment of human, bird, and swine influenza viruses.<sup>36</sup>

## Emergence of Influenza A(H5N1)

For the first time in 1997, direct evidence of the ability of avian influenza viruses to infect humans was found. Detection of 18 human cases of the newly described influenza A(H5N1) were identified in Hong Kong following serious outbreaks on chicken farms.<sup>37 38</sup> Six of the 18 people died; all were infected directly by chickens—there was no direct human-to-human transmission. The epidemic was halted following the slaughter of more than 1.5 million birds.<sup>39</sup>

Concerns again rose in 2003 regarding a possible epidemic of A(H5N1)<sup>40 41</sup> following an outbreak of bird flu among chickens in multiple southeast Asian countries and then evidence of limited human-to-human transmission in Vietnam in early 2004. There were 14 cases identified and 11 people died. Eight countries saw more than 20 million chickens slaughtered following expert advice that this was the only way to effectively extinguish the virus.<sup>42</sup> In all, more than 300 people were infected, of whom about 60% died.<sup>41</sup> The virus has also been sporadically detected in other mammals.<sup>43</sup>

In the last two years, the A(H5N1) clade 2.3.4.4b has spread explosively across most regions of the world following a reassortment event.<sup>44-46</sup> The increased prevalence of the virus in wild birds has led to infection of atypical bird species such as vultures<sup>47</sup> and also infection of multiple mammal species.<sup>48-51</sup> Most recently, it has been reported in dairy cattle in multiple US states<sup>52-55</sup> and has infected people.<sup>56-58</sup> Definable mutations are probably needed before this current A(H5N1) variant can adapt to cause sustained human-to-human transmission, given its failure to do so in the past. The virus isolated from the dairy worker did, however, have one mutation that has been associated with mammalian adaptation of A(H5N1) viruses.<sup>2</sup>

Spread in multiple mammal species may make it easier to develop the capacity for sustained human-to-human transmission and thus risk producing a human pandemic.<sup>59</sup> A 3 May 2024 preprint shows that human avian influenza A virus receptors are widely expressed in the bovine mammary gland, increasing the risk that cattle can act as a 'mixing vessel' for further viral evolution and possible development of the capacity for human-to-human transmission.<sup>10</sup>

From 2003 to 31 March 2024, there were 888 human cases of A(H5N1) influenza reported, of which 463 (52.1%) were fatal.<sup>6</sup> There have been very few human cases of the currently circulating lineage 2.3.4.4b, with 13 between 2022-24 of which two (15.4%) have died.<sup>60</sup> The majority were reported in Cambodia, China, Egypt, Indonesia, and Vietnam. This fatality risk may be overestimated because mild and asymptomatic infections in humans are less likely to be identified than severe disease, which would have shrunk the recorded denominator of total infections.

Influenza (and other) pandemics remain unpredictable in timing and severity. Previous documented pandemics have ranged from the intensity of seasonal influenza (as seen in influenza (H1N1) in 2009<sup>61</sup>) through to the 1918 influenza (H1N1) pandemic with a case fatality risk of about 2%.<sup>62</sup> For other respiratory pandemics the case fatality risk has been even higher, as was seen with SARS in 2003 where it was >10%.<sup>62</sup>

## Details about influenza viruses

Influenza A(H5N1) virus causes HPAI outbreaks with high death rates in chickens and other birds (other HPAI viruses include A(H7N9), A(H5N8), A(H5N5), A(H5N6)).<sup>1</sup> It is distinguished from low pathogenicity avian influenza (LPAI) viruses, a more common form of the virus, which typically causes few or no signs in birds.

The two glycoproteins on the influenza virus membrane, hemagglutinin (HA) and neuraminidase (NA), enable entry and exit of the virus, respectively. HA mediates entry by binding to sialic acids on target cells and NA mediates exit by destruction of these bonds. The sialic acid receptors preferred by avian and human adapted influenza viruses differ slightly in chemical composition. HAs are a principal determinant of the pathogenicity of influenza A viruses. In addition to mediating binding to host cells, HAs initiate infection by inducing fusion between host cell and virus membranes. The capacity to fuse is dependent on the activation of HA by enzymatic cleavage by host proteases. There are striking differences between highly pathogenic and low-pathogenic avian influenza viruses in their sensitivity to these host proteases and as a consequence their intrinsic ability to cause systemic disease, particularly in gallinaceous poultry.<sup>63</sup> After virus replication occurs in the host cells, the receptor-destroying virus enzyme, neuraminidase, removes the sialic-acid residues from the surfaces of the infected cells, releasing the newly made viruses to infect more cells.<sup>64</sup>

The 1980 WHO system of nomenclature of influenza viruses consists of two parts: a type (A, B, C, D) and strain designation and, for influenza A viruses, designation of the antigenic subtypes, based on the characterisation of the surface antigens that determine infection: HA antigens initially were classified as having 12, but now 18, subtypes, H1-H18, and NA antigens initially 9, now 11, subtypes, N1-N11.<sup>65-68</sup> These designations give rise to the HxNy classification of the influenza viruses. There are further divisions of subtypes based on the mutation-driven evolution of the virus.<sup>69</sup>

## One Health approach to understanding and managing the A(H5N1) threat

A(H5N1) poses a risk to humans, wildlife, and poultry/livestock, and as such benefits from a One Health approach.<sup>24</sup> This infection could be devastating to native birdlife and marine mammals as seen internationally.<sup>70</sup> It is also a severe threat to poultry.<sup>71</sup> The current outbreak in livestock in the US shows its broader threat to agriculture.<sup>2</sup> For example, infected dairy cattle can shed virus in milk and potentially transmit infection to other mammals via unpasteurised milk.<sup>3</sup> On one north Texas dairy farm in March 2024, >50% of approximately 24 domestic cats became ill and died after being fed raw milk from sick cows. Laboratory testing of bovine milk samples and specimens from two autopsied cats confirmed they were infected by the same strain of A(H5N1).<sup>3</sup>

While A(H5N1) remains in non-human populations, [Biosecurity New Zealand](#) (Ministry of Primary Industries) is the lead agency for assessing and managing the threat. Given the threat to wildlife, the [Department of Conservation](#) (DOC) is also involved. These agencies also work with the Ministry of Health and [Te Whatu Ora](#)/Health NZ which is actively



monitoring a range of pandemic threats. Those agencies are working together to develop response options that represent the best approach for NZ to protect our unique native species, mitigate the impact on the poultry sector and take preventative measures to protect human health.

Organisations working across the human health, agricultural, and ecological domains as well as those concerned with occupational health and safety, will need to consider a full range of scenarios including a sustained epizootic in dairy cattle in NZ. In the event of an outbreak in poultry and/or livestock, there are a range of possible actions that would be taken. These include movement control, vaccination, or depopulation, depending on the species infected and the location.

[Biosecurity New Zealand](#) is actively monitoring the international spread of A(H5N1) viruses. This virus first appeared in South America in late 2022,<sup>70</sup> the sub-Antarctic island of South Georgia in late 2023, and the Antarctic Peninsula near South America in February 2024. So far, Australia, NZ, the Pacific Islands and much of Antarctica remain free from the A(H5N1) virus. The virus has been detected in most other regions of the world.

Diagnosis of A(H5N1) depends on collecting suitable specimens for specialist testing at two Wallaceville laboratories: the WHO National Influenza Centre for human specimens and the Animal Health Laboratory for animal specimens.

Biosecurity New Zealand leads several [streams of surveillance](#), aimed at detecting A(H5N1) should it arrive in NZ or the Ross Sea region:

- Passive surveillance via Biosecurity NZ's Exotic Pest and Disease hotline. Material has been circulated to the veterinary profession to highlight the clinical signs of A(H5N1) and the poultry industry is in a state of heightened awareness;
- Surveillance of migratory birds and shorebirds not displaying clinical signs of A(H5N1) via a contract between MPI and Dunedin Wildlife Hospital, began in September 2023. Dunedin and other wildlife hospitals will continue to report birds with suspected avian influenza symptoms via the 0800 number.
- Study of the ecology and evolution of Low Pathogenicity Avian Influenza viruses (LPAI) viruses circulating in NZ, run by MPI's Animal Health Laboratory, involving the sampling and testing mallard ducks in conjunction with a Fish and Game New Zealand annual banding programme to track duck numbers;
- Poultry export testing for avian influenza to meet Overseas Market Access Requirements (OMAR) and enable export of day-old chicks and hatching eggs. Managed by the poultry industry, with lab results being provided to MPI. All non-negative samples are sent to the MPI Animal Health Laboratory for confirmatory testing;

Biosecurity NZ is also working with [DOC](#) on any suspected exotic diseases in wild bird populations, including native birds:

- DOC staff in the sub-Antarctic islands and Antarctic New Zealand staff at Scott Base, Antarctica have been issued sampling kits and instructions. Sample-handling systems for this Antarctic and Sub-Antarctic pathway have been validated. DOC staff and

researchers in the sub-Antarctic islands and Chatham Islands have collected samples from seabirds for baseline health monitoring in the 2023/24 summer season. Any detection of Avian Influenza viruses will be reported to Biosecurity NZ.

- A collaboration with the University of Otago, ESR and others to understand the transmission of avian viruses between migratory and sedentary birds in NZ and to develop rapid, in-field, testing.
- DOC is also working on a [HPAI vaccine trial](#), beginning with [five native species](#).

## References

1. Centers for Disease Control and Prevention. Highlights in the history of avian influenza (bird flu) timeline—2020–2024:  
<https://www.cdc.gov/flu/avianflu/timeline/avian-timeline-2020s.htm>; 2024
2. Uyeki TM, Milton S, Abdul Hamid C, et al. Highly Pathogenic Avian Influenza A(H5N1) Virus Infection in a Dairy Farm Worker. *N Engl J Med* 2024 doi: 10.1056/NEJMc2405371
3. Burrough ER, Magstadt DR, Petersen B, et al. Highly Pathogenic Avian Influenza A(H5N1) Clade 2.3.4.4b Virus Infection in Domestic Dairy Cattle and Cats, United States, 2024. *Emerg Infect Dis* 2024;30(7) doi: 10.3201/eid3007.240508
4. Kvalsvig A, Baker MG. How Aotearoa New Zealand rapidly revised its Covid-19 response strategy: lessons for the next pandemic plan. *Journal of the Royal Society of New Zealand* 2021:1-24.
5. Daszak P, Cunningham AA, Hyatt AD. Emerging Infectious Diseases of Wildlife-- Threats to Biodiversity and Human Health. *Science* 2000;287(5452):443-49. doi: doi:10.1126/science.287.5452.443
6. World Health Organization. Cumulative number of confirmed human cases for avian influenza A(H5N1) reported to WHO, 2003-2024. 2024 28 March 2024.  
[https://cdn.who.int/media/docs/default-source/influenza/h5n1-human-case-cumulative-table/cumulative-number-of-confirmed-human-cases-for-avian-influenza-a\(h5n1\)-reported-to-who--2003-2024.pdf](https://cdn.who.int/media/docs/default-source/influenza/h5n1-human-case-cumulative-table/cumulative-number-of-confirmed-human-cases-for-avian-influenza-a(h5n1)-reported-to-who--2003-2024.pdf) (accessed 16 April 2024).
7. Food and Agriculture Organisation of the United Nations, World Health Organization, World Organization for Animal Health. Joint FAO/WHO/WOAH preliminary assessment of recent influenza A(H5N1) viruses  
2024:[https://cdn.who.int/media/docs/default-source/global-influenza-programme/2024\\_04\\_23\\_fao-woah-who\\_h5n1\\_assessment.pdf](https://cdn.who.int/media/docs/default-source/global-influenza-programme/2024_04_23_fao-woah-who_h5n1_assessment.pdf)
8. Nguyen T-Q, Hutter C, Markin A, et al. Emergence and interstate spread of highly pathogenic avian influenza A(H5N1) in dairy cattle. *bioRxiv* 2024:2024.05.01.591751. doi: 10.1101/2024.05.01.591751
9. Kupferschmidt K. To probe outbreak, BSL-3 labs plan to infect cows with flu virus. *Science* 2024;384(6696):610-11.
10. Kristensen C, Jensen HE, Trebbien R, et al. The avian and human influenza A virus receptors sialic acid (SA)- $\alpha$ 2, 3 and SA- $\alpha$ 2, 6 are widely expressed in the bovine mammary gland. *bioRxiv* 2024:2024.05. 03.592326.
11. Geoghegan J, French N. Thousands of migratory birds will make NZ landfall in spring – will they bring a deadly bird flu with them? *The Conversation* 2024 August 18, 2023.  
<https://theconversation.com/thousands-of-migratory-birds-will-make-nz-landfall-in-spring-will-they-bring-a-deadly-bird-flu-with-them-211492> (accessed April 11, 2024).

12. Kojima N, Adlhoch C, Mitja O, et al. Building global preparedness for avian influenza. *The Lancet* doi: 10.1016/S0140-6736(24)00934-6
13. Ministry of Health. New Zealand Influenza Pandemic Plan: A framework for action (2nd edn). Wellington, 2017.
14. World Health Organization. Overview of public health and social measures in the context of COVID-19: interim guidance, 18 May 2020.  
<https://apps.who.int/iris/handle/10665/332115>: World Health Organization, 2020.
15. Baker MG, Wilson N, Blakely T. Elimination could be the optimal response strategy for covid-19 and other emerging pandemic diseases. *BMJ* 2020;371:m4907. doi: 10.1136/bmj.m4907
16. Baker MG, Kvalsvig A, Plank MJ, et al. Continued mitigation needed to minimise the high health burden from COVID-19 in Aotearoa New Zealand. *The New Zealand Medical Journal* 2023;136(1583):67-91.
17. Boyd M, Baker MG, Wilson N. Border closure for island nations? Analysis of pandemic and bioweapon-related threats suggests some scenarios warrant drastic action. *Australian and New Zealand journal of public health* 2020;44(2):89.
18. Karger E, Rosenberg J, Jacobs Z, et al. Forecasting Existential Risks: Evidence from a Long-Run Forecasting Tournament (FRI Working Paper #1): Forecasting Research Institute.  
<https://static1.squarespace.com/static/635693acf15a3e2a14a56a4a/t/64abffe3f024747dd0e38d71/1688993798938/XPT.pdf> 2023.
19. Geddes L. How easy would it be to make a pandemic flu vaccine against H5N1? VaccinesWork:  
<https://www.gavi.org/vaccineswork/how-easy-would-it-be-make-pandemic-flu-vaccine-against-h5n1>, 2024.
20. Helen Branswell. Massive amounts of H5N1 vaccine would be needed if there's a bird flu pandemic. Can we make enough? STAT+ Connect.  
<https://www.statnews.com/2024/04/24/h5n1-bird-flu-vaccine-preparedness/>, 2024.
21. Te Niwha. Likely future pandemic agents and scenarios: An epidemiological and public health framework, 2023:  
[https://www.teniwha.com/assets/Resources/Te-Niwha\\_Full-Report\\_Likely-future-pandemic-agents-and-scenarios\\_Web.pdf](https://www.teniwha.com/assets/Resources/Te-Niwha_Full-Report_Likely-future-pandemic-agents-and-scenarios_Web.pdf).
22. Thornton MI, Iannotti A, Quaranta R, et al. The effectiveness of table-top exercises in improving pandemic crisis preparedness. *IJSSSE* 2021;11:463-71.
23. Kvalsvig A, Barnard LT, Summers J, et al. Integrated Prevention and Control of Seasonal Respiratory Infections in Aotearoa New Zealand: next steps for transformative change. *Policy Quarterly* 2022;18(1):44-51.
24. Mackenzie JS, Jeggo M. The one health approach—why is it so important?: *Trop Med Infect Dis* 2019; 4(2): 88.
25. Baker M, Crump J, Kvalsvig A, et al. Why we need an Aotearoa Centre for Disease Control (CDC). *Public Health Expert Briefing*;16 Nov 2023 doi:  
<https://www.phcc.org.nz/briefing/why-we-need-aotearoa-centre-disease-control-cdc>
26. Baker M, Kvalsvig A, Harwood M. A pandemic that won't go away—as Covid enters its 5th year, NZ needs a realistic strategy. *Public Health Expert Briefing* 2024;28 February 2024 doi:  
<https://www.phcc.org.nz/briefing/pandemic-wont-go-away-covid-enters-its-5th-year-nz-needs-realistic-strategy>
27. Shope RE. Influenza: history, epidemiology, and speculation. *Public Health Rep (1896)* 1958;73(2):165-78.
28. Kilbourne ED. Influenza pandemics of the 20th century. *Emerg Infect Dis* 2006;12(1):9-14. doi: 10.3201/eid1201.051254

29. Smith W, Andrewes CH, Laidlaw PP. A Virus Obtained from Influenza Patients. *The Lancet* 1933;222(5732):66-68. doi: 10.1016/S0140-6736(00)78541-2
30. Salk JE, Francis T, Jr. Immunization against influenza. *Annals of internal medicine* 1946;25(3):443-52. doi: 10.7326/0003-4819-25-3-443
31. Taubenberger JK, Reid AH, Krafft AE, et al. Initial genetic characterization of the 1918 "Spanish" influenza virus. *Science* 1997;275(5307):1793-6. doi: 10.1126/science.275.5307.1793
32. Taubenberger JK, Reid AH, Lourens RM, et al. Characterization of the 1918 influenza virus polymerase genes. *Nature* 2005;437(7060):889-93. doi: 10.1038/nature04230
33. Tumpey TM, Basler CF, Aguilar PV, et al. Characterization of the reconstructed 1918 Spanish influenza pandemic virus. *Science* 2005;310(5745):77-80. doi: 10.1126/science.1119392
34. Scholtissek C. Source for influenza pandemics. *Eur J Epidemiol* 1994;10(4):455-8. doi: 10.1007/BF01719674
35. Dugan VG, Chen R, Spiro DJ, et al. The evolutionary genetics and emergence of avian influenza viruses in wild birds. *PLoS Pathog* 2008;4(5):e1000076. doi: 10.1371/journal.ppat.1000076
36. Cook PW, Stark T, Jones J, et al. Detection and characterization of swine origin influenza A (H1N1) pandemic 2009 viruses in humans following zoonotic transmission. *Journal of virology* 2020;95(2):10.1128/jvi. 01066-20.
37. Claas EC, Osterhaus ADME, van Beek R, et al. Human influenza A H5N1 virus related to a highly pathogenic avian influenza virus. *Lancet* 1998;351(9101):472-7. doi: 10.1016/S0140-6736(97)11212-0
38. Yuen KY, Chan PK, Peiris M, et al. Clinical features and rapid viral diagnosis of human disease associated with avian influenza A H5N1 virus. *Lancet* 1998;351(9101):467-71. doi: 10.1016/S0140-6736(98)01182-9
39. Chan PKS. Outbreak of avian influenza A(H5N1) virus infection in Hong Kong in 1997. *Clin Infect Dis* 2002;34 Suppl 2(Supplement\_2):S58-64. doi: 10.1086/338820
40. Ferguson NM, Fraser C, Donnelly CA, et al. Public health risk from the avian H5N1 influenza epidemic. *Science* 2004;304(5673):968-9. doi: 10.1126/science.1096898
41. Gambotto A, Barratt-Boyes SM, de Jong MD, et al. Human infection with highly pathogenic H5N1 influenza virus. *Lancet* 2008;371(9622):1464-75. doi: 10.1016/S0140-6736(08)60627-3
42. Abbott A, Pearson H. Fear of human pandemic grows as bird flu sweeps through Asia. *Nature* 2004;427(6974):472-73. doi: 10.1038/427472a
43. Robertson SI, Bell DJ, Smith GJ, et al. Avian influenza H5N1 in viverrids: implications for wildlife health and conservation. *Proceedings Biological sciences* 2006;273(1595):1729-32. doi: 10.1098/rspb.2006.3549
44. Kandeil A, Patton C, Jones JC, et al. Rapid evolution of A(H5N1) influenza viruses after intercontinental spread to North America. *Nat Commun* 2023;14(1):3082. doi: 10.1038/s41467-023-38415-7
45. Adlhoch C, Baldinelli F. Avian influenza, new aspects of an old threat. *Euro Surveill* 2023;28(19):2300227. doi: 10.2807/1560-7917.ES.2023.28.19.2300227
46. Xie R, Edwards KM, Wille M, et al. The episodic resurgence of highly pathogenic avian influenza H5 virus. *Nature* 2023;622(7984):810-17. doi: 10.1038/s41586-023-06631-2
47. Mahase E. H5N1: Do we need to worry about the latest bird flu outbreaks? *BMJ* 2023;380:401. doi: 10.1136/bmj.p401
48. Agüero M, Monne I, Sanchez A, et al. Highly pathogenic avian influenza A(H5N1) virus infection in farmed minks, Spain, October 2022. *Euro Surveill* 2023;28(3) doi: 10.2807/1560-7917.ES.2023.28.3.2300001
49. UK Dept for Environment Food & Rural Affairs. Confirmed findings of influenza of avian

origin in non-avian wildlife

<https://www.gov.uk/government/publications/bird-flu-avian-influenza-findings-in-non-avian-wildlife/confirmed-findings-of-influenza-of-avian-origin-in-non-avian-wildlife>: UK Government; 2023

50. USDA Animal and Plant Health Inspection Service. 2022-2023 Detections of Highly Pathogenic Avian Influenza in Mammals  
<https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/animal-disease-information/avian/avian-influenza/hpai-2022/2022-hpai-mammals2023>
51. Plaza PI, Gamarra-Toledo V, Eugui JR, et al. Recent Changes in Patterns of Mammal Infection with Highly Pathogenic Avian Influenza A(H5N1) Virus Worldwide. *Emerg Infect Dis* 2024;30(3):444-52. doi: 10.3201/eid3003.231098
52. Schnirring L. Tests confirm avian flu on New Mexico dairy farm; probe finds cats positive. 2024 April 3 2024. (accessed April 8 2024).
53. USDA. USDA Confirms Highly Pathogenic Avian Influenza in Dairy Herd in New Mexico. 2024 April 1 2024.  
<https://www.aphis.usda.gov/news/agency-announcements/usda-confirms-highly-pathogenic-avian-influenza-dairy-herd-new-mexico> (accessed April 8 2024).
54. World Health Organization. Disease Outbreak News; Avian Influenza A (H5N1) – the United States of America. 2024 9 April 2024 (updated 10 April).  
<http://www.who.int/emergencies/disease-outbreak-news/item/2024-DON512> (accessed 11 April 2024).
55. Kozlov M, Mallapaty S. Bird flu outbreak in US cows: why scientists are concerned. *Nature* 2024 doi: 10.1038/d41586-024-01036-1
56. NCIRD. Update: Human Infection with Highly Pathogenic Avian Influenza A(H5N1) Virus in Texas. 2024 April 5, 2024.  
<https://www.cdc.gov/ncird/whats-new/human-infection-H5N1-bird-flu.htm> (accessed April 7, 2024).
57. World Health Organization. Human infection with avian influenza A(H5) viruses. 2024 29 March 2024. (accessed April 11 2024).
58. World Health Organization. Influenza at the human-animal interface: Summary and risk assessment, from 27 February to 28 March 2024. 2024 March 2024.  
[https://cdn.who.int/media/docs/default-source/influenza/human-animal-interface-risk-assessments/influenza\\_summary\\_ira\\_ha\\_interface\\_march\\_2024.pdf](https://cdn.who.int/media/docs/default-source/influenza/human-animal-interface-risk-assessments/influenza_summary_ira_ha_interface_march_2024.pdf) (accessed 16 April 2024).
59. Kupferschmidt K. From bad to worse. *Science* 2023;380(6640):28-29. doi: 10.1126/science.adi1005
60. Centers for Disease Control and Prevention. Technical Report: Highly Pathogenic Avian Influenza A (H5N1) Viruses  
<https://www.cdc.gov/flu/avianflu/spotlights/2022-2023/h5n1-technical-report.htm>: Accessed, 2024.
61. Wong JY, Kelly H, Ip DK, et al. Case fatality risk of influenza A (H1N1pdm09): a systematic review. *Epidemiology* 2013;24(6):830-41.
62. Petersen E, Koopmans M, Go U, et al. Comparing SARS-CoV-2 with SARS-CoV and influenza pandemics. *The Lancet infectious diseases* 2020;20(9):e238-e44.
63. Böttcher-Friebertshäuser E, Garten W, Matrosovich M, et al. The Hemagglutinin: A Determinant of Pathogenicity. In: Compans RW, Oldstone MBA, eds. *Influenza Pathogenesis and Control - Volume I*. Cham: Springer International Publishing 2014:3-34.
64. Gamblin SJ, Skehel JJ. Influenza hemagglutinin and neuraminidase membrane glycoproteins. *The Journal of biological chemistry* 2010;285(37):28403-9. doi: 10.1074/jbc.R110.129809

65. WHO. A revision of the system of nomenclature for influenza viruses: a WHO memorandum. *Bull World Health Organ* 1980;58(4):585-91.
66. Air GM. Sequence relationships among the hemagglutinin genes of 12 subtypes of influenza A virus. *Proc Natl Acad Sci U S A* 1981;78(12):7639-43. doi: 10.1073/pnas.78.12.7639
67. Sriwilaijaroen N, Suzuki Y. Roles of Glycans and Non-glycans on the Epithelium and in the Immune System in H1-H18 Influenza A Virus Infections. In: Suzuki Y, ed. *Glycovirolgy: Methods and Protocols*. New York, NY: Springer US 2022:205-42.
68. Wu Y, Wu Y, Tefsen B, et al. Bat-derived influenza-like viruses H17N10 and H18N11. *Trends Microbiol* 2014;22(4):183-91. doi: 10.1016/j.tim.2014.01.010
69. WHO/OIE/FAO H5N1 Evolution Working Group. Evolution of the influenza A(H5) haemagglutinin: WHO/OIE/FAO H5 Working Group reports a new clade designated 2.3.4.4. 2015 12 Jan 2015. [https://www.who.int/publications/m/item/evolution-of-the-influenza-a\(h5\)-haemagglutinin-who-oie-fao-h5-working-group-reports-a-new-clade-designated-2.3.4.4](https://www.who.int/publications/m/item/evolution-of-the-influenza-a(h5)-haemagglutinin-who-oie-fao-h5-working-group-reports-a-new-clade-designated-2.3.4.4) (accessed 14 Apr 2024).
70. Leguia M, Garcia-Glaessner A, Muñoz-Saavedra B, et al. Highly pathogenic avian influenza A (H5N1) in marine mammals and seabirds in Peru. *Nature Communications* 2023;14(1):5489.
71. Islam A, Islam S, Flora MS, et al. Epidemiology and molecular characterization of avian influenza A viruses H5N1 and H3N8 subtypes in poultry farms and live bird markets in Bangladesh. *Scientific reports* 2023;13(1):7912.



Public Health Expert Briefing (ISSN 2816-1203)

---

**Source URL:**

<https://www.phcc.org.nz/briefing/potential-avian-influenza-pandemic-time-nz-ramp-preparedness>