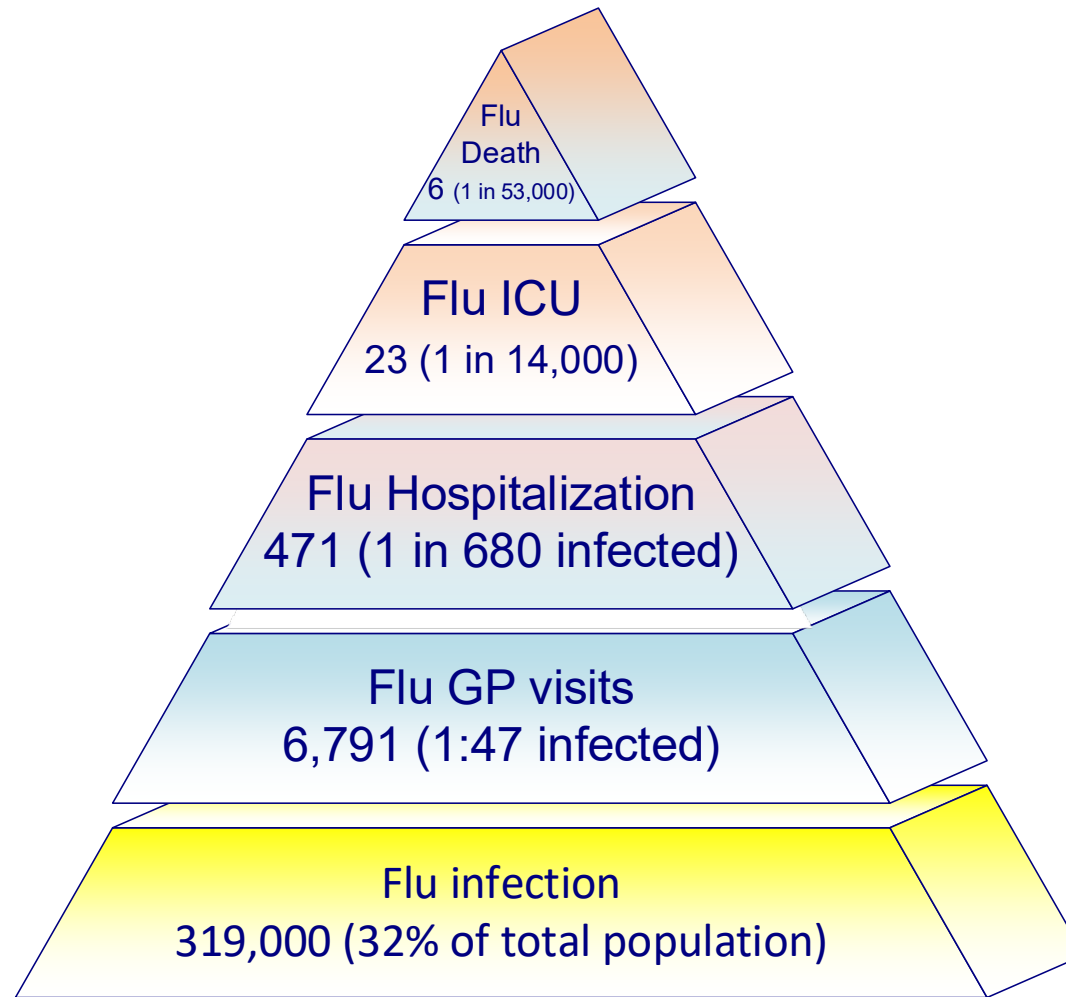




Hold my beer  
and watch this;  
explosive spread  
of A(H5N1)  
influenza

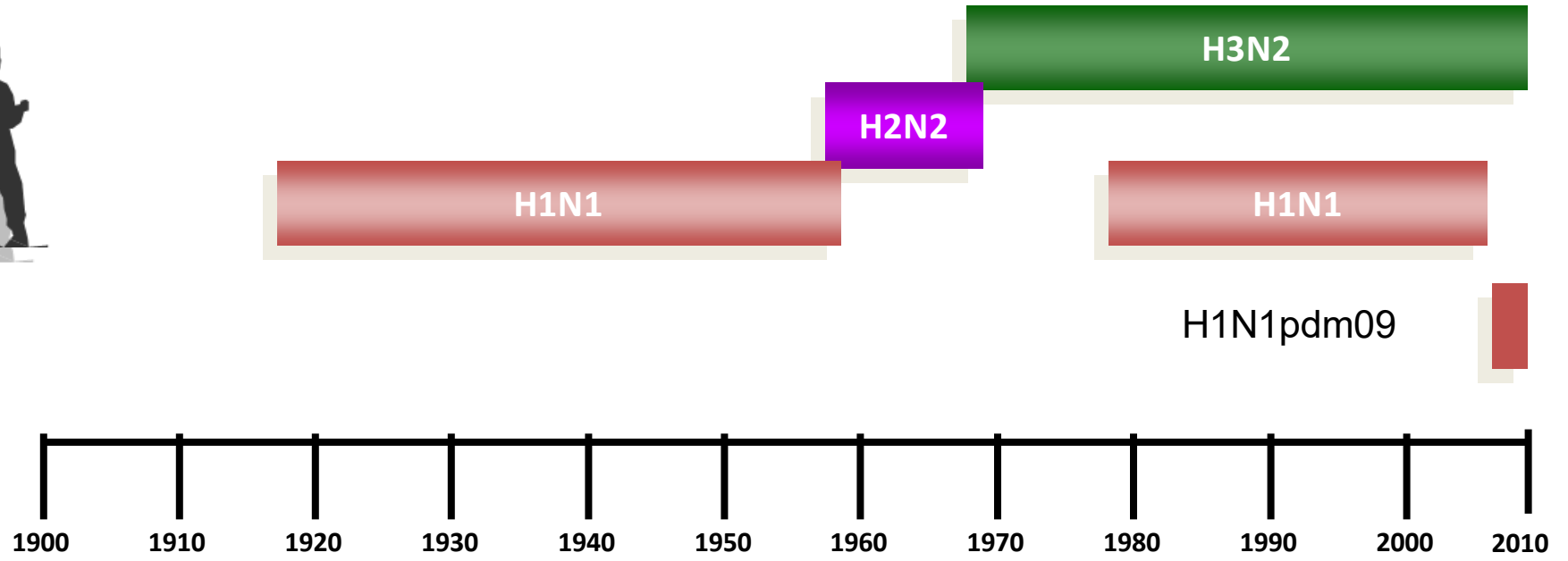


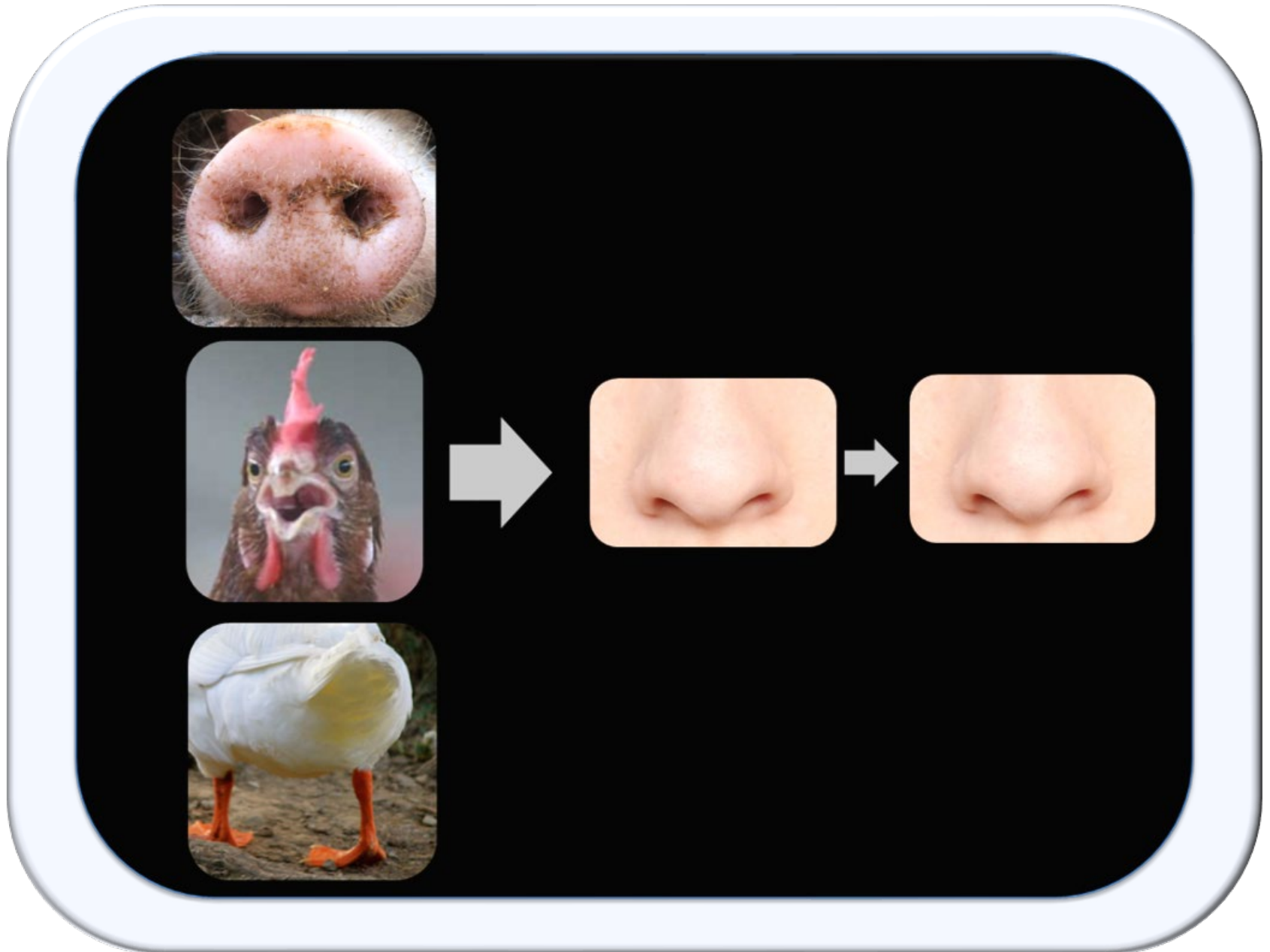
# Seasonal Flu is bad





# Epidemic flu A evolves from pandemics





# Avian influenza exists in two forms

Low pathogenic



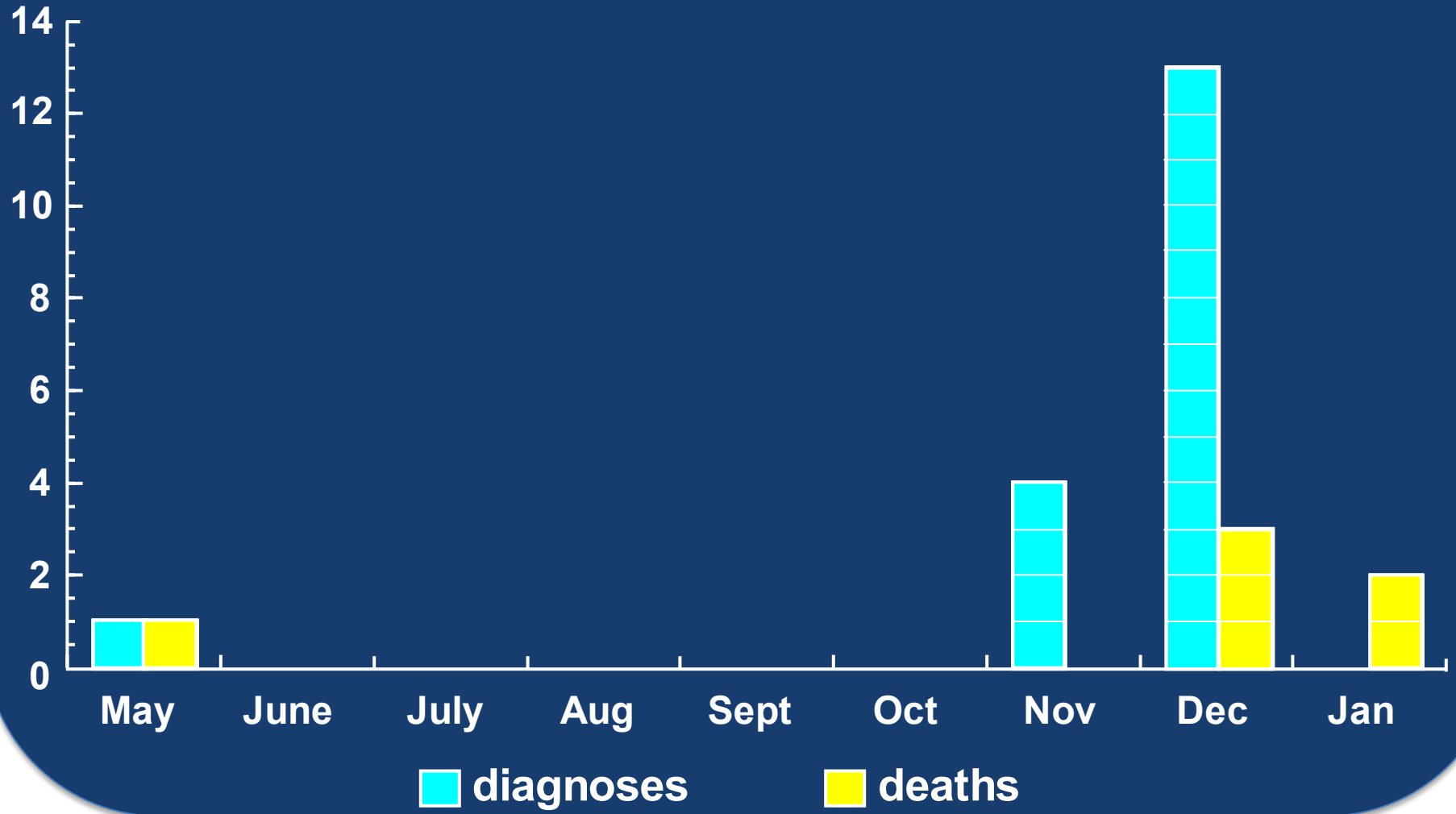
Highly pathogenic



- Occurs upon transmission to domestic poultry
- Historically self limiting in this host



# 1997-1998 Hong Kong H5N1 Avian Influenza Outbreak in Humans





2004 1 21



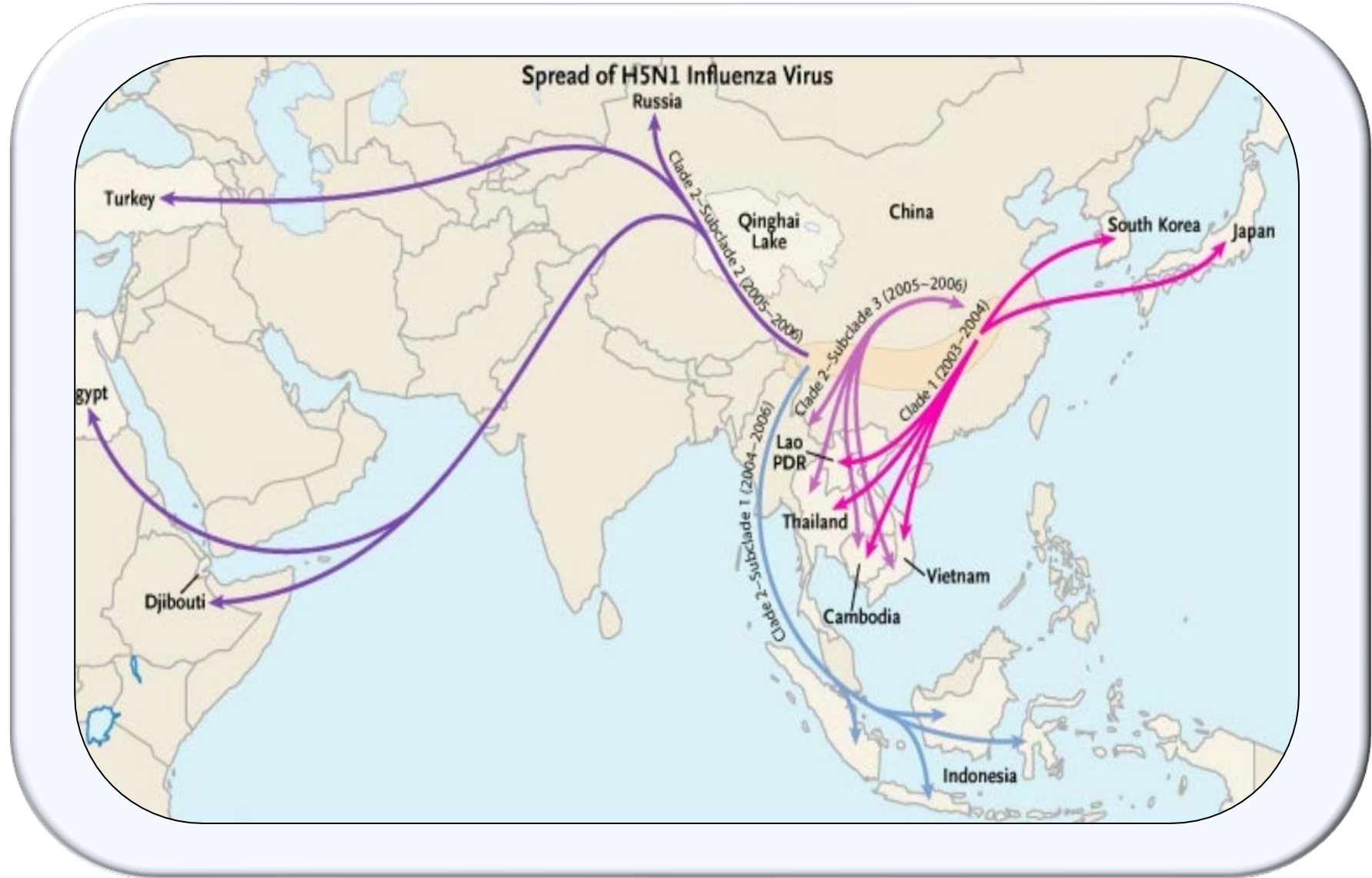
You won't find fire everywhere there is smoke





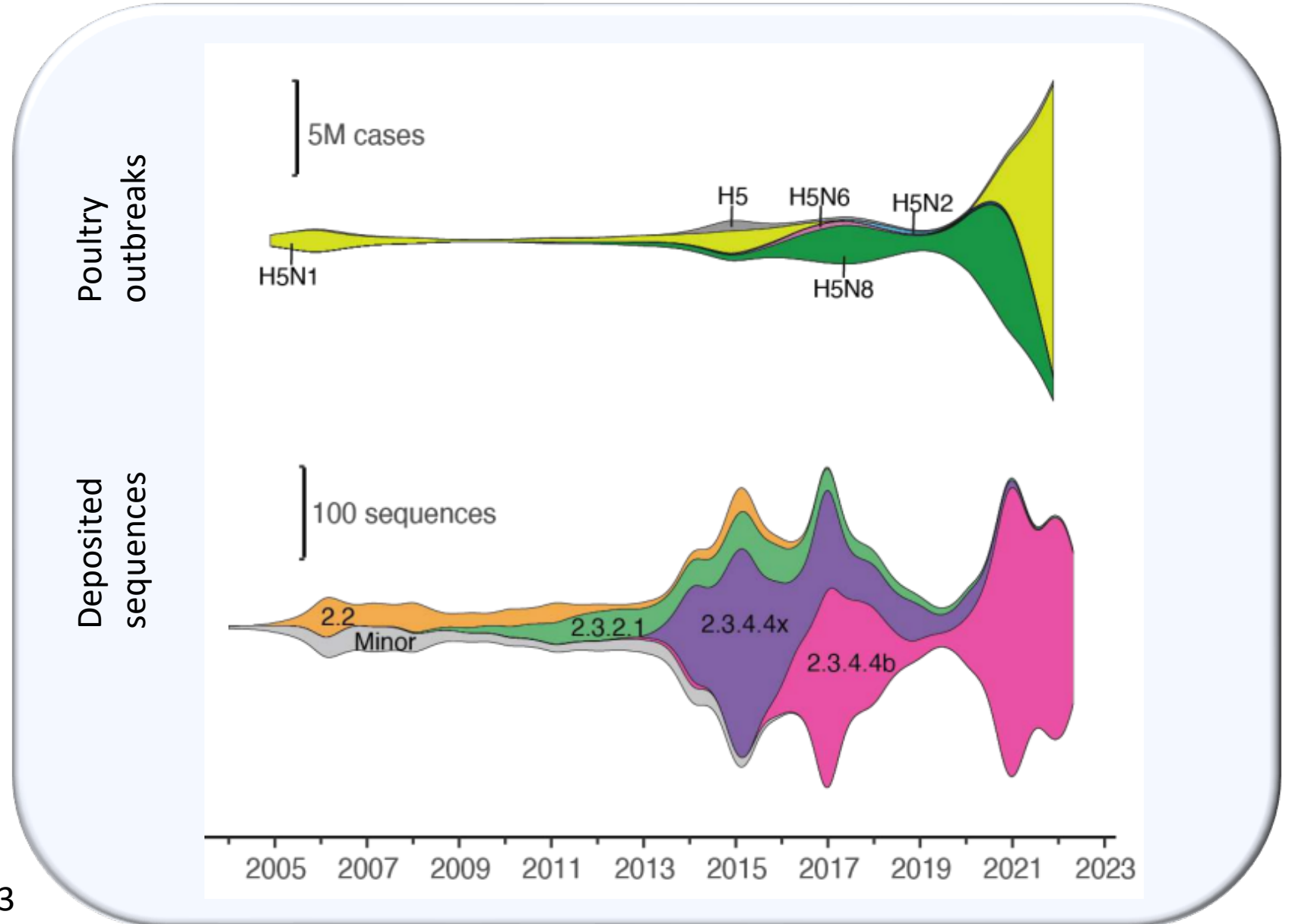


# Early H5 activity





# The hold my beer bit





# Feb 2019

**Table 1. Recent A(H5) activity**

Country, area or territory	Host	Genetic clade*
Australia	Poultry	2.3.2.1a (HSN1)
Bulgaria	Poultry	2.3.4.4b (HSN5)
Canada	Poultry	unknown (HS)
China	Human (2)	2.3.4.4b (HSN5)
Denmark	Poultry	2.3.4.4b (HSN5)
Dominican Republic	Wild birds	2.3.4.4b (HSN5)
Egypt	Poultry	2.3.2.1a (HSN1)
India	Wild birds	2.3.4.4b (HSN5)
Indonesia	Poultry	unknown (HS)
Iran	Poultry	2.3.4.4b (HSN5)
Japan	Poultry	unknown (HS)
Kenya	Poultry	2.3.4.4b (HSN5)
Laos	Poultry	unknown (HS)
Madagascar	Poultry	unknown (HS)
Malaysia	Wild birds	unknown (HSN)
Nigeria	Human (1)	2.3.4.4b (HSN5)
Russian Federation	Wild birds	2.3.4.4b (HSN5)
Taiwan	Poultry	2.3.4.4b (HSN5)
United Kingdom	Poultry	unknown (HSN)
United States	Poultry	unknown (HSN)
Vanuatu	Poultry	2.3.4.4b (HSN5)

\* Genetic clades of human cases reported to WHO within the reporting period (23 September 2018 to 1 February 2019).

17 countries/regions

# Feb 2020

**Table 1. Recent A(H5) activity**

Country, area or territory	Host	Genetic clade*
Bangladesh	Poultry	2.3.2.1a (HSN1)
Bulgaria	Poultry	2.3.4.4b (HSN5)
Canada	Wild birds	2.3.2.1a (HSN1); 2.3.4.4b (HSN5)
China	Wild birds	2.3.4.4b (HSN5)
Taiwan, China	Poultry	2.3.4.4b (HSN5)
Denmark	Poultry	2.3.4.4b (HSN5)
Dominican Republic	Poultry	2.3.4.4b (HSN5)
Egypt	Poultry	2.3.4.4b (HSN5)
Germany	Poultry	2.3.4.4b (HSN5)
Hungary	Wild birds	2.3.4.4b (HSN5)
India	Poultry	2.3.4.4b (HSN5)
Indonesia	Unknown (HS)	unknown (HS)
Iran (Islamic Republic of)	Wild birds	2.3.4.4b (HSN5)
Italy	Poultry	2.3.4.4b (HSN5)
Japan	Wild birds	2.3.4.4b (HSN5)
Kenya	Poultry	2.3.4.4b (HSN5)
Laos	Poultry	2.3.4.4b (HSN5)
Malaysia	Poultry	2.3.4.4b (HSN5)
Nigeria	Poultry	2.3.4.4b (HSN5)
Russian Federation	Wild birds	2.3.4.4b (HSN5)
Taiwan	Wild birds	2.3.4.4b (HSN5)
United Kingdom	Poultry	2.3.4.4b (HSN5)
United States	Poultry	2.3.4.4b (HSN5)
Vanuatu	Poultry	2.3.4.4b (HSN5)

\* Utilizing proposed updates to the unified nomenclature for HPAI A(H5) viruses.

20 countries/regions

# Feb 2021

**Table 1. H5 activity reported to international agencies since September 2020**

Country, area or territory	Host	Genetic clade*
Algeria	Poultry	unknown (HSN)
Australia	Poultry	unknown (HSN)
Austria	Wild birds	unknown (HSN)
Bangladesh	Wild birds	2.3.4.4b (HSN5)
Belgium	Poultry	2.3.2.1a (HSN1)
Brunei	Wild birds	2.3.4.4b (HSN5)
Bulgaria	Poultry	2.3.4.4b (HSN5)
Canada	Human (1)	2.3.2.1a (HSN1)
China	Poultry environment	2.3.4.4b (HSN5); 2.3.2.1f (HSN1)
Colombia	Wild birds	unknown (HSN); 2.3.4.4b (HSN5)
Germany	Wild birds	unknown (HSN)
Hungary	Poultry	2.3.4.4b (HSN5)
India	Poultry	2.3.4.4b (HSN5)
Indonesia	Unknown (HS)	unknown (HSN)
Iran (Islamic Republic of)	Wild birds	2.3.4.4b (HSN5)
Israel	Poultry	2.3.4.4b (HSN5)
Italy	Wild birds	2.3.4.4b (HSN5)
Japan	Wild birds	2.3.4.4b (HSN5)
Kenya	Poultry	2.3.4.4b (HSN5)
Laos	Wild birds	2.3.4.4b (HSN5)
Malaysia	Poultry	2.3.4.4b (HSN5)
Maldives	Wild birds	2.3.4.4b (HSN5)
Nigeria	Wild birds	2.3.4.4b (HSN5)
Philippines	Poultry	2.3.4.4b (HSN5)
Russian Federation	Wild birds	2.3.4.4b (HSN5)
Saudi Arabia	Poultry	2.3.4.4b (HSN5)
Slovakia	Wild birds	2.3.4.4b (HSN5)
Ukraine	Poultry	2.3.2.1a (HSN1); 2.3.4.4b (HSN5)
Vanuatu	Poultry	2.3.4.4b (HSN5)

\* Utilizing proposed updates to the unified nomenclature for HPAI A(H5) viruses.

49 countries/regions

# Feb 2022

**Table 1. H5 activity reported to international agencies since September 2021**

Country, area or territory	Host	Genetic clade*
Australia	Wild birds	unknown (HSN)
Bangladesh	Poultry	2.3.4.4b (HSN5)
Belgium	Poultry	2.3.4.4b (HSN5)
Bolivia	Wild birds	2.3.4.4b (HSN5)
Bulgaria	Poultry	2.3.4.4b (HSN5)
Canada	Wild birds	2.3.4.4b (HSN5)
China	Human (1)	2.3.2.1a (HSN1)
Denmark	Poultry	2.3.4.4b (HSN5)
Dominican Republic	Wild birds	2.3.4.4b (HSN5)
Egypt	Poultry	2.3.4.4b (HSN5)
Germany	Poultry	2.3.4.4b (HSN5)
Hungary	Wild birds	2.3.4.4b (HSN5)
India	Poultry	2.3.4.4b (HSN5)
Indonesia	Unknown (HS)	unknown (HSN)
Iran (Islamic Republic of)	Wild birds	2.3.4.4b (HSN5)
Italy	Poultry	2.3.4.4b (HSN5)
Japan	Wild birds	2.3.4.4b (HSN5)
Kenya	Poultry	2.3.4.4b (HSN5)
Laos	Wild birds	2.3.4.4b (HSN5)
Malaysia	Poultry	2.3.4.4b (HSN5)
Maldives	Wild birds	2.3.4.4b (HSN5)
Nigeria	Wild birds	2.3.4.4b (HSN5)
Philippines	Poultry	2.3.4.4b (HSN5)
Russian Federation	Wild birds	2.3.4.4b (HSN5)
Saudi Arabia	Poultry	2.3.4.4b (HSN5)
Slovakia	Wild birds	2.3.4.4b (HSN5)
Ukraine	Poultry	2.3.2.1a (HSN1); 2.3.4.4b (HSN5)
Vanuatu	Poultry	2.3.4.4b (HSN5)

\* Utilizing proposed updates to the unified nomenclature for HPAI A(H5) viruses.

66 countries/regions

# Feb 2023

**Table 1. H5 activity reported to international agencies since September 2022**

Country, area or territory	Host	Genetic clade*
Australia	Wild birds	unknown (HSN)
Bangladesh	Poultry	2.3.4.4b (HSN5)
Belgium	Poultry	2.3.4.4b (HSN5)
Bolivia	Wild birds	2.3.4.4b (HSN5)
Bulgaria	Poultry	2.3.4.4b (HSN5)
Canada	Wild birds	2.3.4.4b (HSN5)
China	Human (1)	2.3.2.1a (HSN1)
Denmark	Poultry	2.3.4.4b (HSN5)
Dominican Republic	Wild birds	2.3.4.4b (HSN5)
Egypt	Poultry	2.3.4.4b (HSN5)
Germany	Poultry	2.3.4.4b (HSN5)
Hungary	Wild birds	2.3.4.4b (HSN5)
India	Poultry	2.3.4.4b (HSN5)
Indonesia	Unknown (HS)	unknown (HSN)
Iran (Islamic Republic of)	Wild birds	2.3.4.4b (HSN5)
Italy	Poultry	2.3.4.4b (HSN5)
Japan	Wild birds	2.3.4.4b (HSN5)
Kenya	Poultry	2.3.4.4b (HSN5)
Laos	Wild birds	2.3.4.4b (HSN5)
Malaysia	Poultry	2.3.4.4b (HSN5)
Maldives	Wild birds	2.3.4.4b (HSN5)
Nigeria	Wild birds	2.3.4.4b (HSN5)
Philippines	Poultry	2.3.4.4b (HSN5)
Russian Federation	Wild birds	2.3.4.4b (HSN5)
Saudi Arabia	Poultry	2.3.4.4b (HSN5)
Slovakia	Wild birds	2.3.4.4b (HSN5)
Ukraine	Poultry	2.3.2.1a (HSN1); 2.3.4.4b (HSN5)
Vanuatu	Poultry	2.3.4.4b (HSN5)

\* Utilizing proposed updates to the unified nomenclature for HPAI A(H5) viruses.

65 countries/regions

Recent increase in distribution

## Why?

- The virus?
- Changes in agricultural practices?
- Changes in wildlife?
- Changes in environmental conditions?



# New hosts



The New York Times

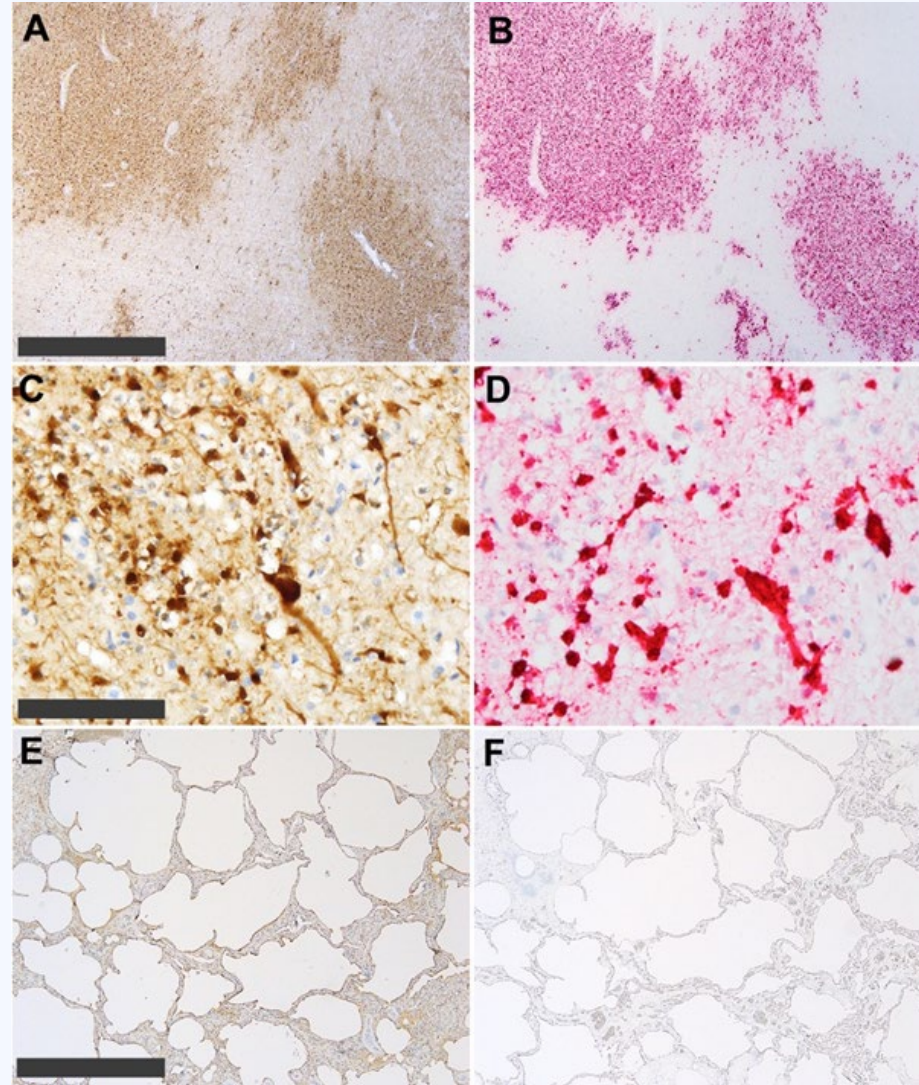
## ***Bird Flu Found in Dolphin in Florida and Porpoise in Sweden***

The findings represent the first time a highly pathogenic form of the virus, which has devastated bird populations this year, has been detected in cetaceans.





# New features





# Current numbers US

www.cdc.gov



Wild Birds

Wild Birds Detected

**7,098**

as of 6/21/2023 | [Full Report >](#)



Poultry

Poultry Affected

**58,789,591**

as of 6/7/2023 | [Full Report >](#)



Humans

Reported Human Cases in the U.S.

**1**

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



Wild mammals

Mammals Detected

**196**

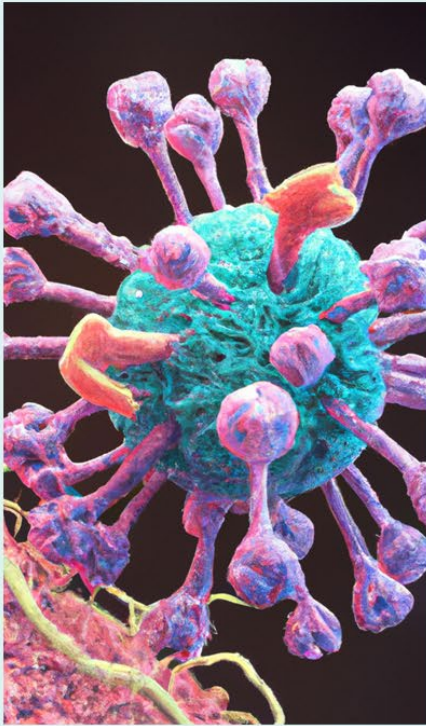
as of  
06/23/2023

www.usda.gov

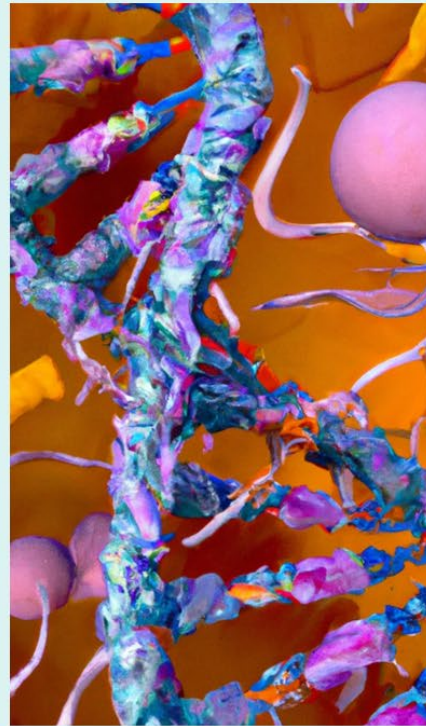


# The good news, these are still very much bird viruses

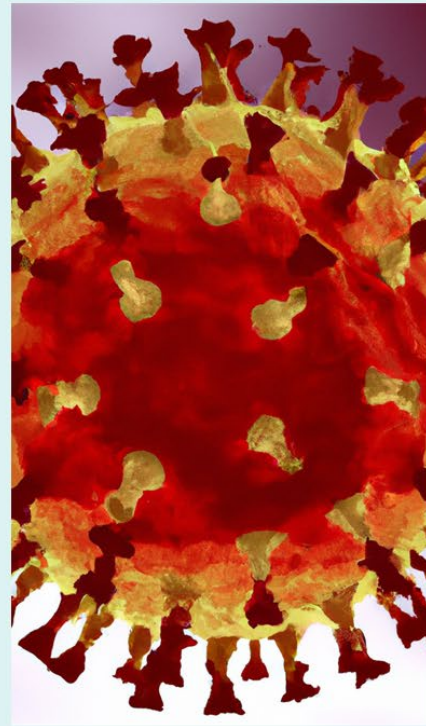
Receptor binding changes



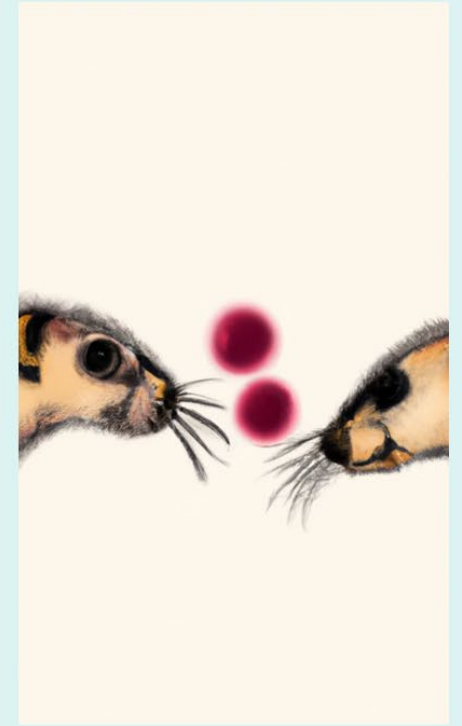
Replication efficiency



HA stabilizing mutations



Ferret transmission



- Single amino acid changes can switch these



# New hosts



The New York Times

## ***Bird Flu Found in Dolphin in Florida and Porpoise in Sweden***

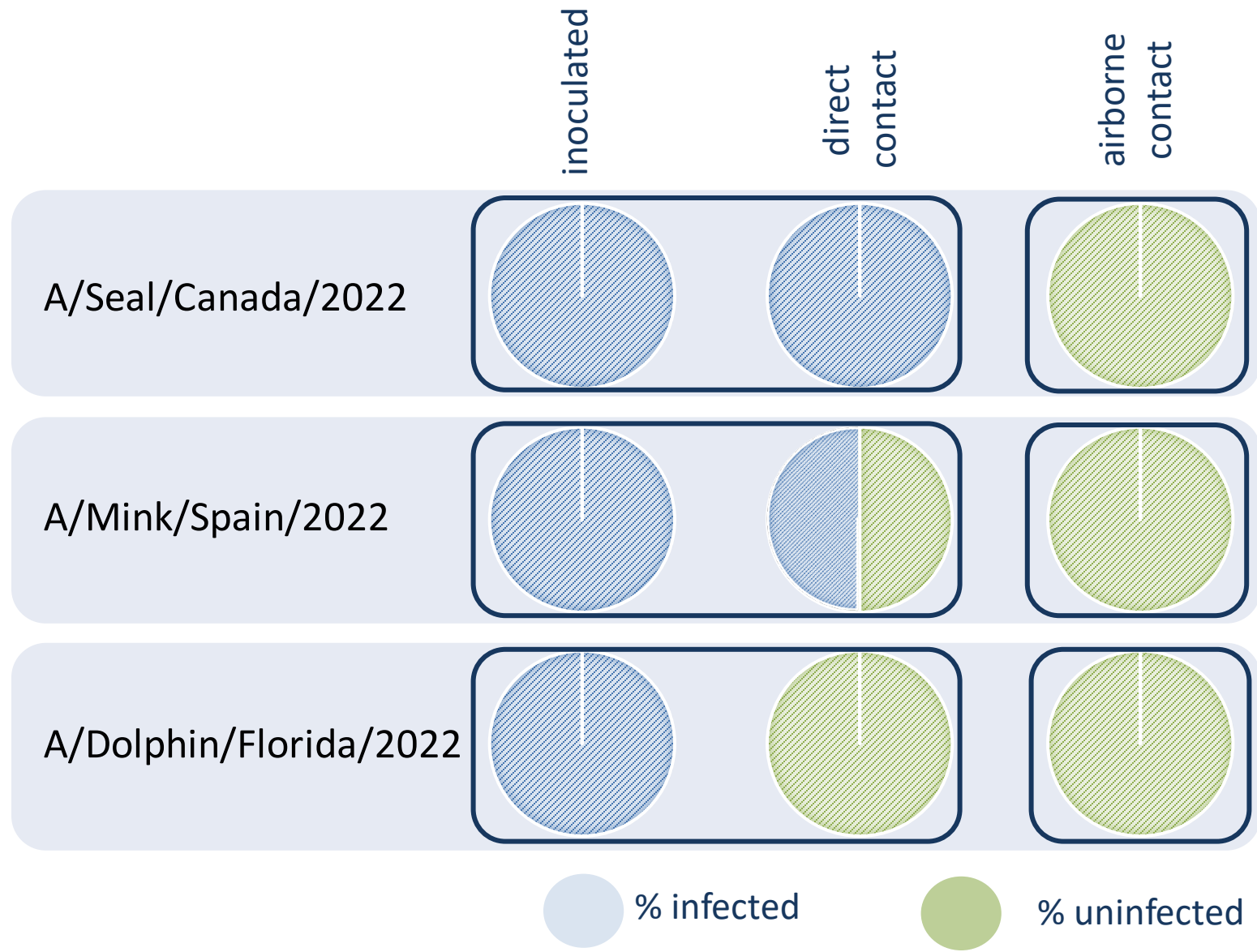
The findings represent the first time a highly pathogenic form of the virus, which has devastated bird populations this year, has been detected in cetaceans.



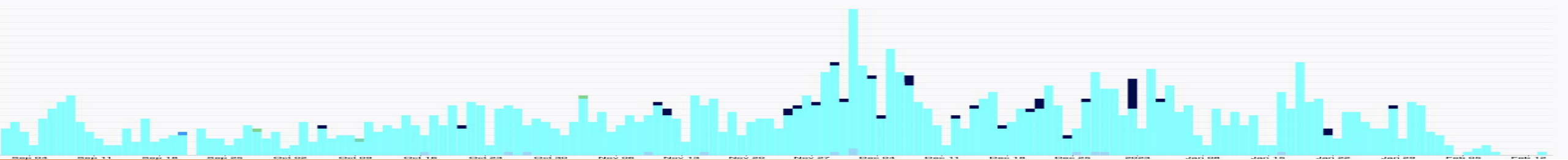
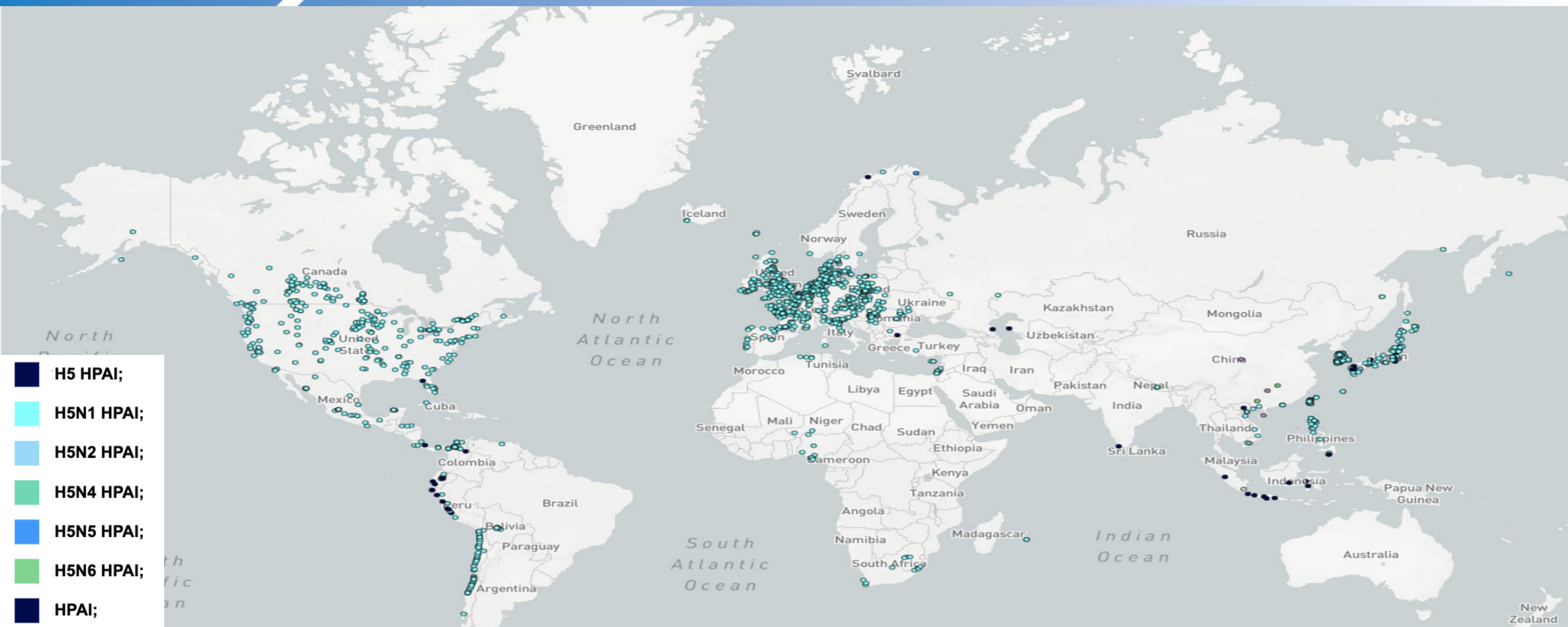




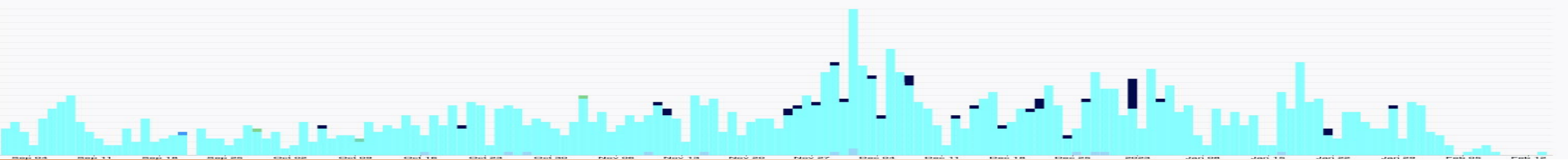
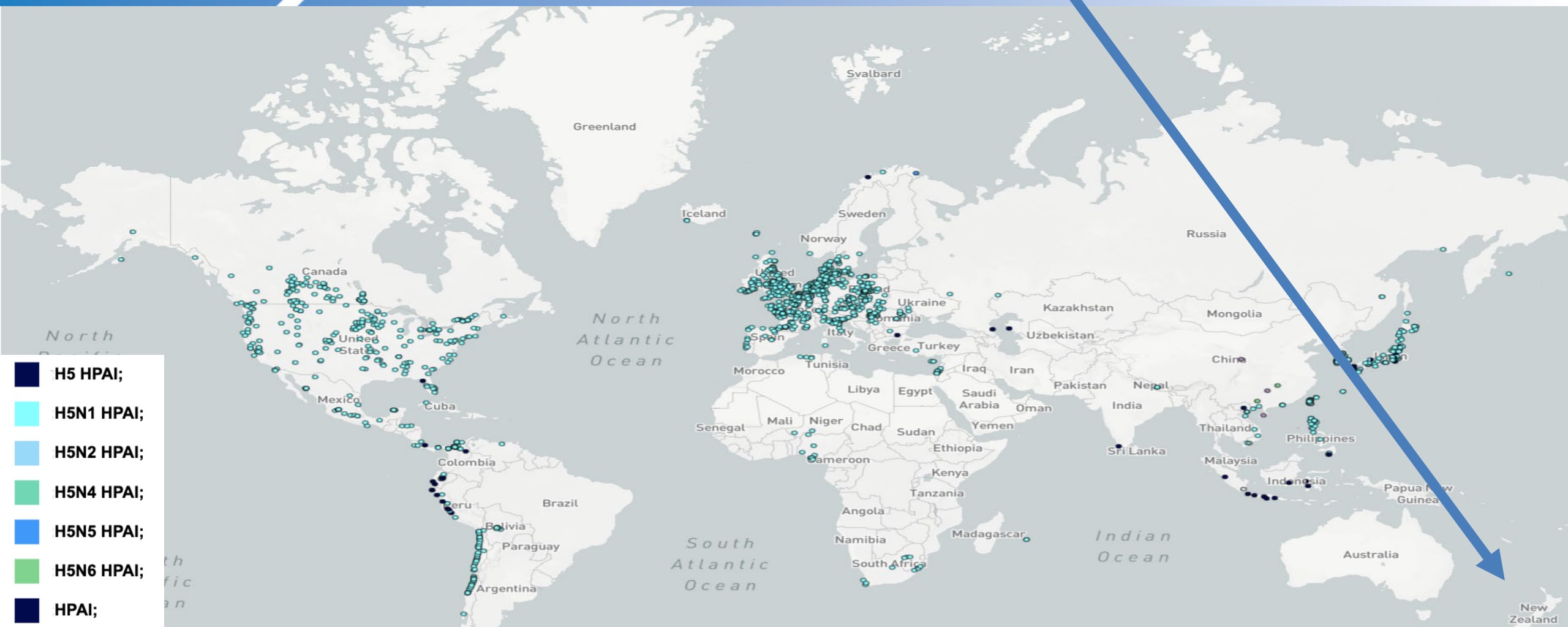
# Ferret transmission of mammalian A(H5N1) viruses



# New Countries (many likely now endemic)



# What about this Country?





# AIV in Australia/NZ is unique

- Lack of migratory ducks drives uniqueness

## PLOS PATHOGENS

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RESEARCH ARTICLE

### Australia as a global sink for the genetic diversity of avian influenza A virus

Michelle Wille<sup>1,2,3\*</sup>, Victoria Grillo<sup>4</sup>, Silvia Ban de Gouvea Pedroso<sup>4</sup>, Graham W. Burgess<sup>5</sup>, Allison Crawley<sup>6</sup>, Celia Dickason<sup>6</sup>, Philip M. Hansbro<sup>7</sup>, Md. Ahasanul Hoque<sup>8</sup>, Paul F. Horwood<sup>5</sup>, Peter D. Kirkland<sup>9</sup>, Nina Yu-Hsin Kung<sup>10</sup>, Stacey E. Lynch<sup>11</sup>, Sue Martin<sup>12</sup>, Michaela McArthur<sup>13</sup>, Kim O'Riley<sup>11</sup>, Andrew J. Read<sup>9</sup>, Simone Warner<sup>11</sup>, Bethany J. Hoyer<sup>14</sup>, Simeon Lisovski<sup>14</sup>, Trent Leen<sup>15,16</sup>, Aeron C. Hurt<sup>1</sup>, Jeff Butler<sup>17</sup>, Ivano Broz<sup>17</sup>, Kelly R. Davies<sup>17</sup>, Patrick Mileto<sup>17</sup>, Matthew J. Neave<sup>17</sup>, Vicky Stevens<sup>17</sup>, Andrew C. Breed<sup>18,19</sup>, Tommy T. Y. Lam<sup>20</sup>, Edward C. Holmes<sup>2</sup>, Marcel Klaassen<sup>14</sup>, Frank Y. K. Wong<sup>17\*</sup>

- The H5 virus isn't sticking to the rules (e.g., introductions into Americas)



# Summary

- Flu is bad
  - Pandemics are bad
    - H5 bird flu viruses are bad
- Not having migratory waterfowl isn't so bad

Fukuda gives the auditory equivalent of a shrug. “Anyone who tries to predict anything about influenza is a bit foolish and hasn’t been in the field very long,” he said.

- The H5 virus is teaching us new things



# Acknowledgments

Rob Webster/St. Jude Children's Research Hospital/ALSAC

Sue and the SHIVERS team and participants

Wlodek Stanislawek, Biosecurity New Zealand

Becky Poulson, Dave Stallknecht, UGA

Mia Torchetti, USDA

Yohannes Berhane, National Centre for Foreign Animal Disease, Canada

Michael Walsh, Andrew Allison, Allison Murawski, U Florida

And many many others

