Emerging Infectious Diseases

Hannah Nam MD MSc

Assistant Professor of Clinical Medicine

Director, Transplant and Immunocompromised Host Infectious Diseases

Department of Infectious Diseases

University of California – Irvine

Financial Disclosure

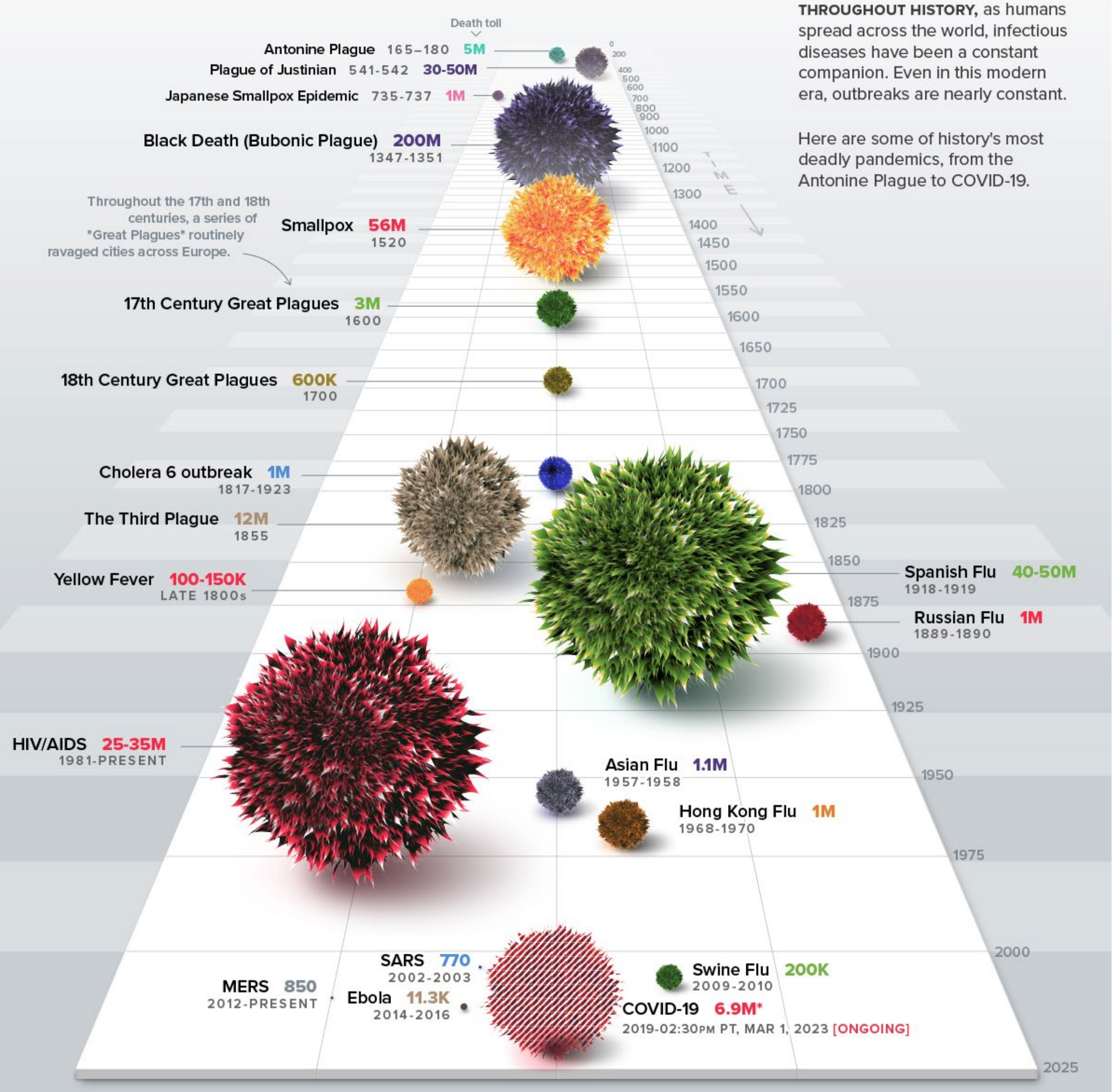
- None

HISTORY OF **PANDEMICS**

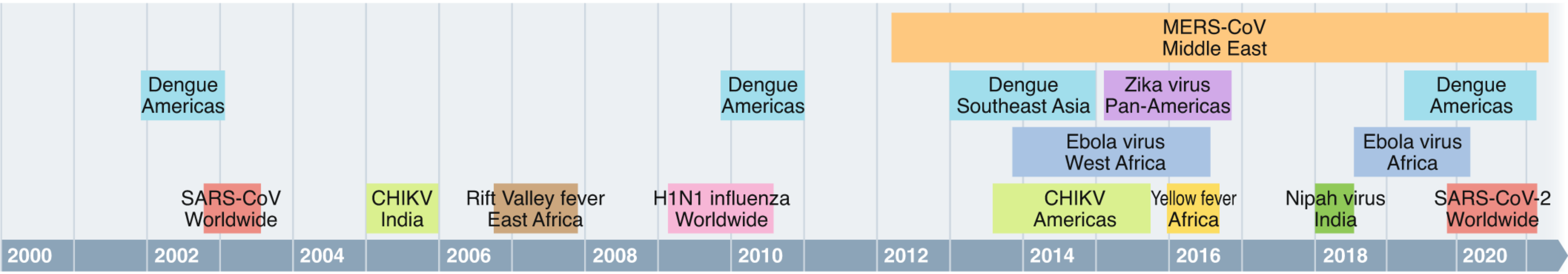
PAN·DEM·IC (of a disease) prevalent over a whole country or the world.

THROUGHOUT HISTORY, as humans spread across the world, infectious diseases have been a constant companion. Even in this modern era, outbreaks are nearly constant.

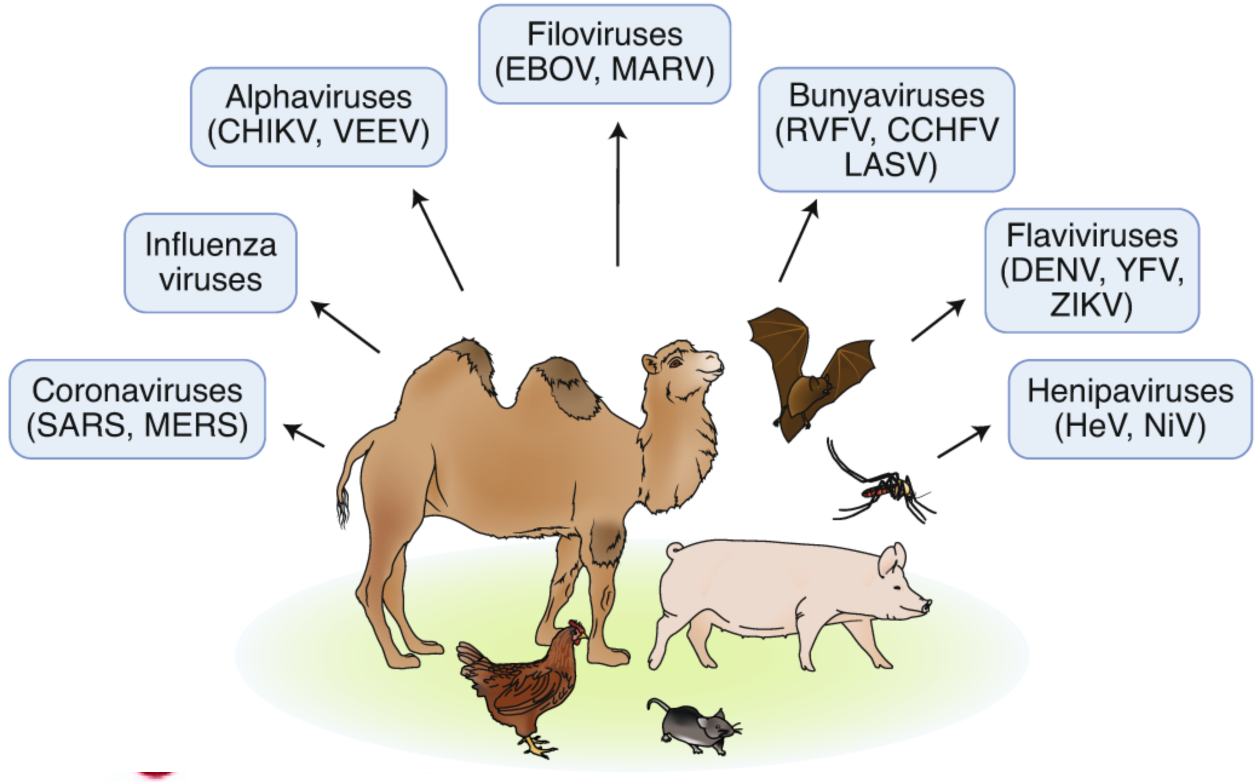
Here are some of history's most deadly pandemics, from the Antonine Plague to COVID-19.



a 21st century viral disease outbreaks



b Zoonotic reservoirs and vectors

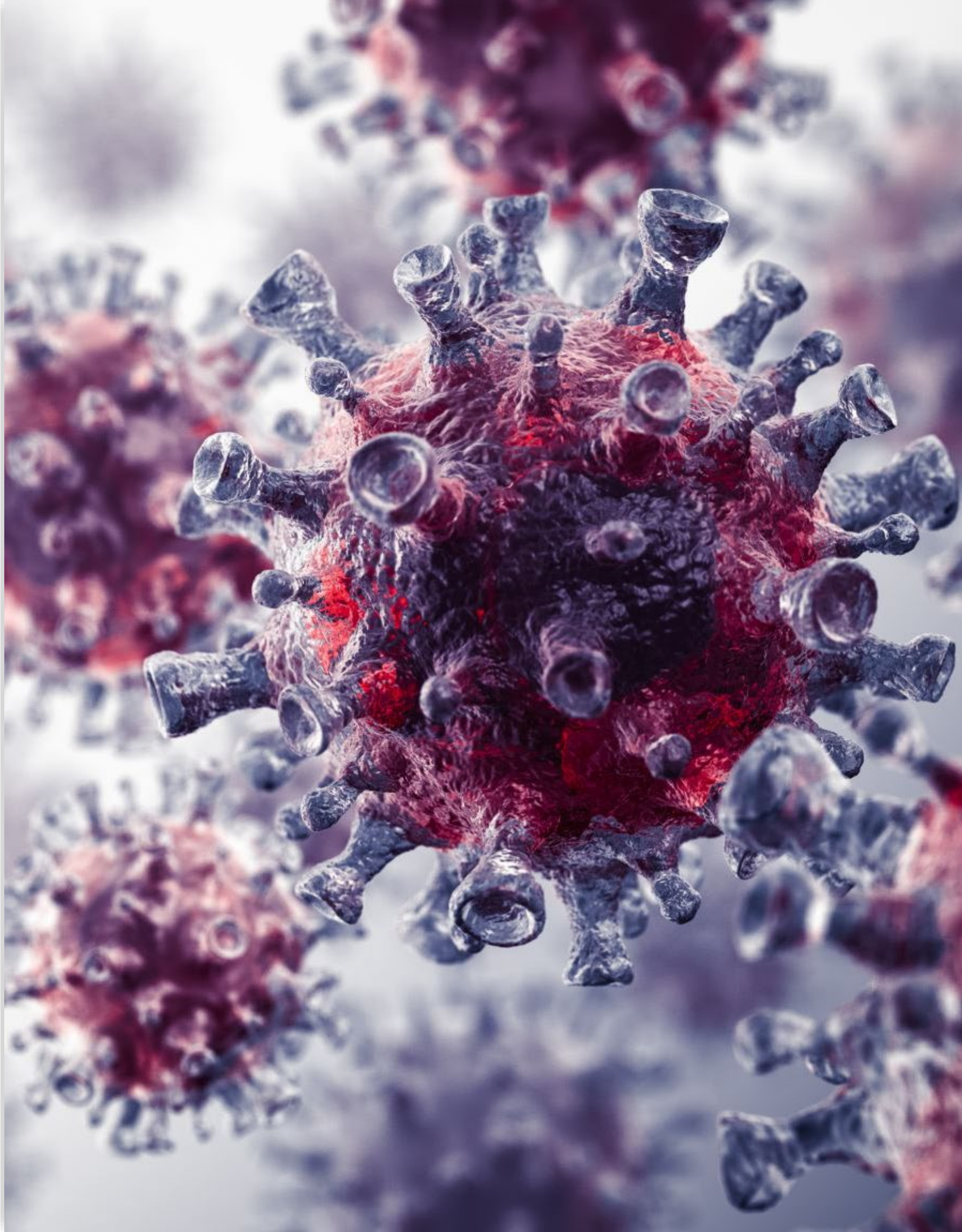


Meganck et al (2021). *Nature Medicine* **27:** 401–410.

Emerging Infectious Diseases: Why now?

The threat posed by emerging infectious diseases will continue to **increase**.

The longer we wait, the harder it becomes to build on lessons learned from COVID-19.

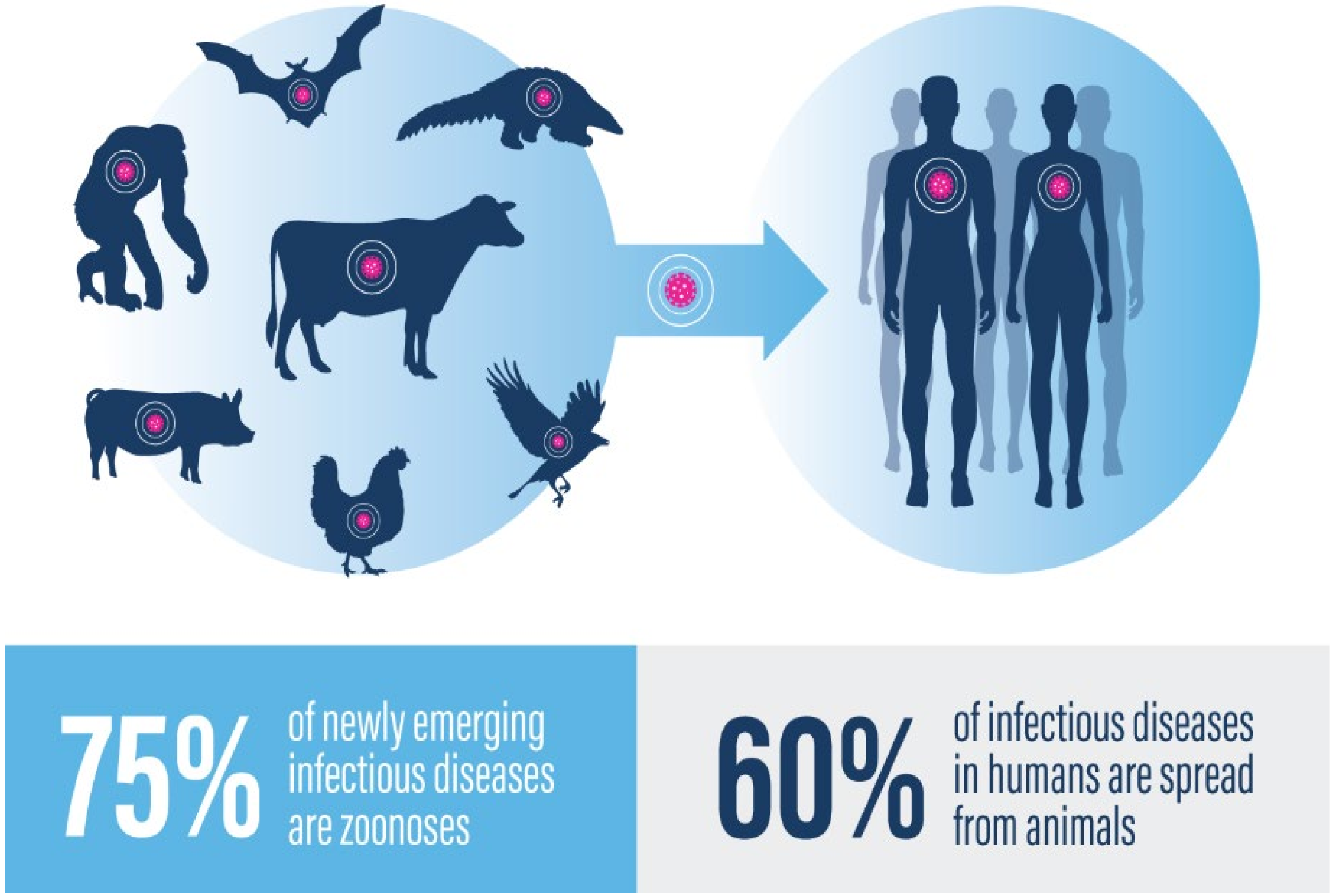


Emerging Infectious Diseases: Why now?

Urbanization and the expanding animal-human interface

- 60% of human infectious diseases are zoonotic in origin.
- However, 75% of **emerging** infectious diseases have a zoonotic origin.

Zoonotic diseases are responsible for 2.5 billion cases of illness and 2.7 million deaths worldwide, each year.

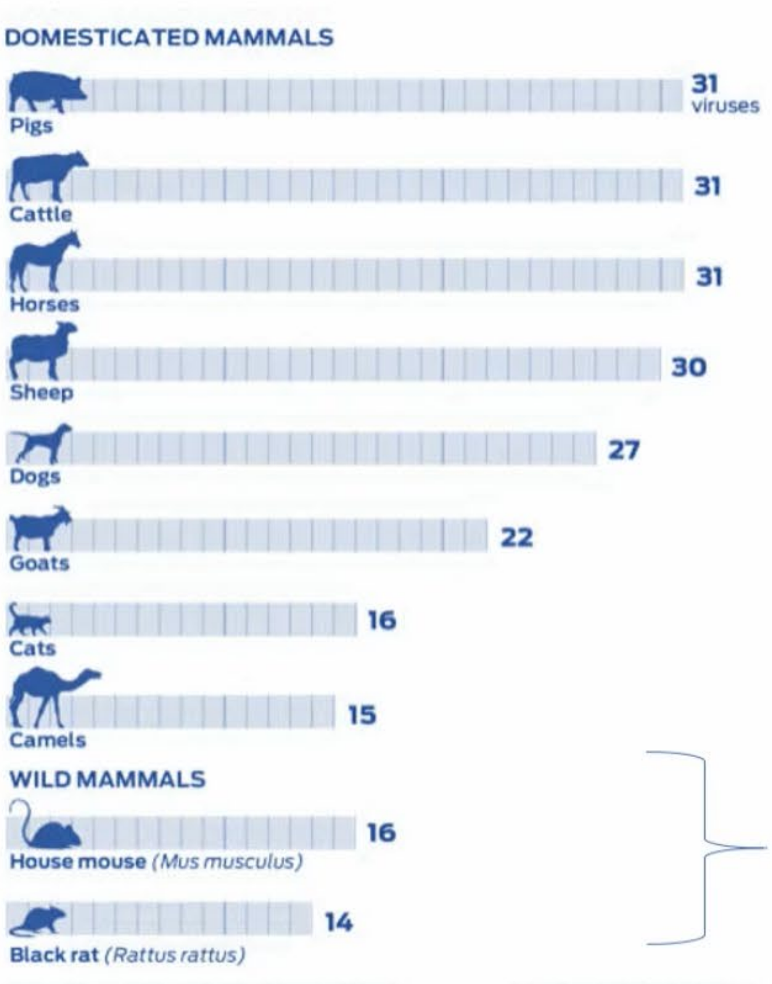


Species sharing the most zoonotic viruses with humans to date

Global shifts in mammalian population trends reveal key predictors of virus spillover risk

Christine K. Johnson[1], Peta L. Hitchens[2], Pranav S. Pandit[1], Julie Rushmore[1], Tierra Smiley Evans[1], Cristin C. W. Young[1] and Megan M. Doyle[1]

[1]EpiCenter for Disease Dynamics, One Health Institute, School of Veterinary Medicine, University of California, Davis, CA 95616, USA

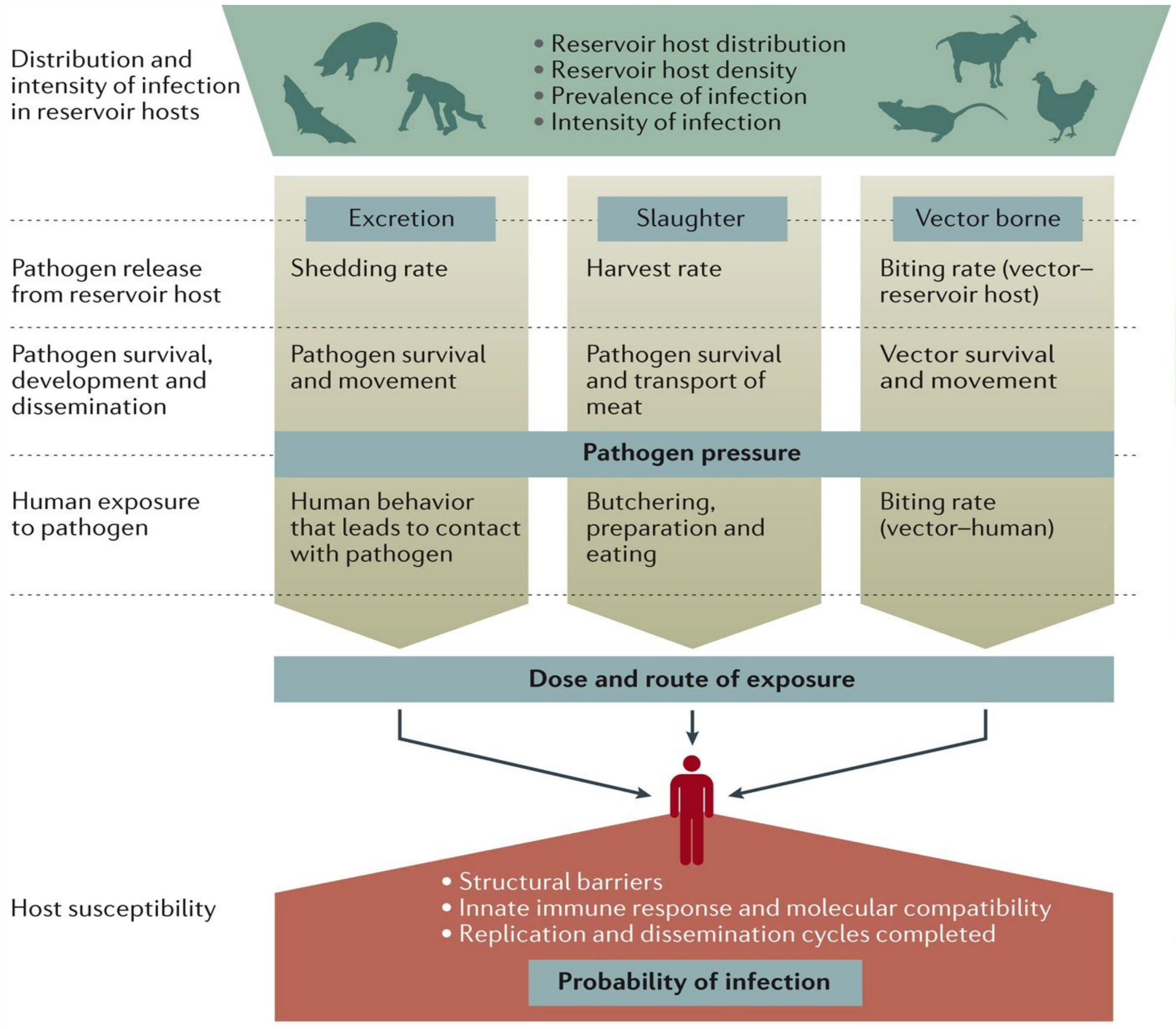


Linked to agricultural production

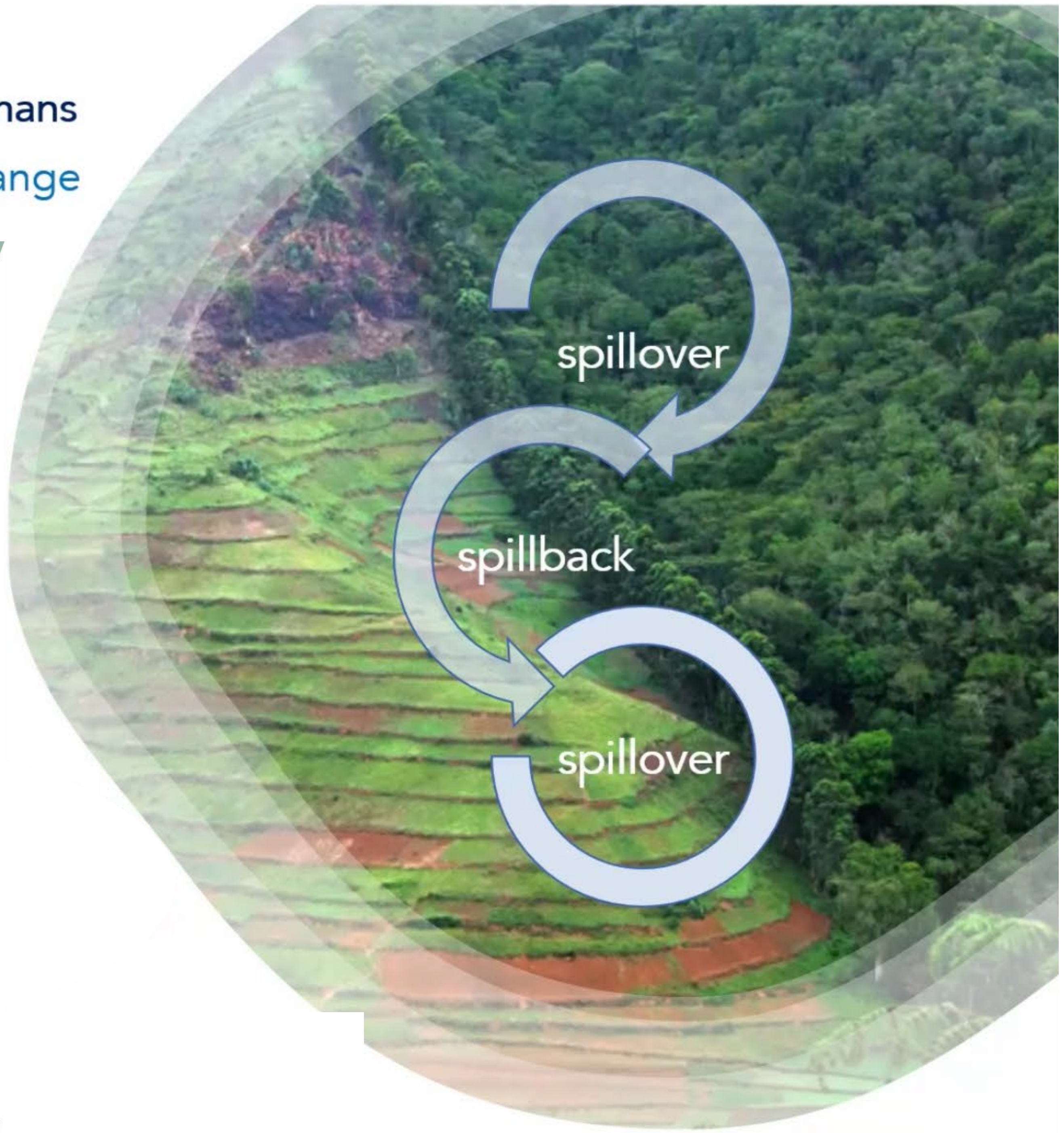
Linked to urbanization

Spillover of infectious disease from animals to humans

an irreversible consequence of ecosystem change



Nature Reviews | Microbiology



Activities driving spillover of viruses from wildlife

Global shifts in mammalian population trends reveal key predictors of virus spillover risk

Christine K. Johnson[1], Peta L. Hitchens[2], Pranav S. Pandit[1], Julie Rushmore[1], Tierra Smiley Evans[1], Cristin C. W. Young[1] and Megan M. Doyle[1]

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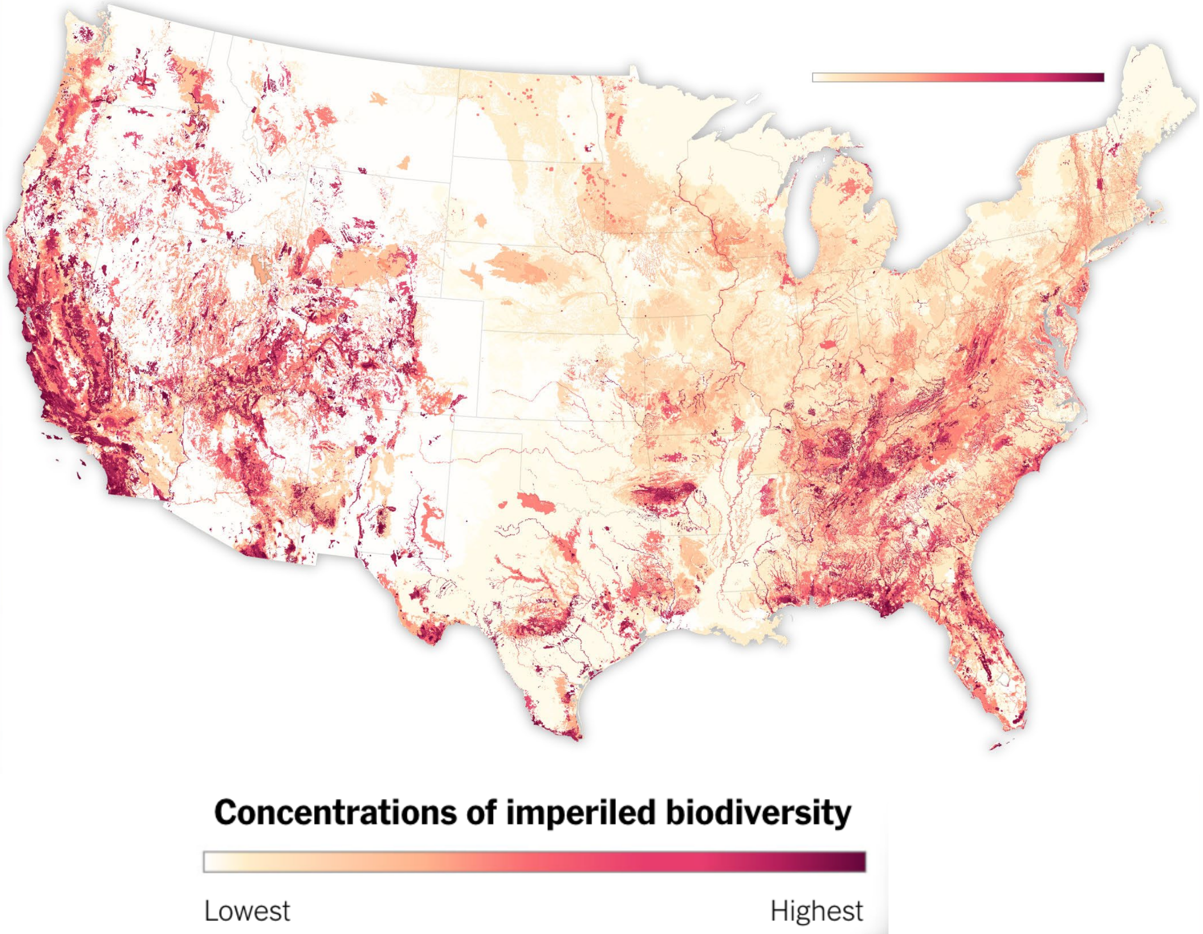
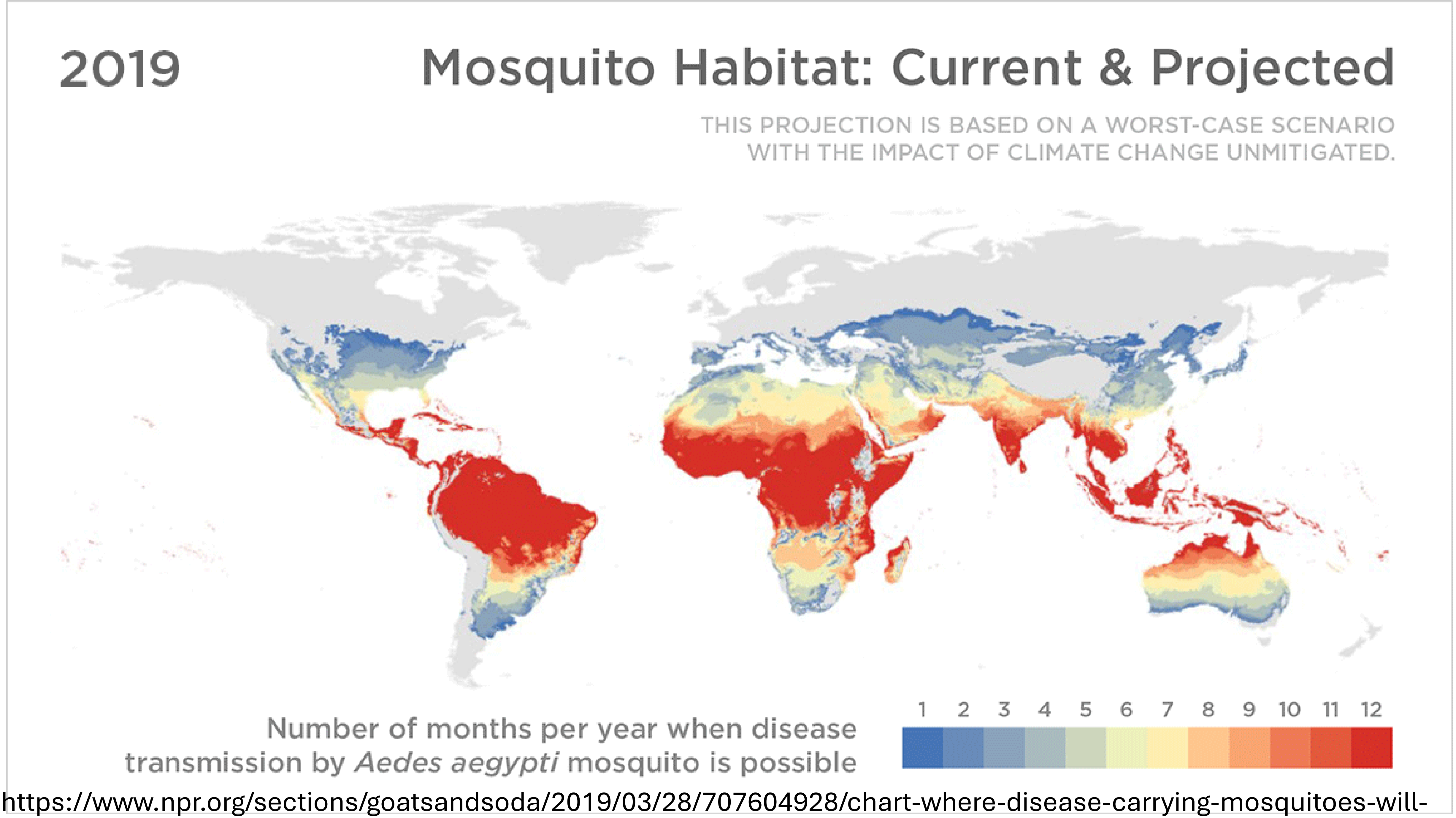
- Species in global decline because of exploitation and habitat loss shared more viruses with people
- **Degradation of habitat**, due to deforestation, development, and conversion to cropland – increases animal-human interactions
- **Exploitation of wildlife** through hunting and the live wild animal trade – facilitate contact and virus transmission



https://www.nytimes.com/interactive/2022/03/03/climate/biodiversity-map.html

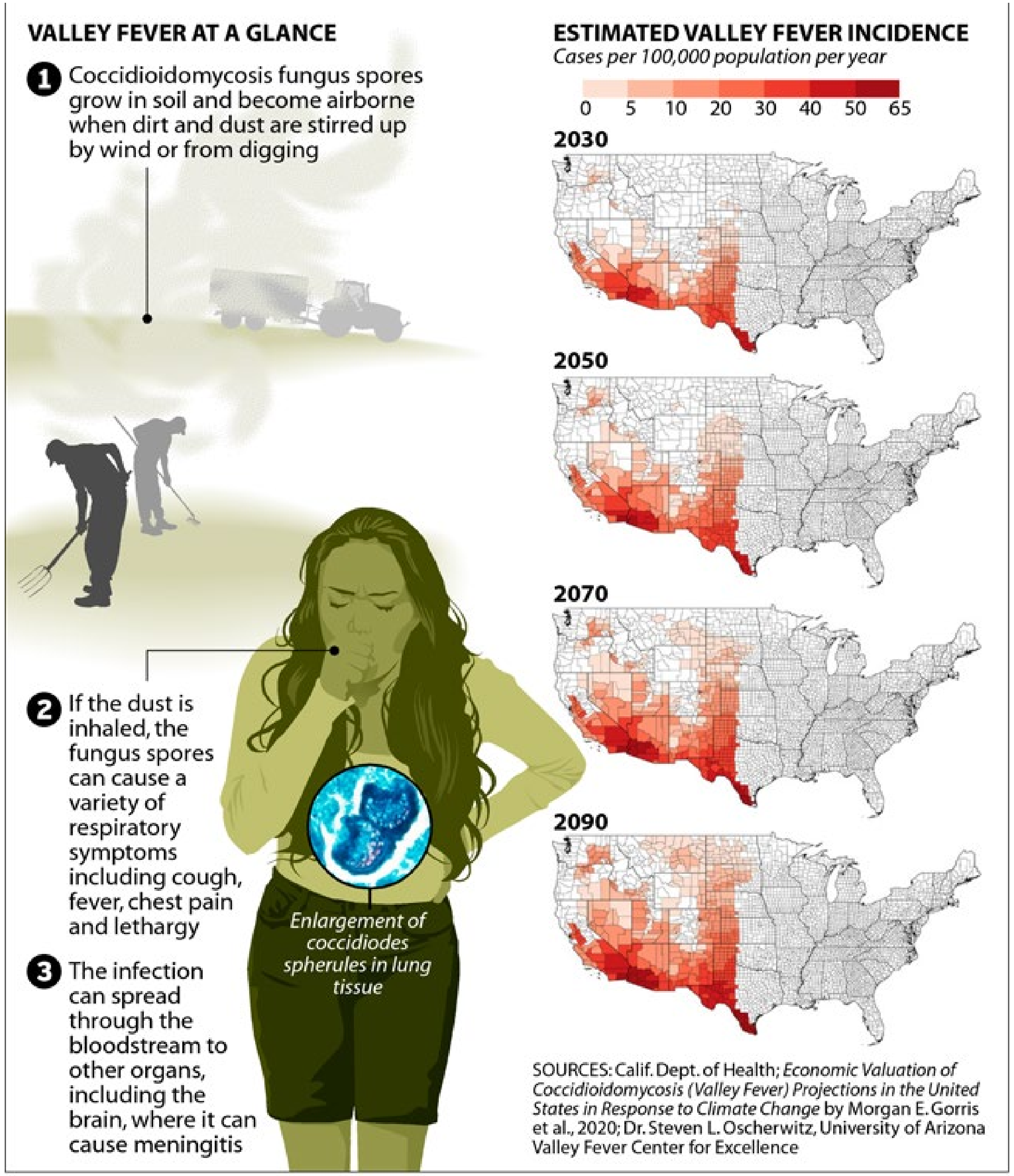
Emerging Infectious Diseases: Why now?

- **Climate change:** expansion of mosquito and tick-borne illnesses, changing habitats for animals and fungi, and alterations to water habitats.



https://www.npr.org/sections/goatsandsoda/2019/03/28/707604928/chart-where-disease-carrying-mosquitoes-will-go-in-the-future

Projected changes to coccidiomycoses distribution



PAUL HORN / Inside Climate News

Emerging Infectious Diseases: Why now?

- **Increasing international travel:** International travel anticipated to reach pre-pandemic levels by 2024 and double by 2040.
  - Animals are also globally transported in wildlife trade supply chains.

The Global Spread of COVID-19

As of Jan. 20: 4

https://www.businessinsider.com/map-tracks-novel-coronavirus-spread-in-countries-around-the-world-2020-3

Major Infectious Disease Outbreaks in 2023

- Antimicrobial resistance
- Arboviruses
- Avian influenza
- Botulism
- Candida auris
- Candida auris
- COVID-19
- Diphtheria
- Fungal meningitis
- mpox
- Nipah Virus
- Plague
- Polio
- STI's
- Viral Hemorrhagic Fevers

COVID-19 and Influenza

The Continued Pandemic

CDC Fall/Winter 2023-2024 Vaccine Recommendations

- **Updated COVID-19 Vaccine -** Recommended for all persons 6 months and older
- **Influenza Vaccine -** Recommended for persons 6 months and older; People 65 and older should get a higher dose or adjuvanted flu vaccine
- **RSV Vaccine**
  - **Adults 60+** should talk to their medical provider to see if the vaccine is right for them
  - **Infants during RSV season**: We have two ways to protect infants from RSV. Most infants will not need both.

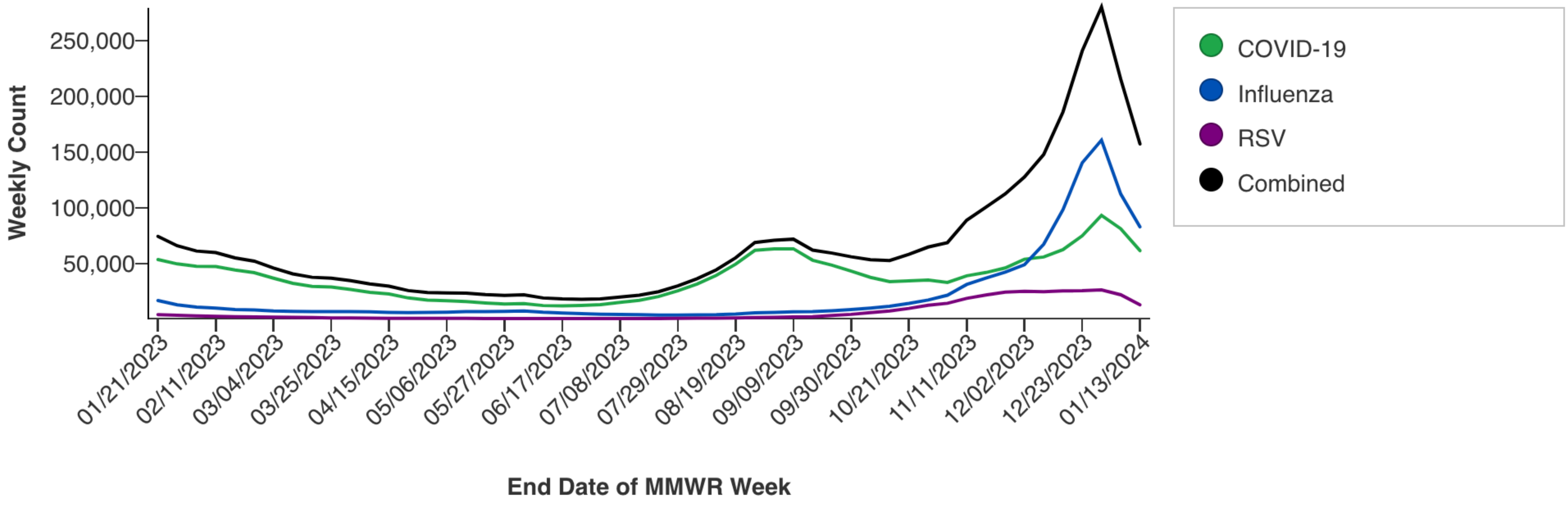
1. **Maternal RSV vaccination** at 32-36 weeks of gestation
2. **Nirsevimab:** Infants younger than 8 months entering RSV season and some older children between 8-19 months with increased risk for severe RSV

Weekly Emergency Department Visits

Make a selection from the filters to change the visualization information.

Age Group

All Ages

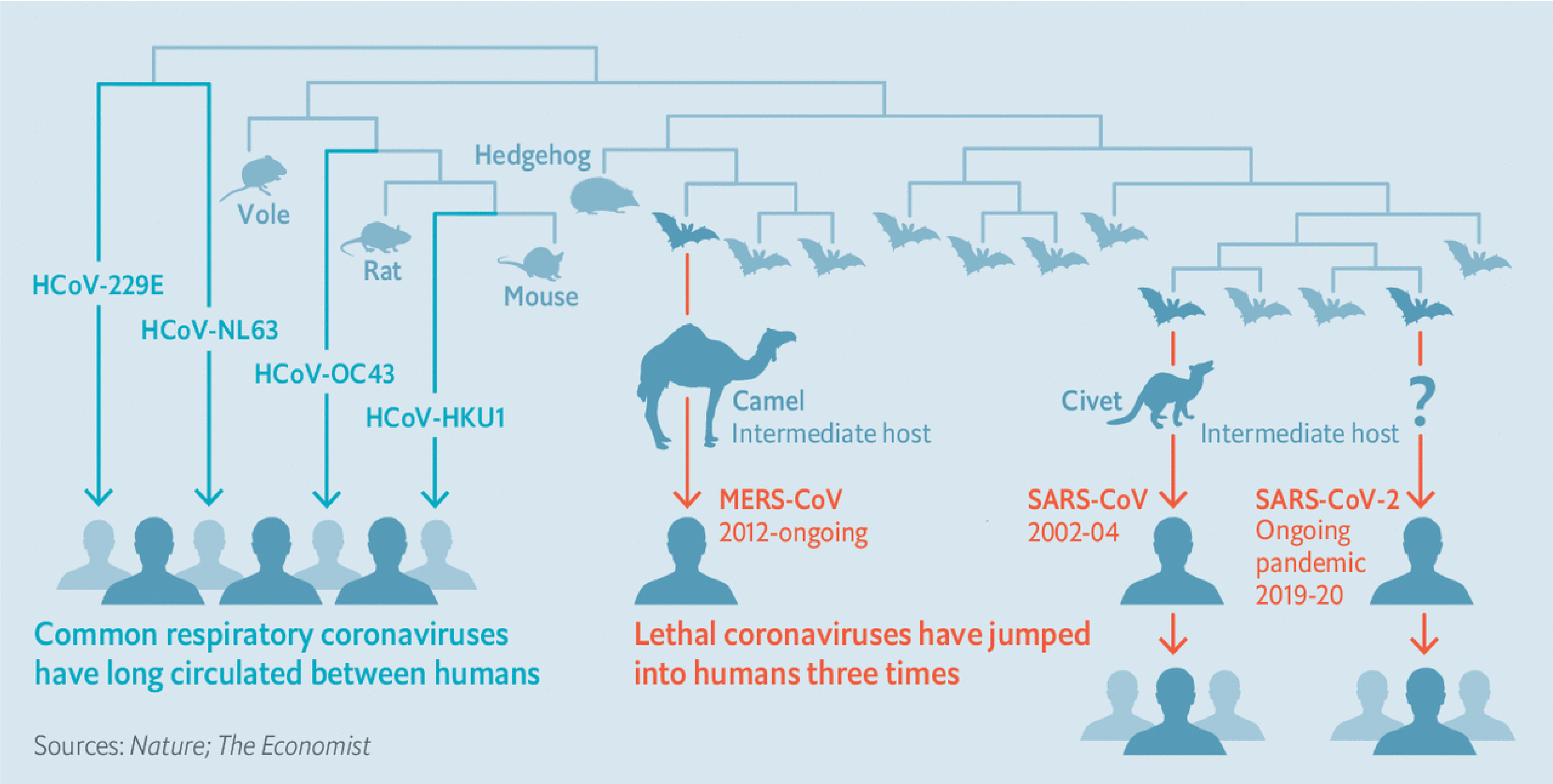


CDC Resp-NET 2024

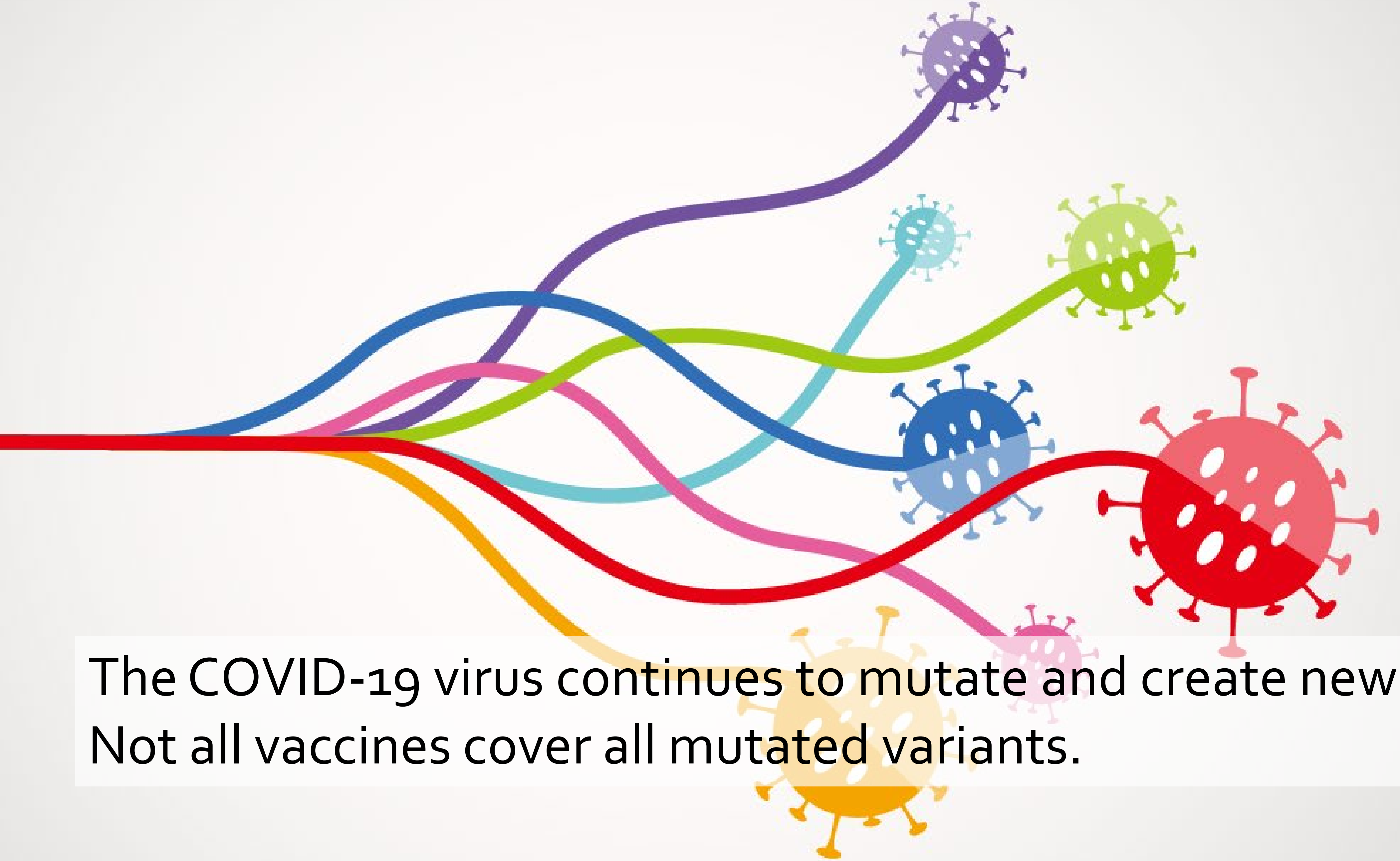
COVID-19

The Current State

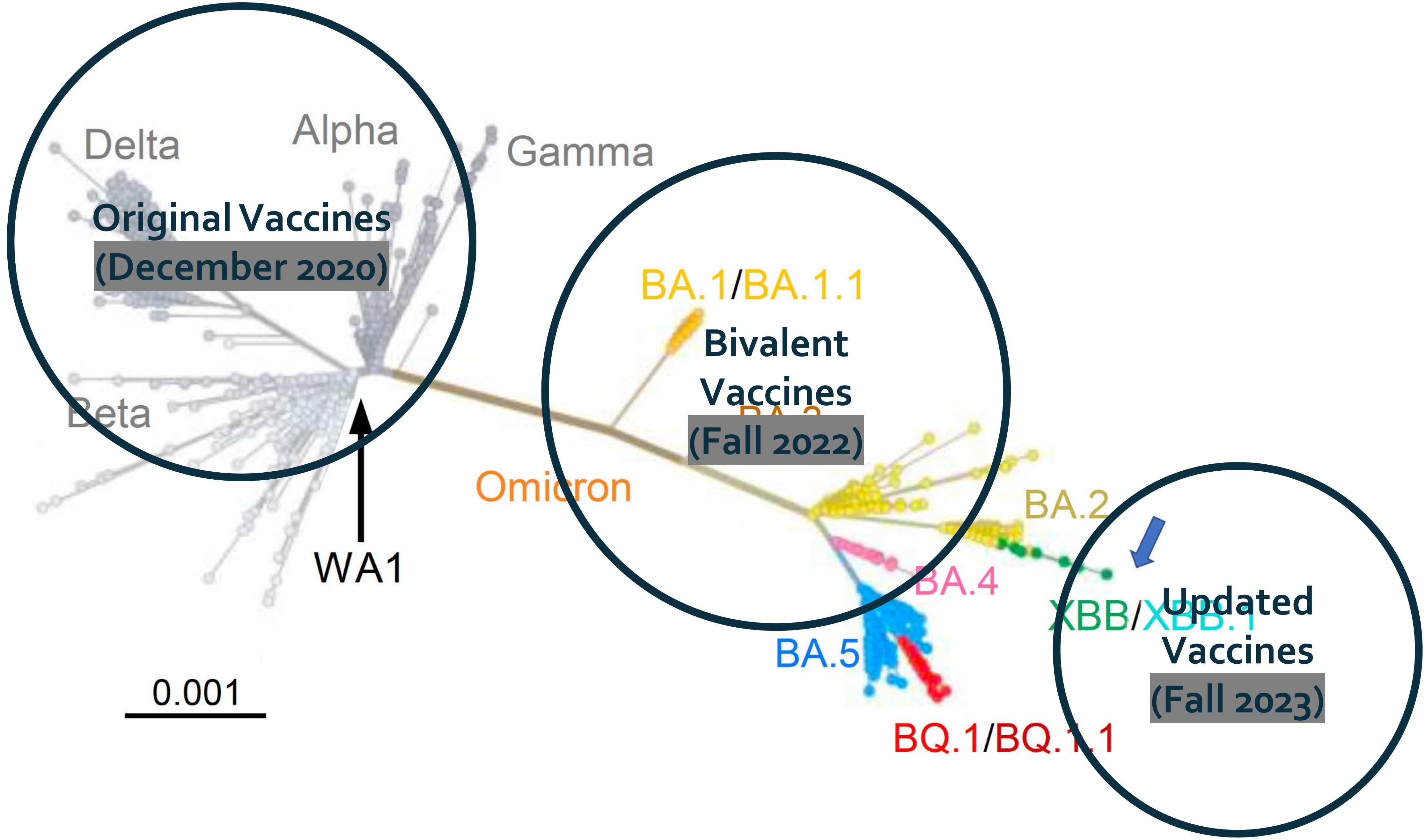
Coronavirus Outbreaks and Zoonotic Origins



The Economist



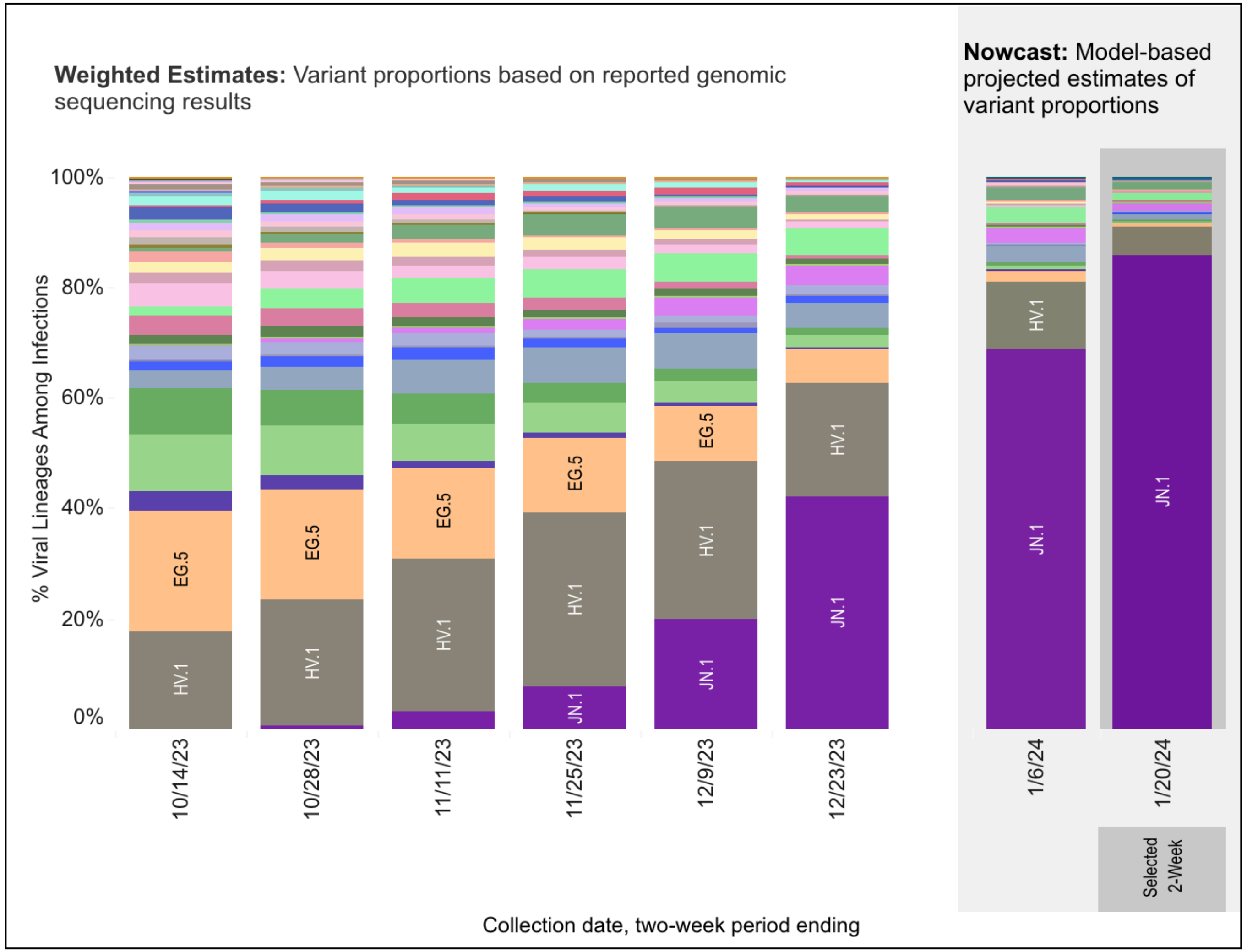
The COVID-19 virus continues to mutate and create new variants.
Not all vaccines cover all mutated variants.



Delta
Alpha
Gamma
Original Vaccines
(December 2020)
Beta
WA1
0.001
Omicron
BA.1/BA.1.1
Bivalent
Vaccines
(Fall 2022)
BA.2
BA.4
BA.5
BQ.1/BQ.1.1
XBB/XBB.1
Updated
Vaccines
(Fall 2023)

Weighted and Nowcast Estimates in United States for 2-Week Periods in 10/1/2023 – 1/20/2024

Hover over (or tap in mobile) any lineage of interest to see the amount of uncertainty in that lineage's estimate.



Nowcast Estimates in United States for 1/7/2024 – 1/20/2024

USA

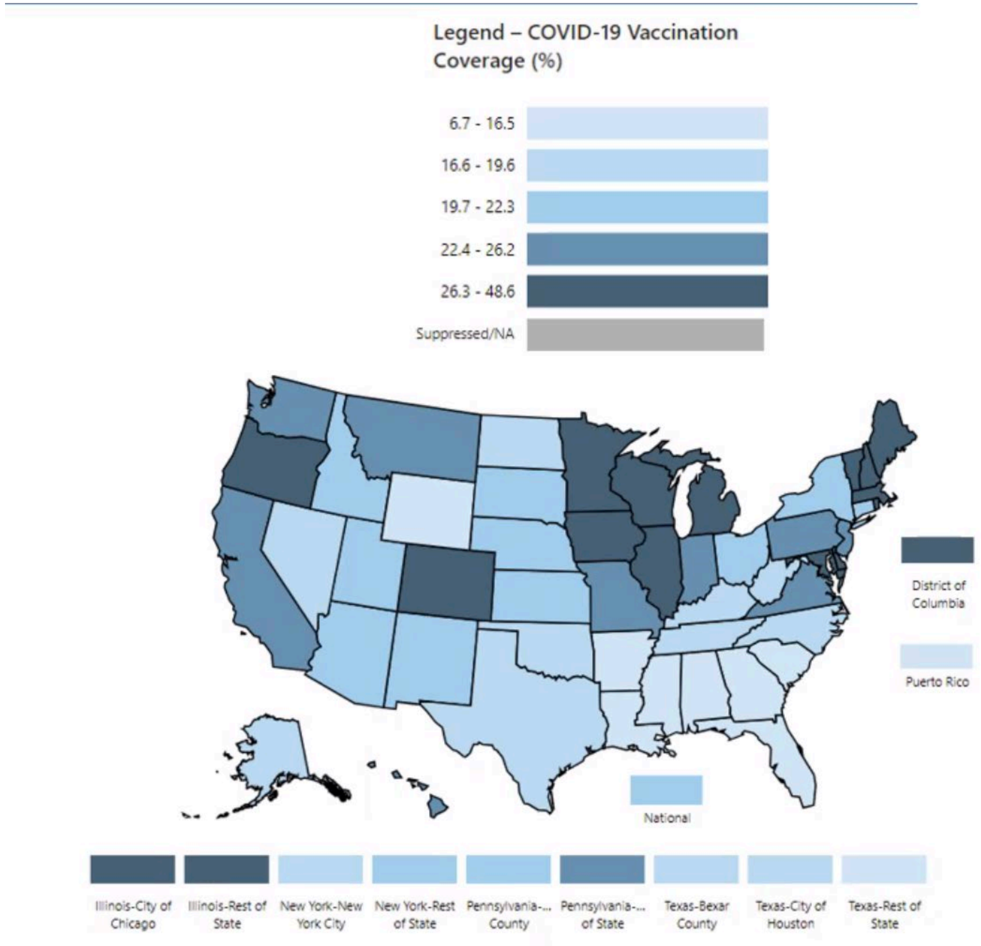
WHO label	Lineage #	%Total	95%PI
Omicron	JN.1	85.7%	82.9-88.2%
	HV.1	5.3%	4.4-6.4%
	JD.1.1	1.6%	1.4-2.0%
	BA.2.86	1.5%	1.1-2.1%
	JG.3	1.5%	1.2-1.9%
	HK.3	1.5%	1.2-1.8%
	EG.5	0.6%	0.5-0.8%
	GE.1	0.4%	0.1-1.5%
	JF.1	0.2%	0.2-0.3%
	FL.1.5.1	0.2%	0.2-0.3%
	EG.5.1.8	0.2%	0.2-0.3%
	BA.2	0.1%	0.0-0.6%
	XBB.1.16.6	0.1%	0.1-0.2%
	XBB.1.16.17	0.1%	0.1-0.3%
	XBB.1.5.70	0.1%	0.1-0.2%
	XBB.1.16.11	0.1%	0.1-0.1%
	GK.1.1	0.1%	0.1-0.1%
	XBB	0.1%	0.0-0.1%
	XBB.1.9.1	0.1%	0.0-0.1%
	HF.1	0.1%	0.0-0.1%
	XBB.1.16.15	0.1%	0.0-0.1%
	XBB.2.3	0.0%	0.0-0.1%
	XBB.1.16	0.0%	0.0-0.0%
	GK.2	0.0%	0.0-0.0%
	CH.1.1	0.0%	0.0-0.0%
	XBB.1.5	0.0%	0.0-0.0%
	EG.6.1	0.0%	0.0-0.0%
	XBB.1.16.1	0.0%	0.0-0.0%
	XBB.1.5.68	0.0%	0.0-0.0%
	XBB.1.9.2	0.0%	0.0-0.0%
	XBB.2.3.8	0.0%	0.0-0.0%
	XBB.1.42.2	0.0%	0.0-0.0%
	XBB.1.5.72	0.0%	0.0-0.0%
	XBB.1.5.59	0.0%	0.0-0.0%
Other	Other*	0.0%	0.0-0.0%

* Enumerated lineages are US VOC and lineages circulating above 1% nationally in at least one 2-week period. "Other" represents the aggregation of lineages which are circulating <1% nationally during all 2-week periods displayed.

While all lineages are tracked by CDC, those named lineages not enumerated in this graphic are aggregated with their parent lineages, based on Pango lineage definitions, described in more detail here: https://www.pango.network/the-pango-nomenclature-system/statement-of-nomenclature-rules/.

2023 US COVID Vaccine Uptake

- **National** (as of Jan 6)
  - 21% of adults vaccinated
    - 43% among ≥ 75 yo
  - Of the remaining 79%
    - Definitely will: 18%
    - Probably will: 35%
    - Probably or definitely will not: 47%
- **California** (as of Jan 2)
  - 12% of adults vaccinated



CDC Vaccine Dashboard (2024)

Vaccination Reduces Risk of Long COVID

- **Prevents Long COVID**
  - Reduces viral load during infection
  - Large staggered cohort study of patients in UK, Spain, and Estonia [Catala et al. Lancet Respir Med 2024]
    - Vaccine reduces long COVID by 29-52% across 3 cohorts
  - Meta analysis of 24 studies [Marra et al. Antimicrob Stewardship Healthcare Epi Oct 2023]
    - 2 doses reduce long COVID by 37%, 3 doses by 69%

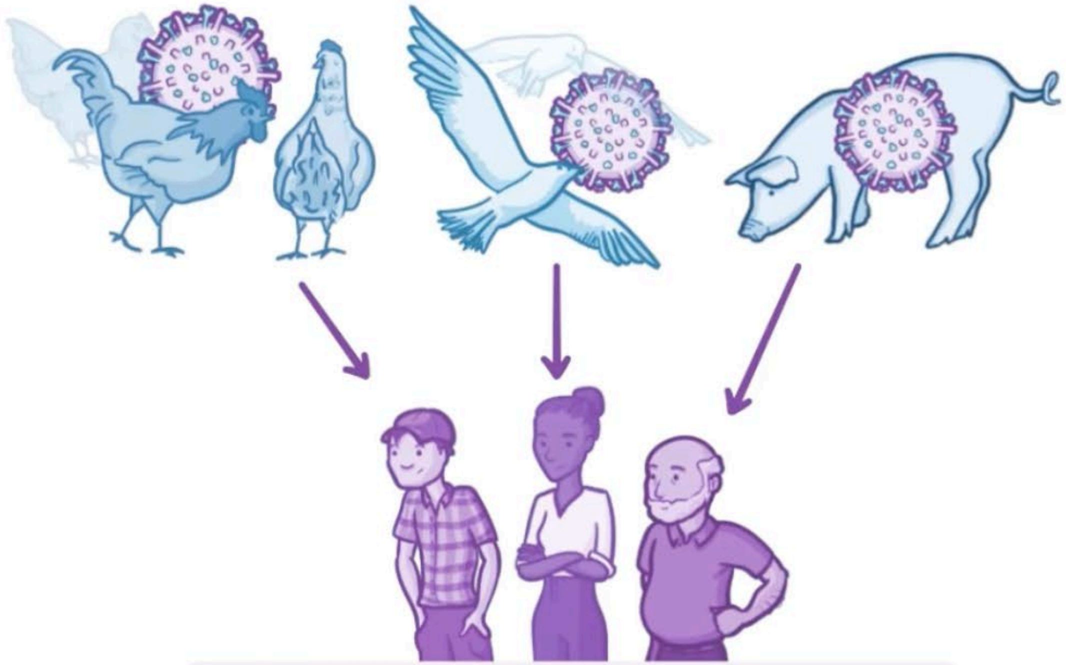
COVID-19 Global Challenges Ahead

- Reduced testing and surveillance
- Decline in submission and delay in availability of genomic sequences
- Emergence and re-emergence of variants
- Difficulty assessing changes in disease severity
- Waning immunity and low booster coverage in at-risk populations
- Access and affordability of life-saving medical countermeasures
- Reduced funding to WHO

Influenza

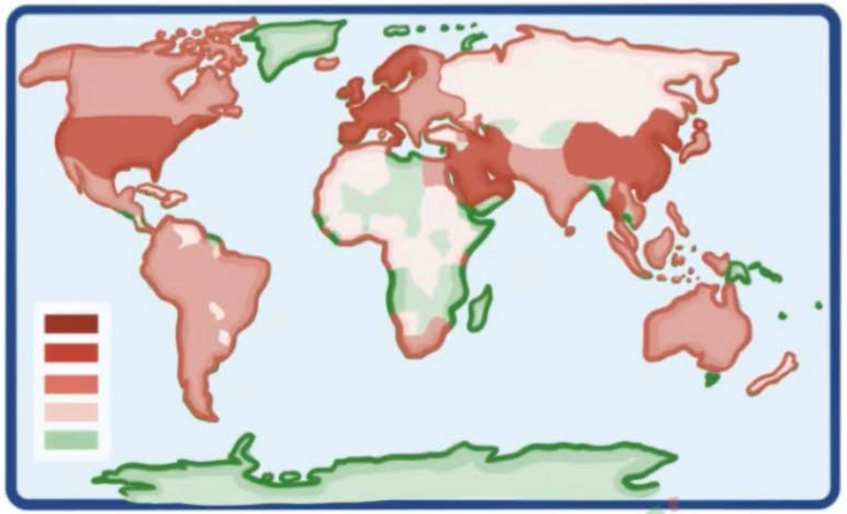
Update and Surveillance

ZOONOTIC INFLUENZAS



~ 3-5 MILLION cases of SEVERE ILLNESS

~ 500,000 DEATHS

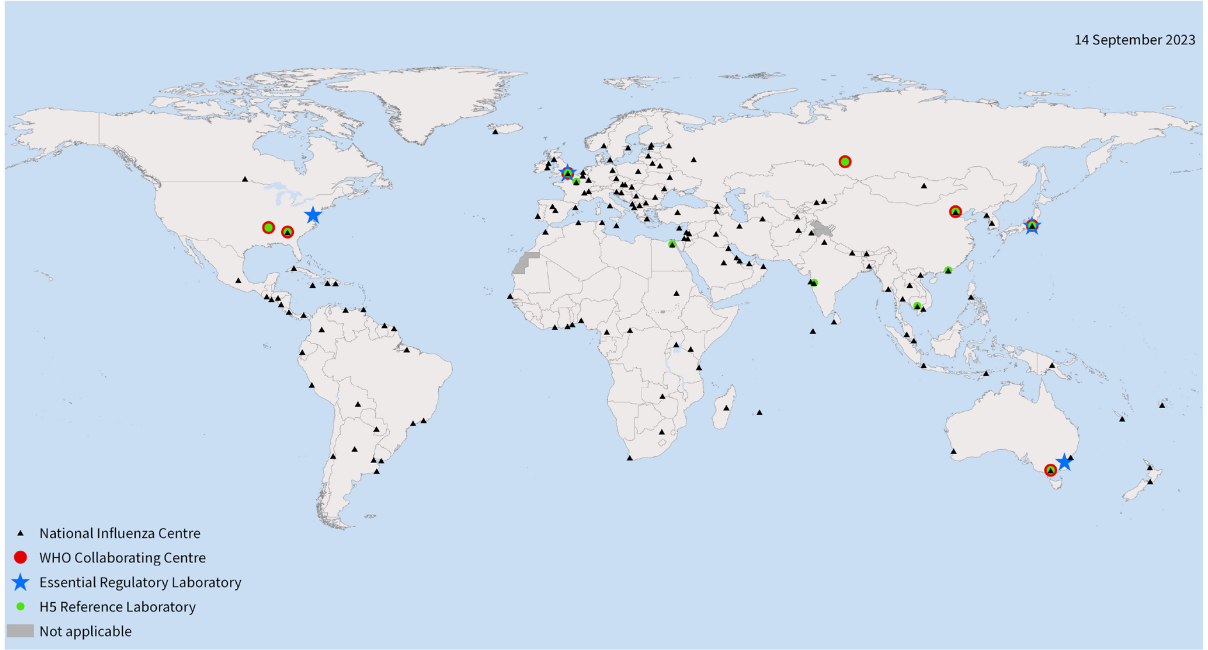


* RESPIRATORY SYMPTOMS
* FEVER
* EPIDEMICS or PANDEMICS

Predicting Seasonal Influenza

- 144 Influenza Centers in 114 countries conduct ongoing surveillance for circulating flu viruses
- Epidemiological, Genetic, Antigenic data, Evolutionary Analysis, and Vaccine Effectiveness studies are analyzed
- Twice-yearly meetings from WHO to determine the composition of flu vaccines
- Production of vaccines take 6 months

WHO Global Influenza Surveillance and Response System (GISRS)



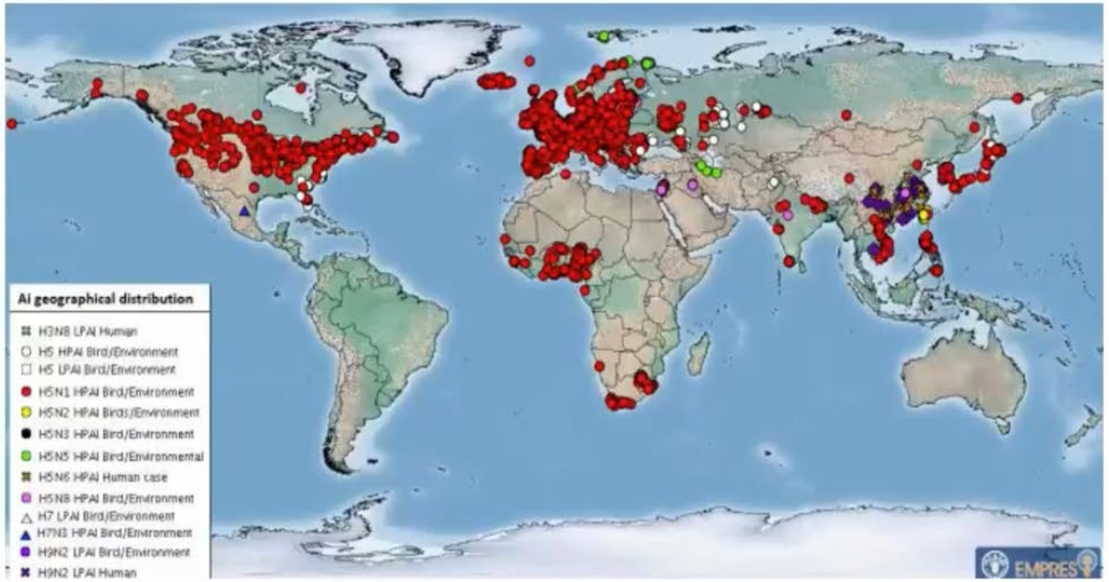
The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of WHO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

Data source: WHO Global Influenza Programme
Map creation date: 21 September 2023
Map production: WHO Global Influenza Programme

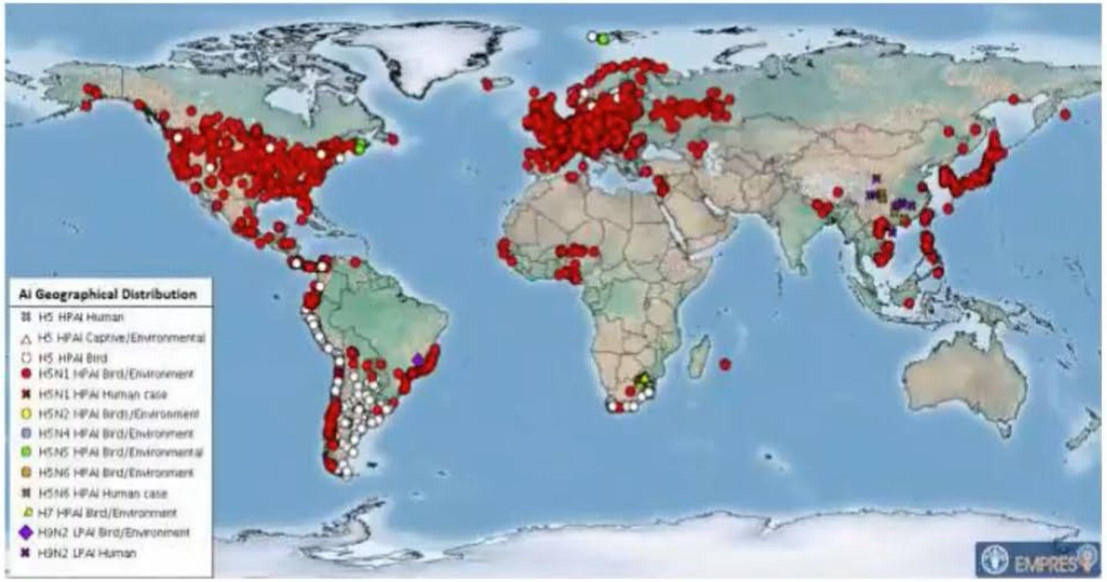
World Health Organization

Global Avian Influenza with Zoonotic Potential H5N1

October 2021 - October 2022



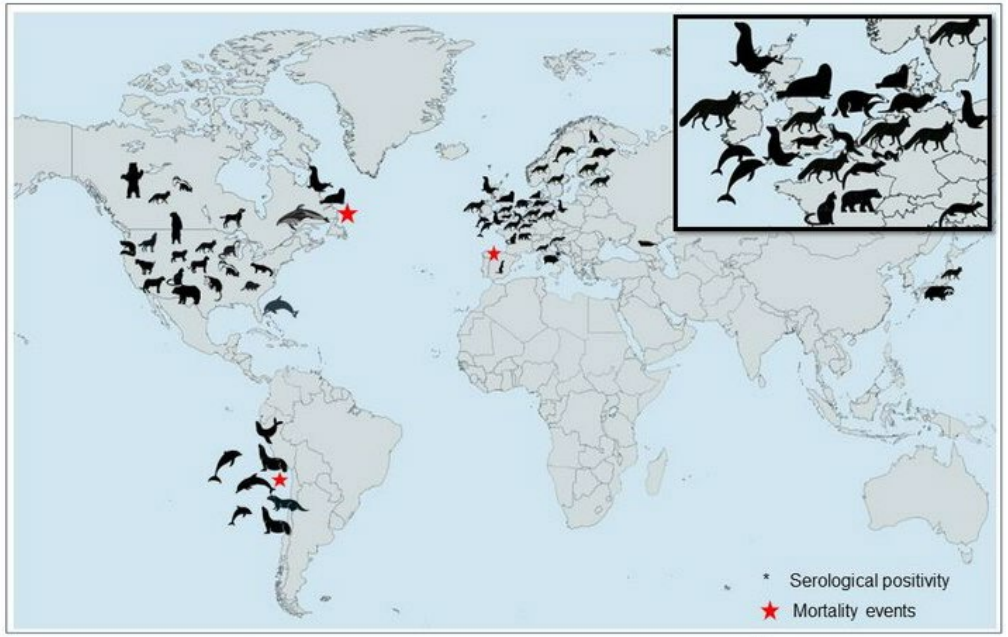
October 2022 - October 2023



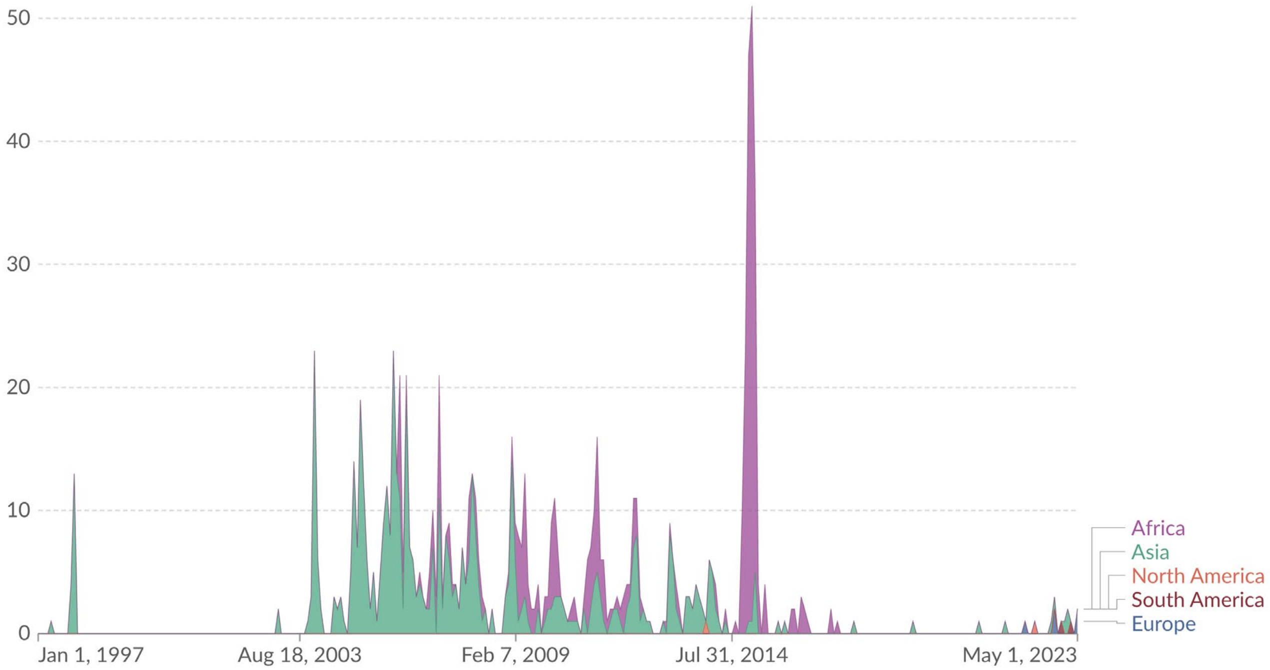
H5N1 in Mammals vs Humans

- Since 2020, H5 has spread predominantly via migratory birds
- Increased detections in non-avian species likely through contact with live or dead birds
- Outbreaks in farmed mink (Spain), seals (USA), sea lions (Peru and Chile), foxes and mink (Finland)
- Detected in domesticated animals such as cats in Poland and South Korea
- Limited number of human infections despite poultry outbreaks, detection in mammals

Geographic distribution of A(H5) virus in non-human mammals since 2016



Monthly Incidence of Influenza A (H5N1) in humans



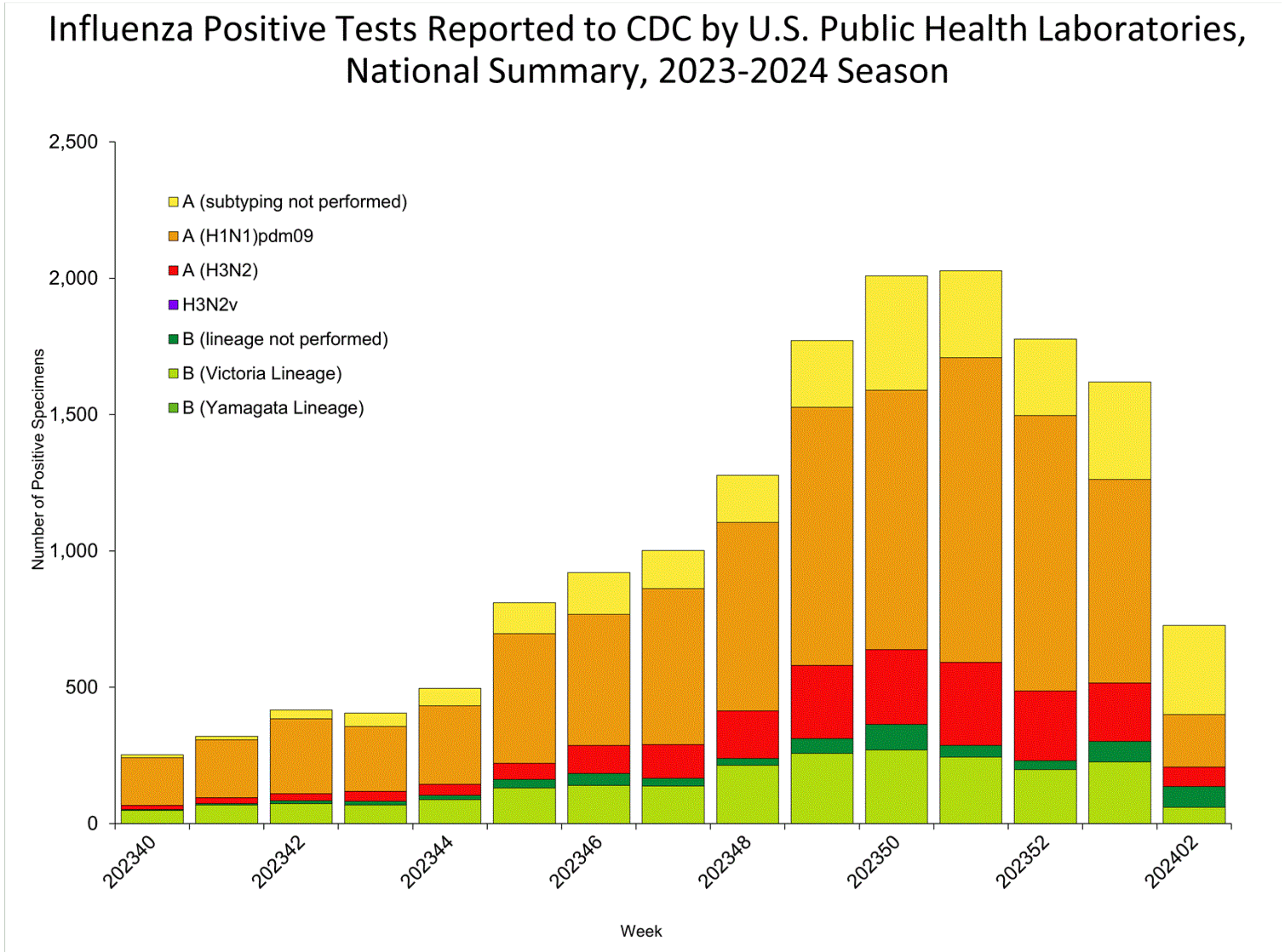
Data source: WHO, Global Influenza Programme (2023)

1. **Highly-pathogenic avian influenza (HPAI)**: Highly-pathogenic avian influenza (HPAI) is a severe form of bird flu that can quickly spread and cause deadly disease in poultry. Some cases have also been recorded in humans, particularly from H5N1 and H7N9 flu strains, and have had a high case fatality rate.

Avian Influenza: Continued Challenges

- Diversity of viruses and continued evolution
- Introduction in new geographic areas
- Little to no population immunity
- May cause severe disease in humans
- Affects food security
- Politically sensitive
- Pandemic fatigue

Current Influenza Subtypes in the US



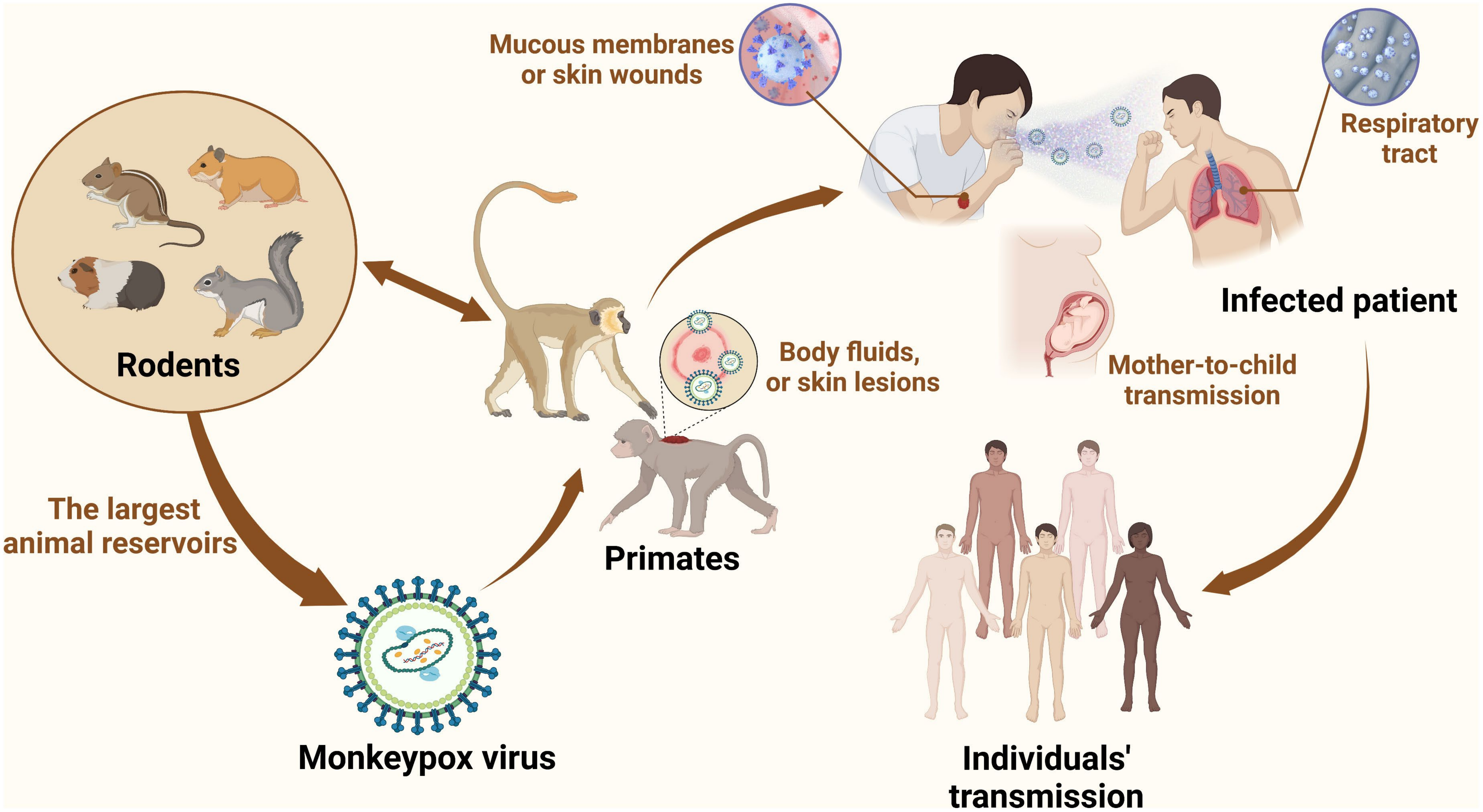
PSA: Flu Vaccine

- Efficacy
  - Vaccination decreased likelihood of hospitalization in those age 18-64 by 23%, and ≥65 by 41%
  - Decreased ED/UC Visits in those age 18-64 by 45%, and ≥65 by 41%
- Vaccine Uptake
  - Continued overall decline since 2020
  - Age 18-29 at 32% vs Age ≥75 at 80%
  - All adults 47% (vs 50% in 2020-2021)

CDC: Flu-NET

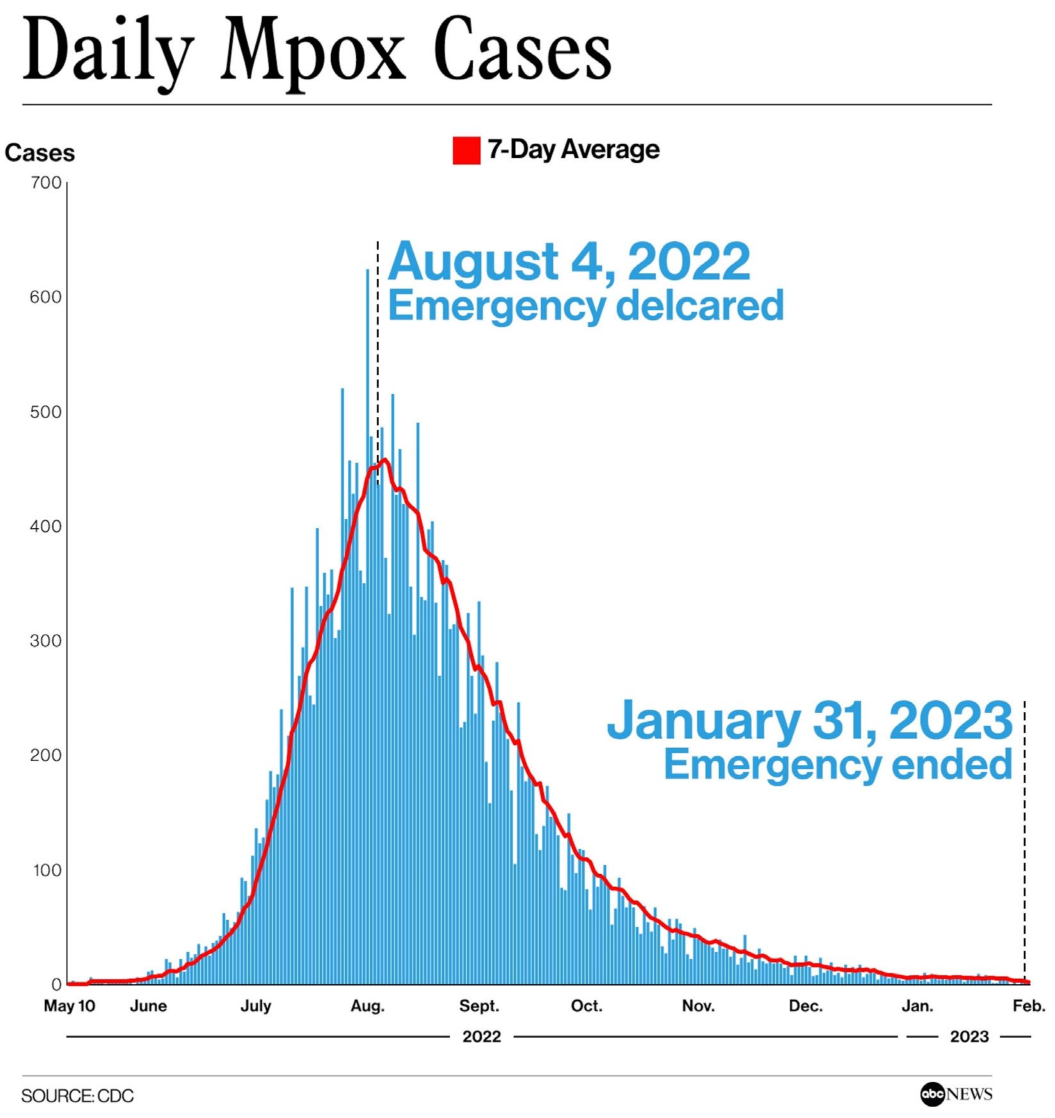
mpox

Isn’t gone

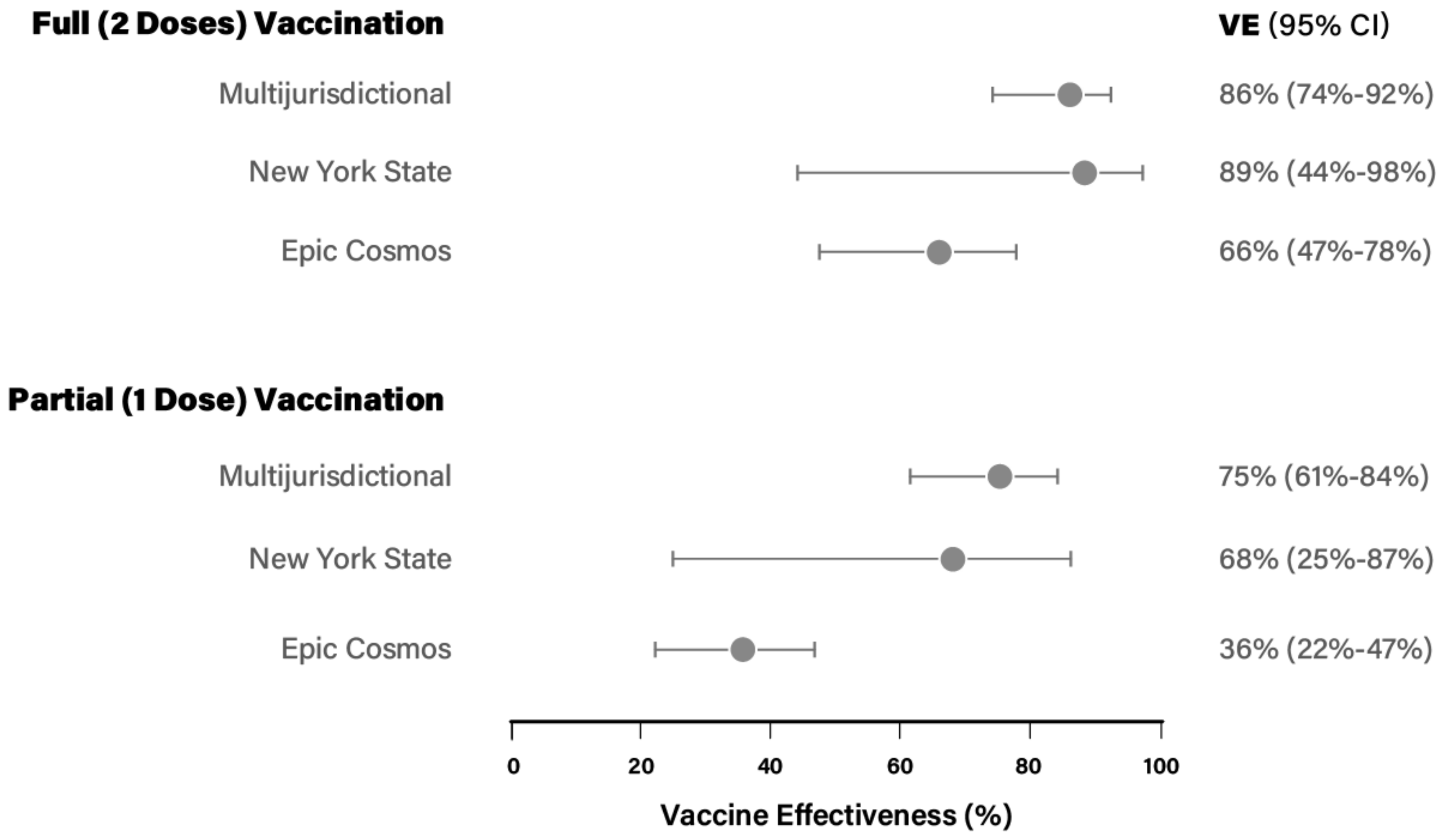

Mucous membranes
or skin wounds
Respiratory
tract
Rodents
Infected patient
Body fluids,
or skin lesions
Mother-to-child
transmission
Primates
The largest
animal reservoirs
Monkeypox virus
Individuals'
transmission

Rapid mpox control in the US (2023)

- Aggressive, highly coordinated public health response
- Strong, unified response from leaders in the LGBTQ community
- Evidence-based public outreach and education
- Rapid deployment of existing vaccines and treatments that had been stockpiled for smallpox



Adjusted vaccine effectiveness (VE) of JYNNEOS vaccine against mpox by study and number of doses



https://www.cdc.gov/poxvirus/mpox/cases-data/JYNNEOS-vaccine-effectiveness.html

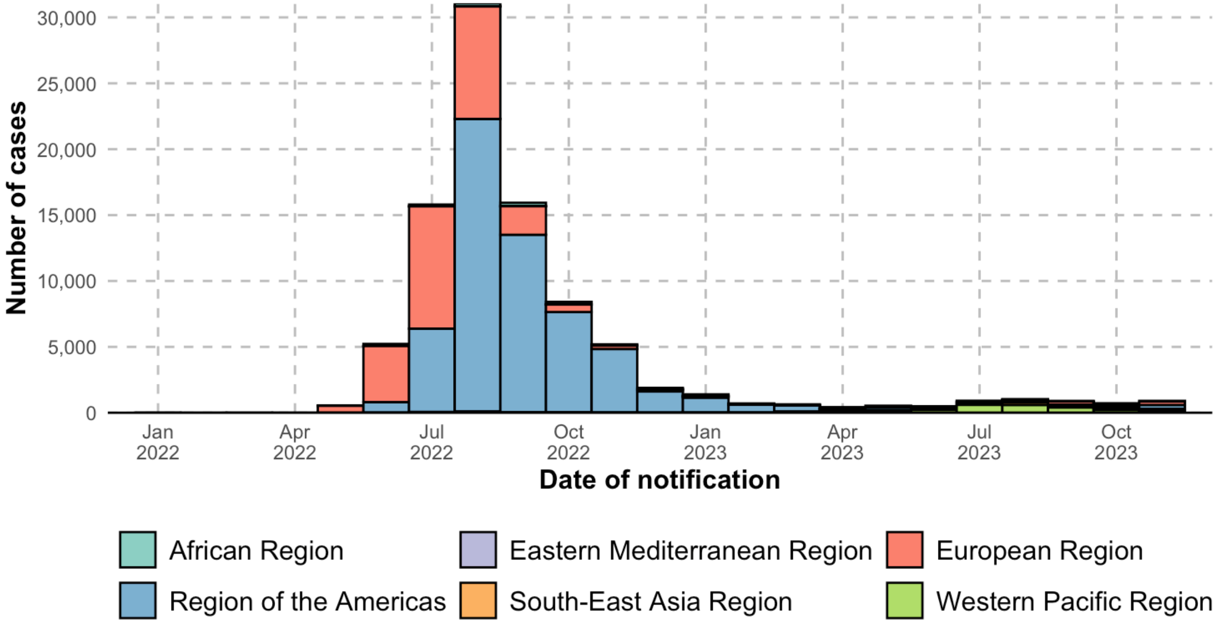
Global Mpox Cases (through November 2023)

November 2023

906	4	26
Confirmed cases	Deaths	Countries reporting cases

Overall

92 783	171	116
Confirmed cases	Deaths	Countries reporting cases



Source: WHO

Pre-2022 Outbreaks

Post-2022 Outbreaks

Mpox kills 600 in largest ever DRC outbreak

Experts warn the strain of the disease behind the new outbreak has the potential to spread worldwide

Maeve Cullinan, GLOBAL HEALTH REPORTER
24 November 2023 • 3:13pm

Experts warn the outbreak is being driven by a strain of the virus that previously spread exclusively th
spreading between humans. | CREDIT: HOGP/National Institute of Allergy and Infectious Diseases/AP

Morbidity and Mortality Weekly Report (*MMWR*)

Mpox Outbreak — Los Angeles County, California, May 4–August 17, 2023

Weekly / January 18, 2024 / 73(2);44–48

Print

Colleen M. Leonard, MPH[1]; Kathleen Poortinga, MPH[1]; Erin Nguyen, MPH[1]; Abraar Karan, MD[2]; Sonali Kulkarni, MD[1]; Rebecca Cohen, MD[1]; Jacob M. Garrigues, PhD[1]; Amy N. Marutani, MPH[1]; Nicole M. Green, PhD[1]; Andrea A. Kim, PhD[1]; Kwa Sey, PhD[1]; Mario J. Pérez, MPH[1] (VIEW AUTHOR AFFILIATIONS)

View suggested citation

China | Viral slurs

Many of the world's new mpox cases are in China

Conservatism and nationalism are blocking efforts to curb the disease's spread

IMAGE: CHLOE CUSHMAN

Oct 5th 2023 | BEIJING

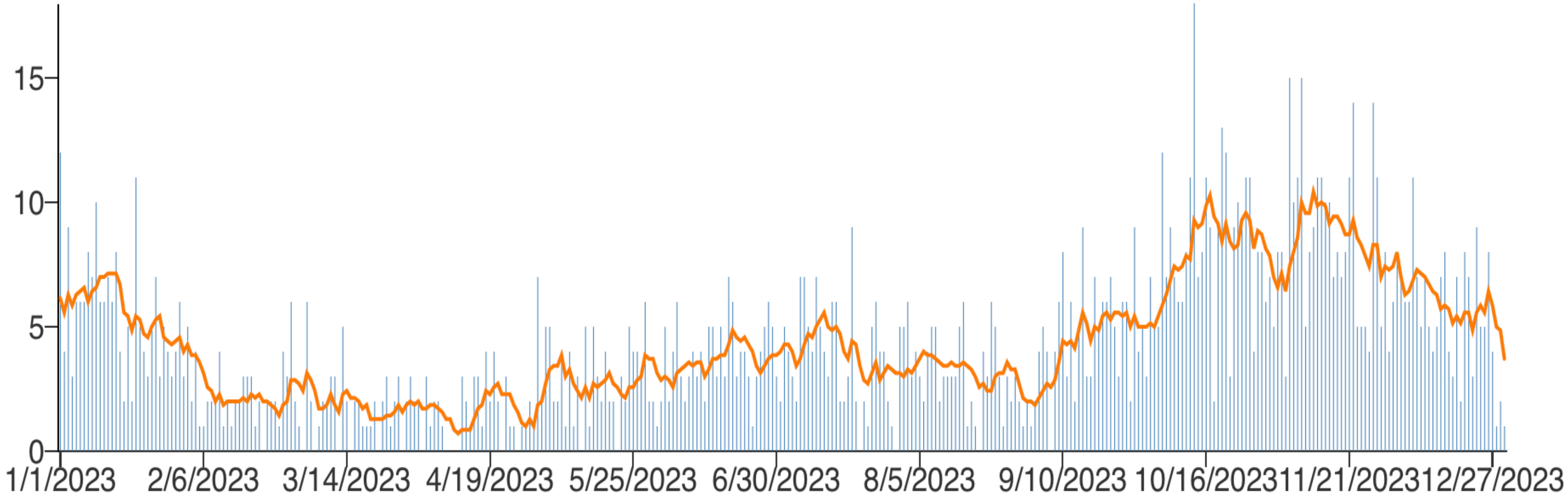
Share

US Cases: After ending the Public Health Emergency (1/2023 – 12/2023)

2023

Apply Filters

Reset All

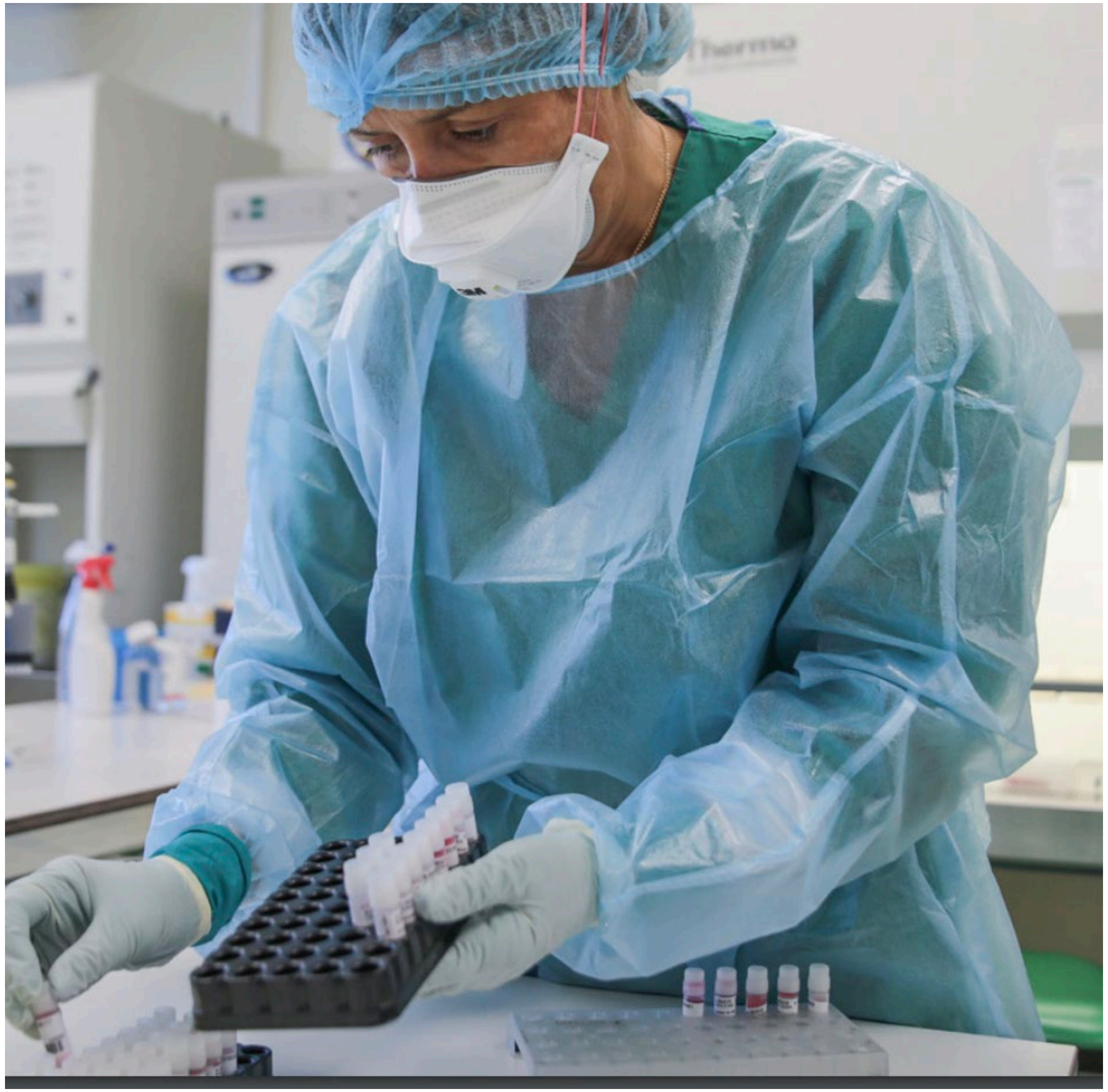


Global situation: mpox

- Outside of Africa: mostly gay, bisexual, and other men who have sex with men
- In Africa: men, women and children
- 30~50% of persons living with HIV
- Immunosuppressed at a greater risk of severe disease
- Clade I and II sexually transmissable

WHO Strategic Framework for mpox (2023 – 2027)

- Maintain global surveillance, make mpox nationally notifiable to share information with WHO
- Integrate mpox surveillance, detection, prevention, care, and research with HIV and STI programs
- Strengthen capacity in resource-limited settings including Risk Communication and Community Engagement (RCCE) and One Health/Animal Health
- Implement a strategic research agenda for evidence generation
- Enhance access to diagnostics, vaccines, and therapeutics to enhance global health equity
- Each country to develop elimination or control plans according to the context



Mpox: Challenges

- Fear and stigma
- Decreased surveillance and reporting
- Gaps in testing capacity and genomic surveillance
- Equity to countermeasures
- Understanding mpox virus ecology and dynamics of spillover events
- Elimination of human-to-human transmission depends on local action

Candida auris

A Global Threat

Candida auris

- *Candida* species resistant to multiple classes of antifungals
  - Invasive infections associated with 30-72% mortality
  - Can lead to clusters of infections with pan-resistance
- Very difficult to limit spread and eliminate from the patient environment
  - Bed and handrails can remain contaminated for weeks if not cleaned properly
- Isolation is "lifelong," as patients can remain colonized for many months

C. auris Background

- First discovered 2009 in Japan
- However genomic data reveals emergence from all around the globe (Asia, Americas, Africa, etc)

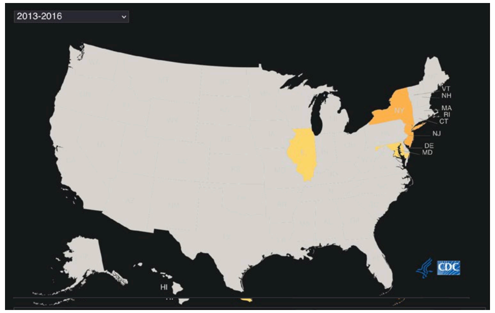
ORIGINAL ARTICLE

Candida auris sp. nov., a novel ascomycetous yeast isolated from the external ear canal of an inpatient in a Japanese hospital

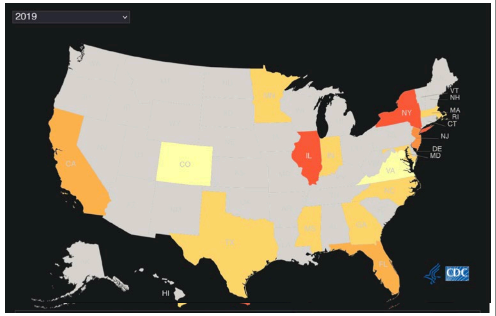
Kazuo Satoh[1,2], Koichi Makimura[1,3], Yayoi Hasumi[1], Yayoi Nishiyama[1], Katsuhisa Uchida[1] and Hideyo Yamaguchi[1]

[1]Teikyo University Institute of Medical Mycology, 359 Otsuka, Hachioji, Tokyo 192-0395, [2]Japan Health Sciences Foundation, 13-4 Nihonbashi-Kodenmacho, Chuo-ku, Tokyo 103-0001 and [3]Genome Research Center, Graduate School of Medicine and Faculty of Medicine, Teikyo University, Otsuka 359, Hachioji, Tokyo 192-0395, Japan

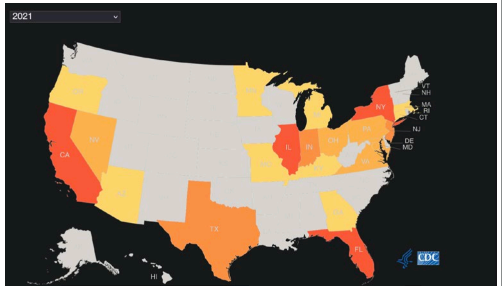
The spread of *Candida auris* (US)



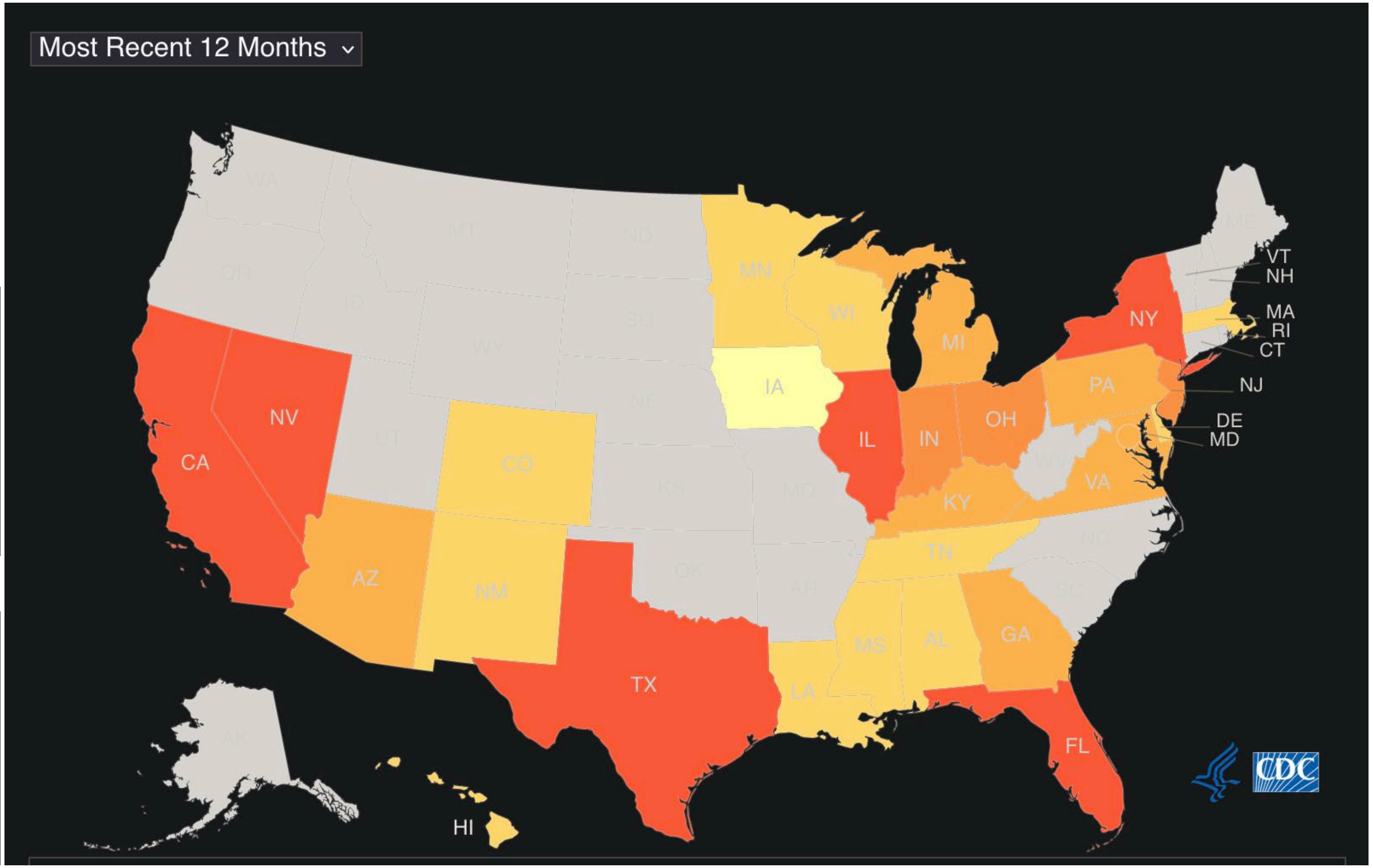
2013-2016



2019



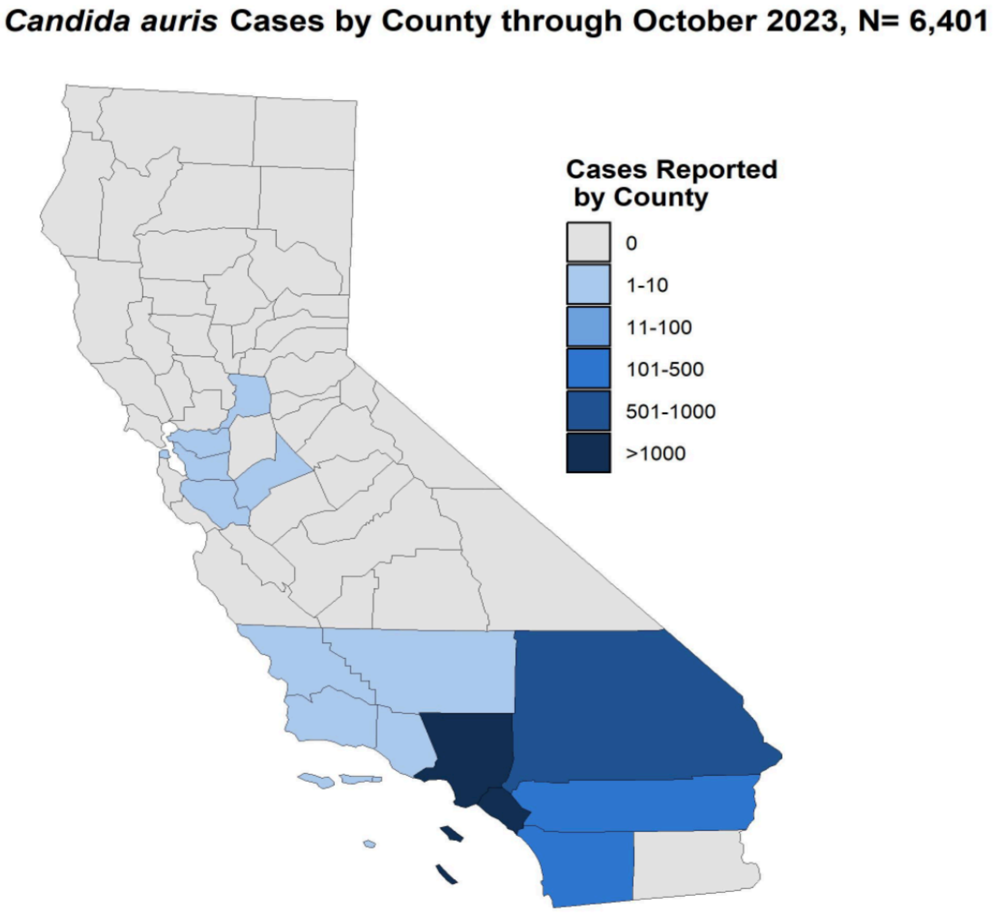
2021



2023

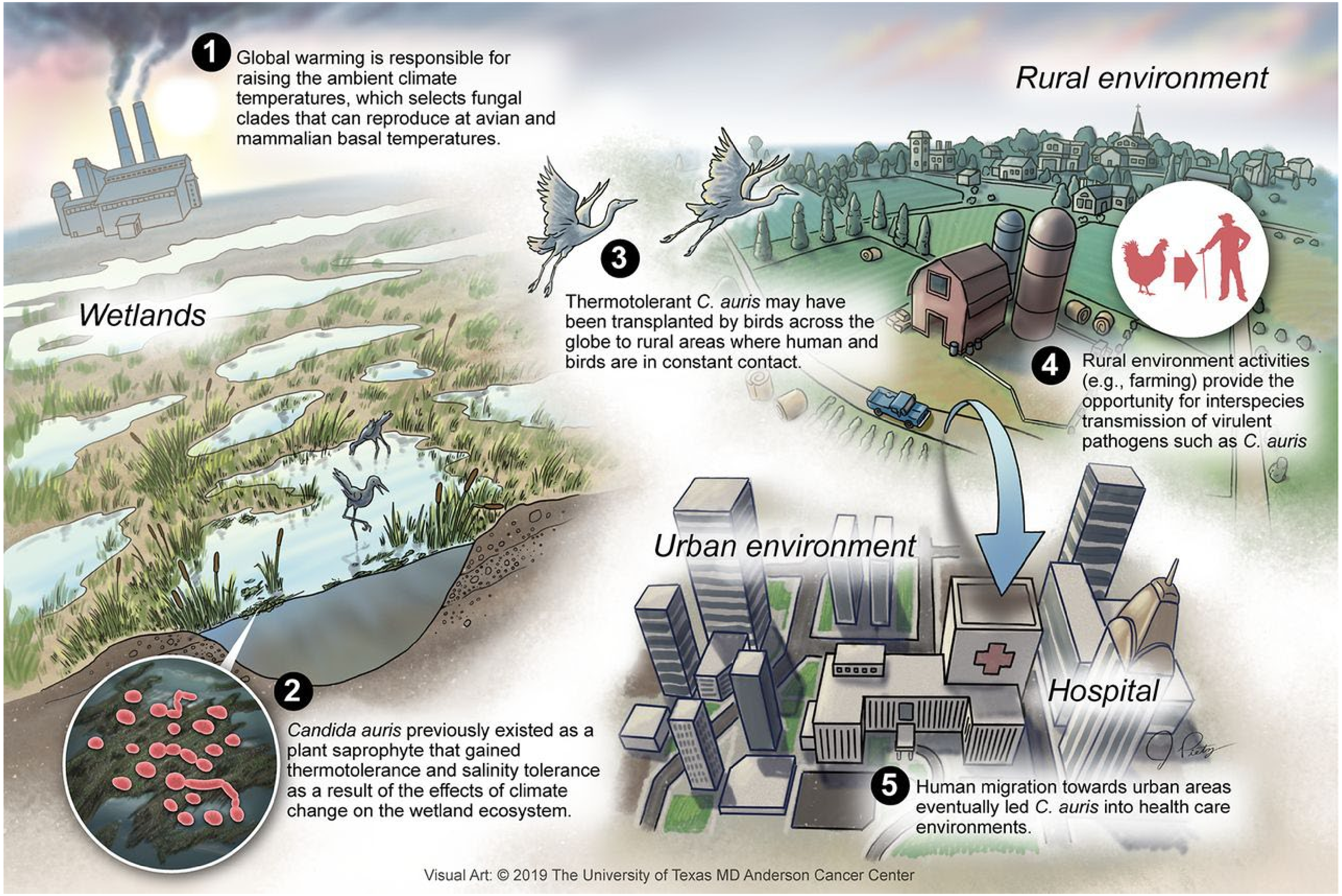
Data Source: CDC https://www.cdc.gov/fungal/candida-auris/tracking-c-auris.html

C. auris in California (2023)



Counties with ≥1 Reported Case	Cases through October 2023
Alameda	<11
Contra Costa	<11
Kern	<11
Los Angeles	3,173
Orange	2,116
Riverside	345
Sacramento	<11
San Bernardino	619
San Diego	124
San Francisco	<11
San Luis Obispo	<11
Santa Barbara	<11
Santa Clara	<11
Stanislaus	<11
Ventura	<11
Total	**6,401**

California Department of Public Health

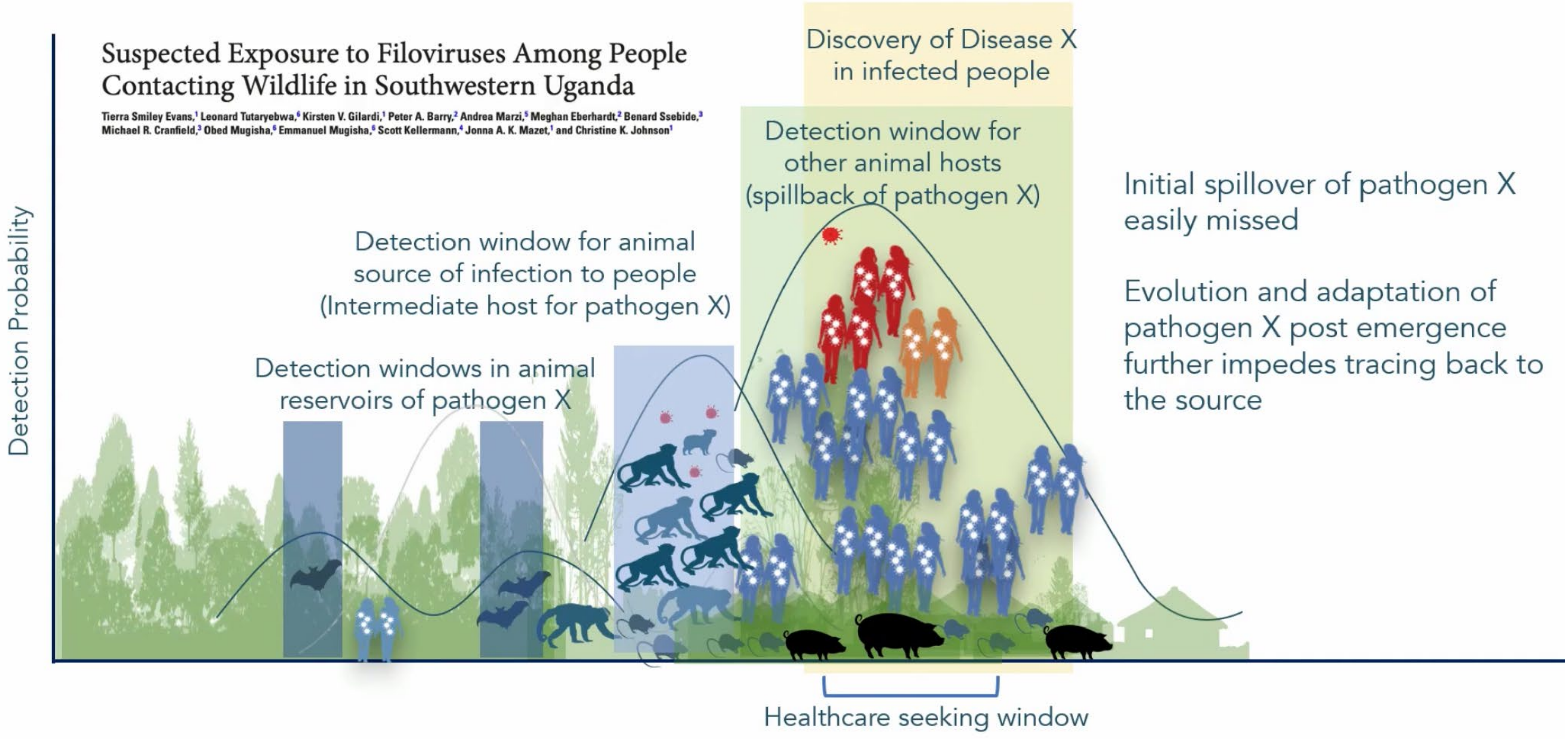


Casadevall et al (2019). ASM Journals 10 (4)

Summary

- Emerging infections will continue to increase, likely due to multiple factors:
  - **Urbanization** and the expanding animal-human interface
  - Climate change
  - **Increasing international travel and global trade**
- Up to 75% of emerging infectious agents are zoonotic in origin
  - Coronavirus
  - Zoonotic influenza
  - Mpox
- Climate change can potentially lead to multidrug pathogens such as *Candida auris*

Challenges to Tracing Emerging Infectious Disease Events to their Source



POLICY FORUM

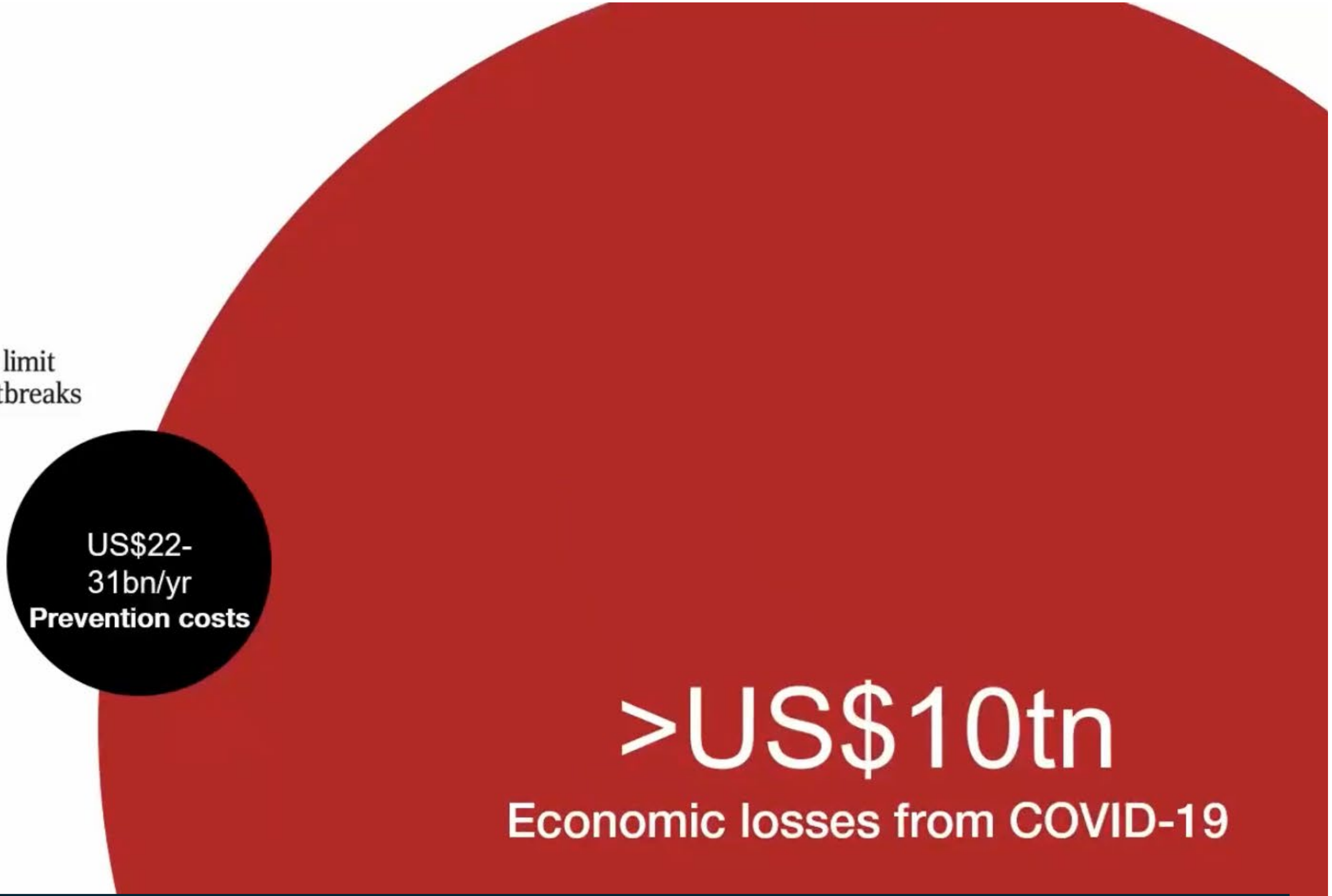
ECOLOGY AND ECONOMICS: COVID-19

Ecology and economics for pandemic prevention

Investments to prevent tropical deforestation and to limit wildlife trade will protect against future zoonosis outbreaks

Science 24 Jul 2020

DOI: 10.1126/science.abc3189



The economic cost of COVID-19 was over 10 trillion dollars,
while less than 31 billion per year are spent on prevention of future zoonosis outbreaks

Where do we go from here?

Emerging Infectious Disease Preparedness

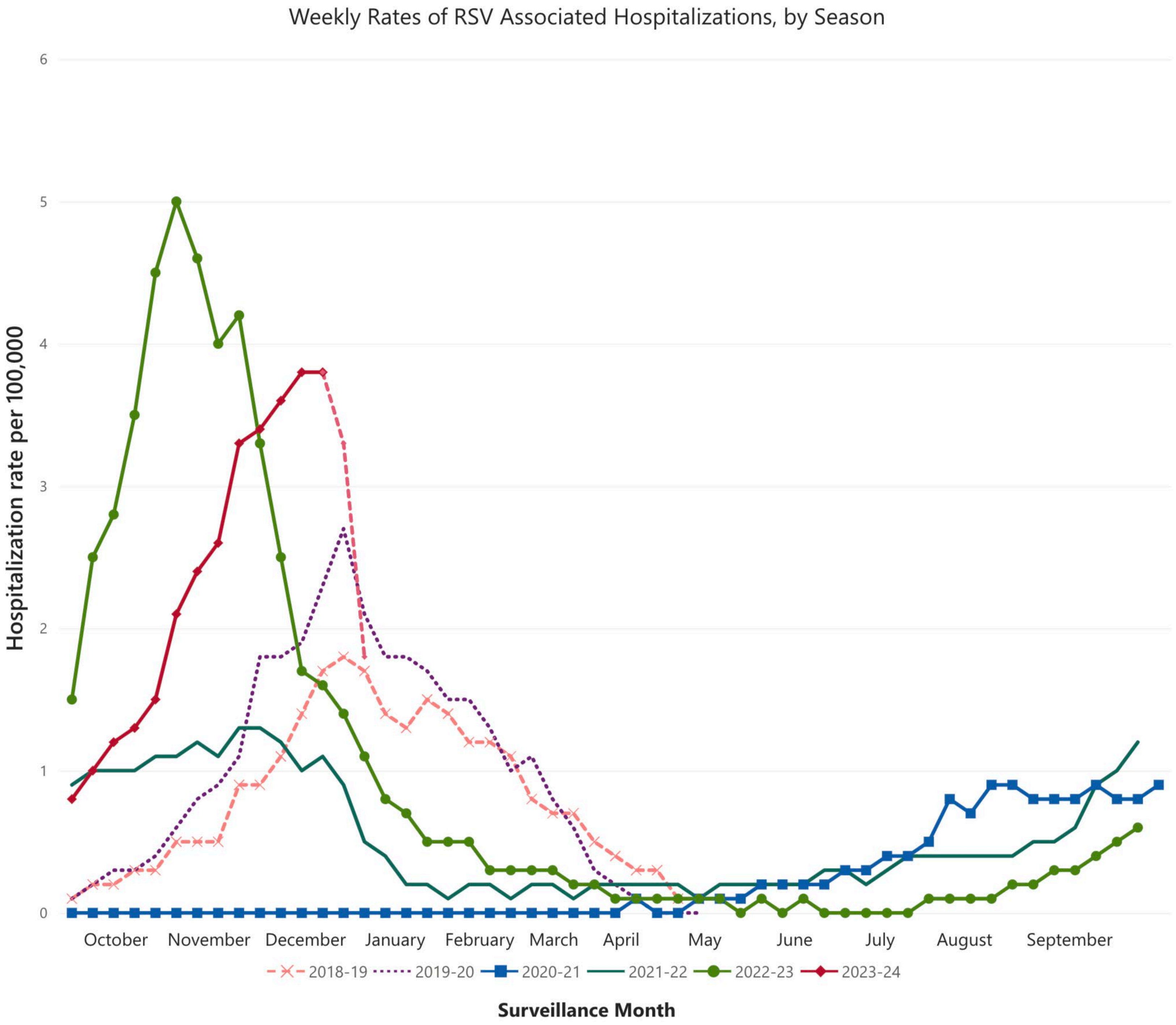
- Transdisciplinary collaboration between animal, human, and environmental health professionals strengthened by routine data and information sharing
- Internationally collaborative research in between outbreaks
- Community engagement in all stages of research and outbreak control
- Next generation tools and techniques should be developed for pathogen X surveillance


I'm an
#OrganDonor,
are you?
1 organ donor can save up to 8 lives. Register today.


organ
donor

Thank you!


RSV
Just FYI



Weekly Rates of RSV Associated Hospitalizations, by Season
Hospitalization rate per 100,000
0
1
2
3
4
5
6
October
November
December
January
February
March
April
May
June
July
August
September
2018-19
2019-20
2020-21
2021-22
2022-23
2023-24
Surveillance Month

TABLE 2. In-hospital outcomes among adults aged ≥60 years hospitalized with respiratory syncytial virus, COVID-19, or influenza — Investigating Respiratory Viruses in the Acutely Ill Network, 25 hospitals,* 20 U.S. states, February 1, 2022–May 31, 2023

	No./Total no. (%)						
In-hospital outcomes	**RSV patients n = 304**	**COVID-19 patients n = 4734**	**Influenza patients n = 746**	**RSV vs. COVID-19 aOR† (95% CI)**	**p-value**	**RSV vs. influenza aOR† (95% CI)**	**p-value**
Standard flow oxygen therapy§	157/197 (79.7)	2,169/3,726 (58.2)	390/593 (65.8)	2.97 (2.07–4.27)	<0.001	2.07 (1.37–3.11)	<0.001
HFNC or NIV¶	59/256 (23.0)	495/4,223 (11.7)	94/687 (13.7)	2.25 (1.65–3.07)	<0.001	1.99 (1.36–2.90)	<0.001
ICU admission	74/304 (24.3)	819/4,734 (17.3)	125/746 (16.8)	1.49 (1.13–1.97)	0.005	1.55 (1.11–2.19)	0.01
IMV or death	41/304 (13.5)	481/4,734 (10.2)	52/746 (7.0)	1.39 (0.98–1.96)	0.07	2.08 (1.33–3.26)	0.001

Abbreviations: aOR = adjusted odds ratio; HFNC = high-flow nasal cannula; ICU = intensive care unit; IMV = invasive mechanical ventilation; NIV = noninvasive ventilation; RSV = respiratory syncytial virus.

* https://www.cdc.gov/flu/vaccines-work/ivy.htm

† Multivariable logistic regression models were adjusted for age, sex, race and ethnicity, number of organ systems with chronic medical conditions, and U.S. Department of Health and Human Services region.

§ Standard flow oxygen therapy was defined as receipt of supplemental oxygen therapy at a flow rate <30 L/minute as the highest level of oxygen support received during hospitalization.

¶ HFNC or NIV was defined as patients who received either HFNC (oxygen therapy at a flow rate ≥30 L/minute) or NIV as the highest level of oxygen support received during hospitalization.

- RSV outstripped both COVID-19 vs influenza in terms of in-hospital mortality and morbidity with higher need for O2 (OR 2.97 vs 2.07), HFNC (OR 2.25 vs 1.99), ICU admission (OR 1.49 vs 1.55), IMV, or death (OR 1.39 vs 2.08)
- IMV or death: RSV 13.5% ≥ COVID-19 10.2% ≥ influenza 7.0%

Surie et al (2023). MMWR 72(40);1083–1088