

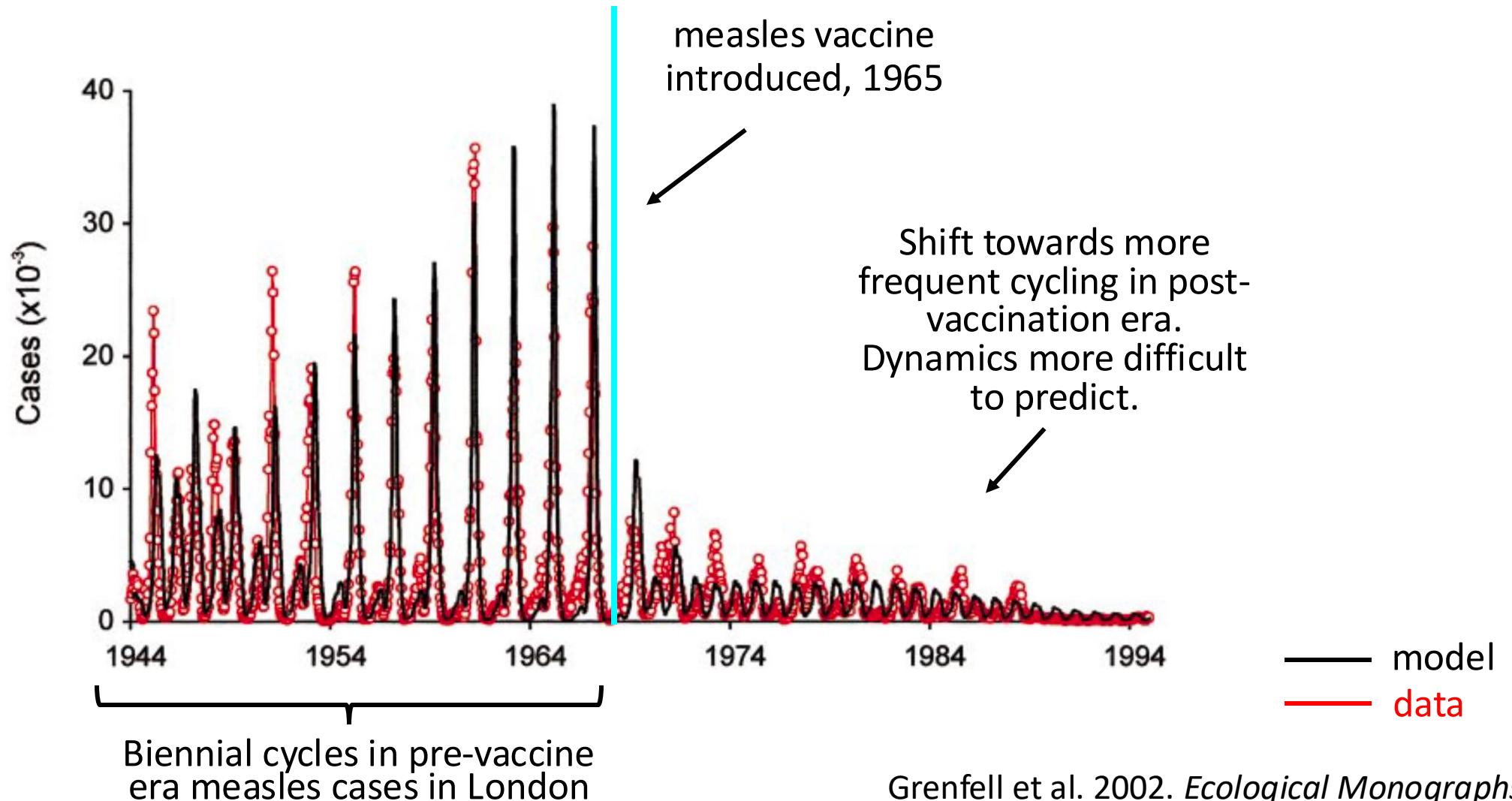
Introduction to SARS-CoV-2 in Global Health

UChicago Center in Paris

Paris, France

January 2025

But first! ...Biennial measles cycles from build-up of susceptible kids through births



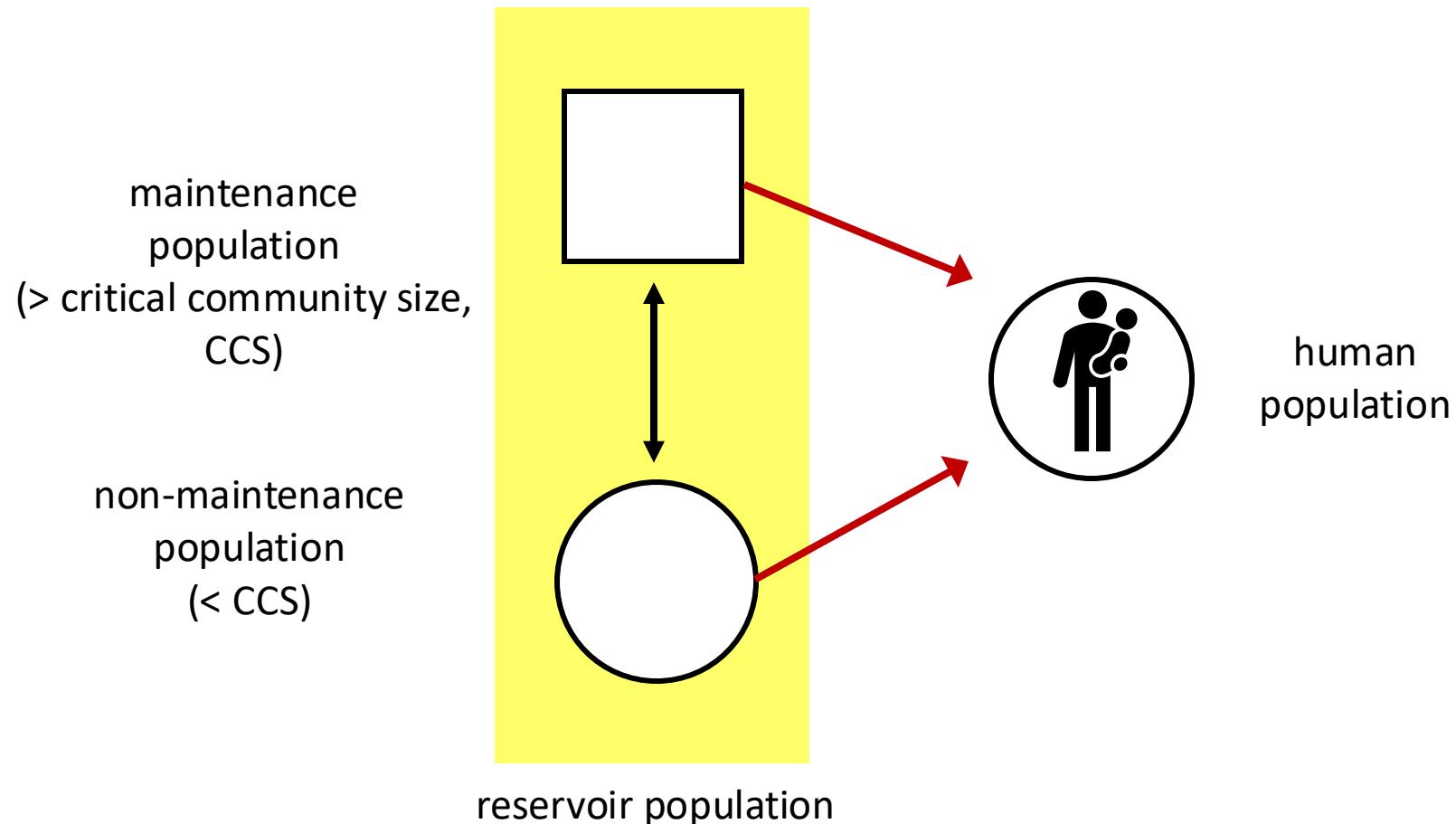
Goals for this lecture

- To refresh our understanding of zoonotic diseases
- To place SARS-CoV-2 in the broad context of coronaviruses in general
- To introduce the role of bats as zoonotic reservoirs
- To learn about the expansion of NGS capacity in LMICs after COVID-19
- To identify socio-economic disparities in intervention (e.g. vaccine) access highlighted by COVID-19

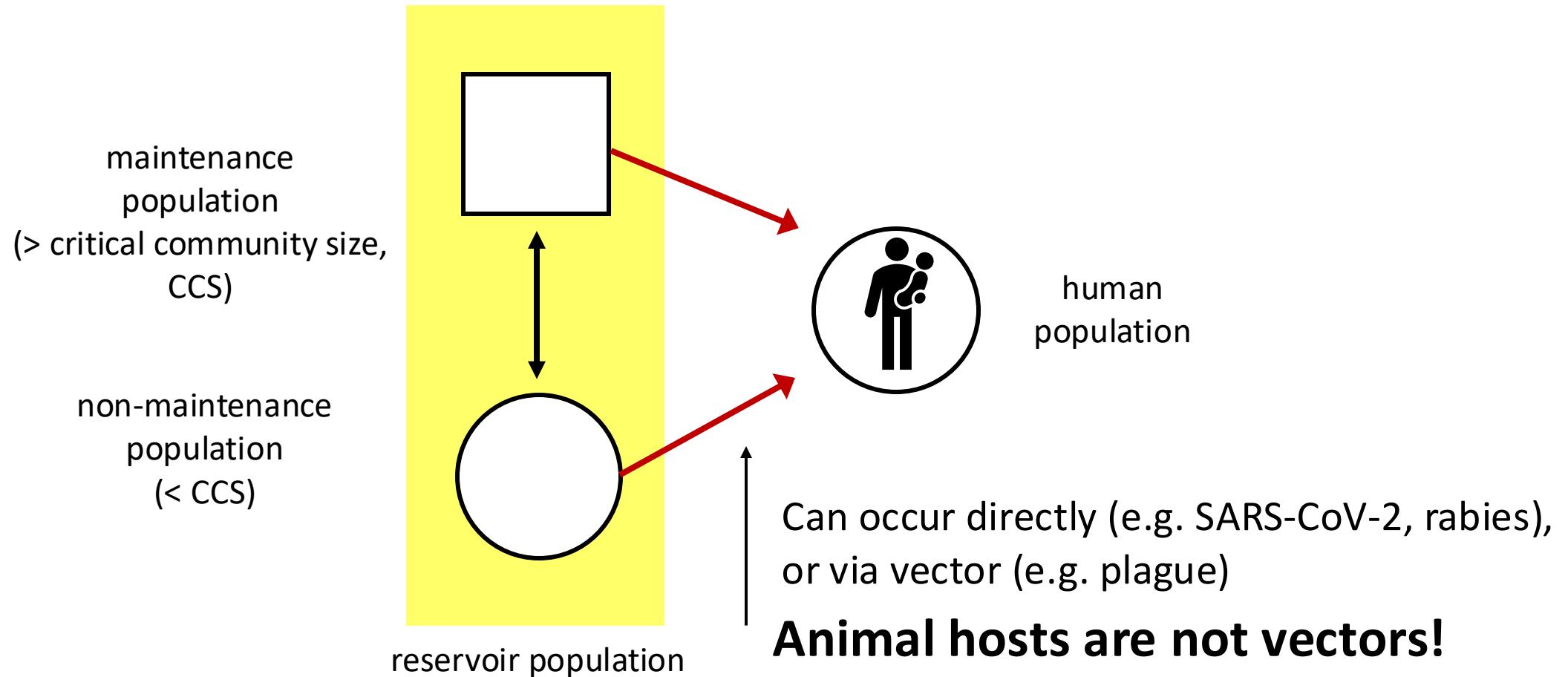
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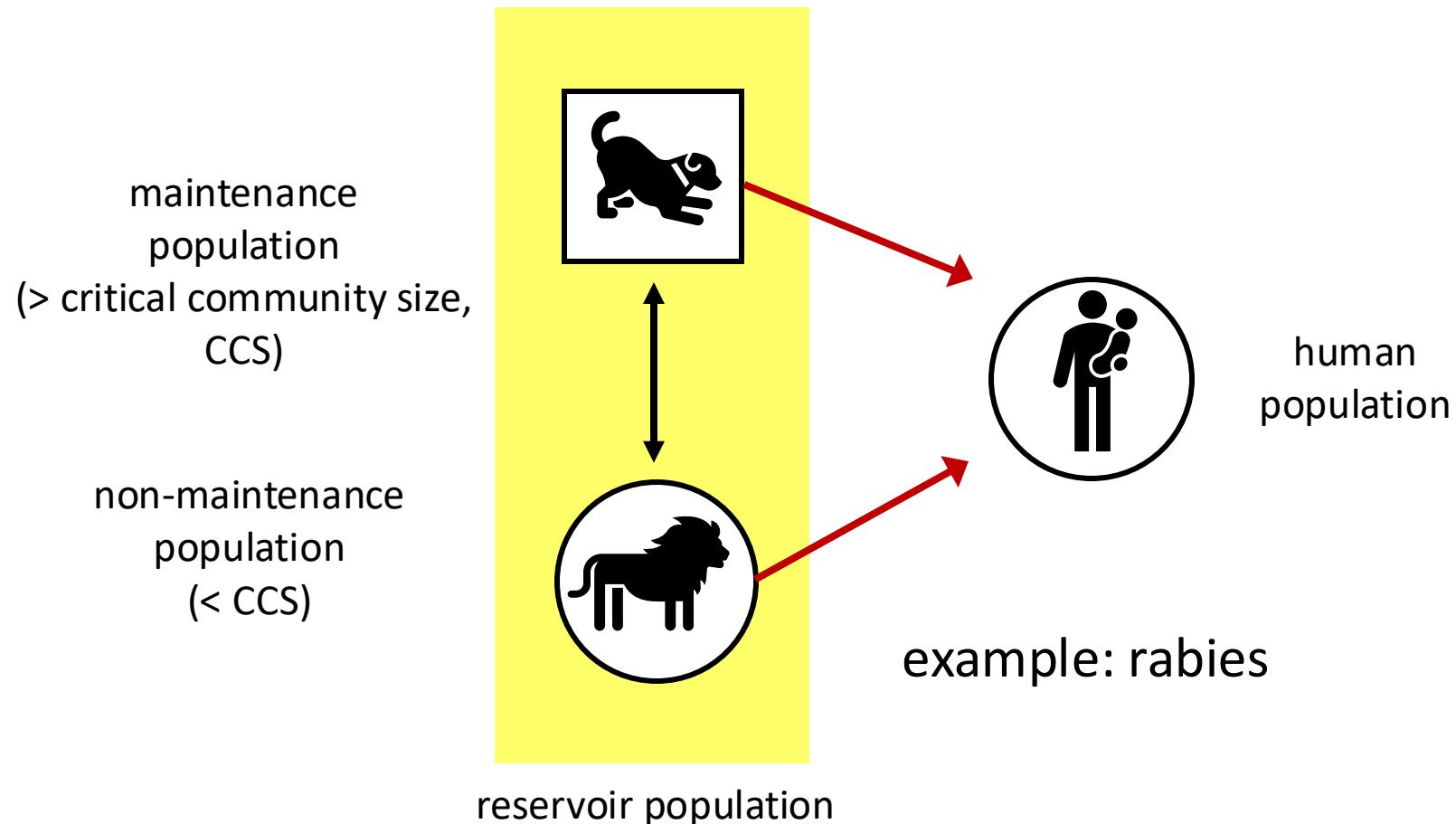
Zoonosis is the transmission of a pathogen from a **wildlife reservoir host** to a **human target host** population.



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Pathogens can be classed according to their host relationships.

Stage I

Transmits exclusively in animals



canine parvovirus

Stage II

Human cases from spillovers only



rabies virus

Stage III

Stuttering chains of transmission in humans



monkeypox (pre-2022)

Stage IV

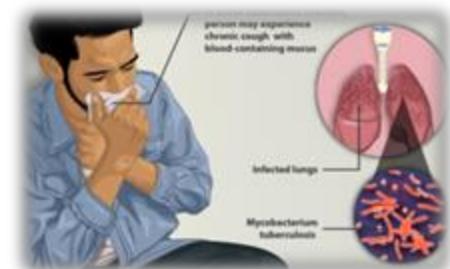
Sustained transmission and human outbreaks



Ebola virus (especially post-2014)

Stage V

Transmits exclusively in humans



Tuberculosis

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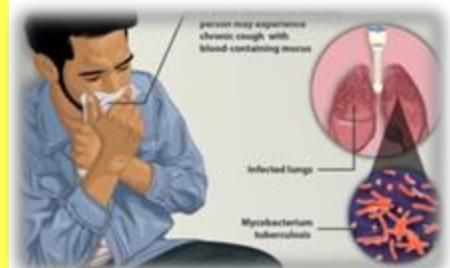
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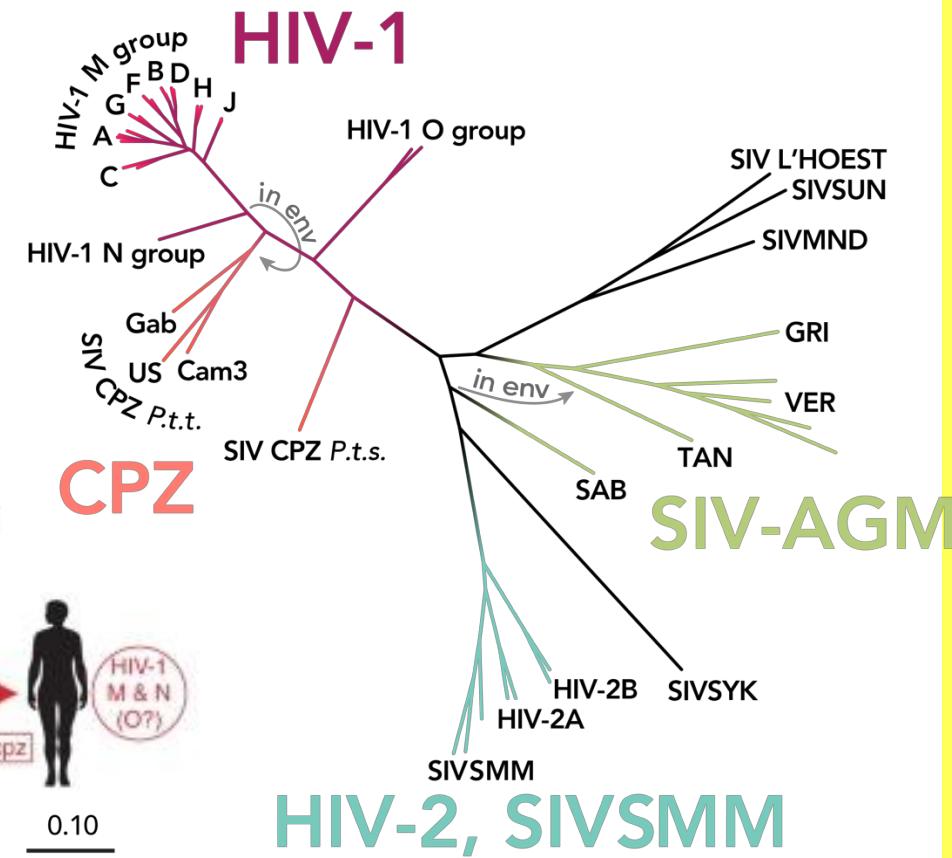
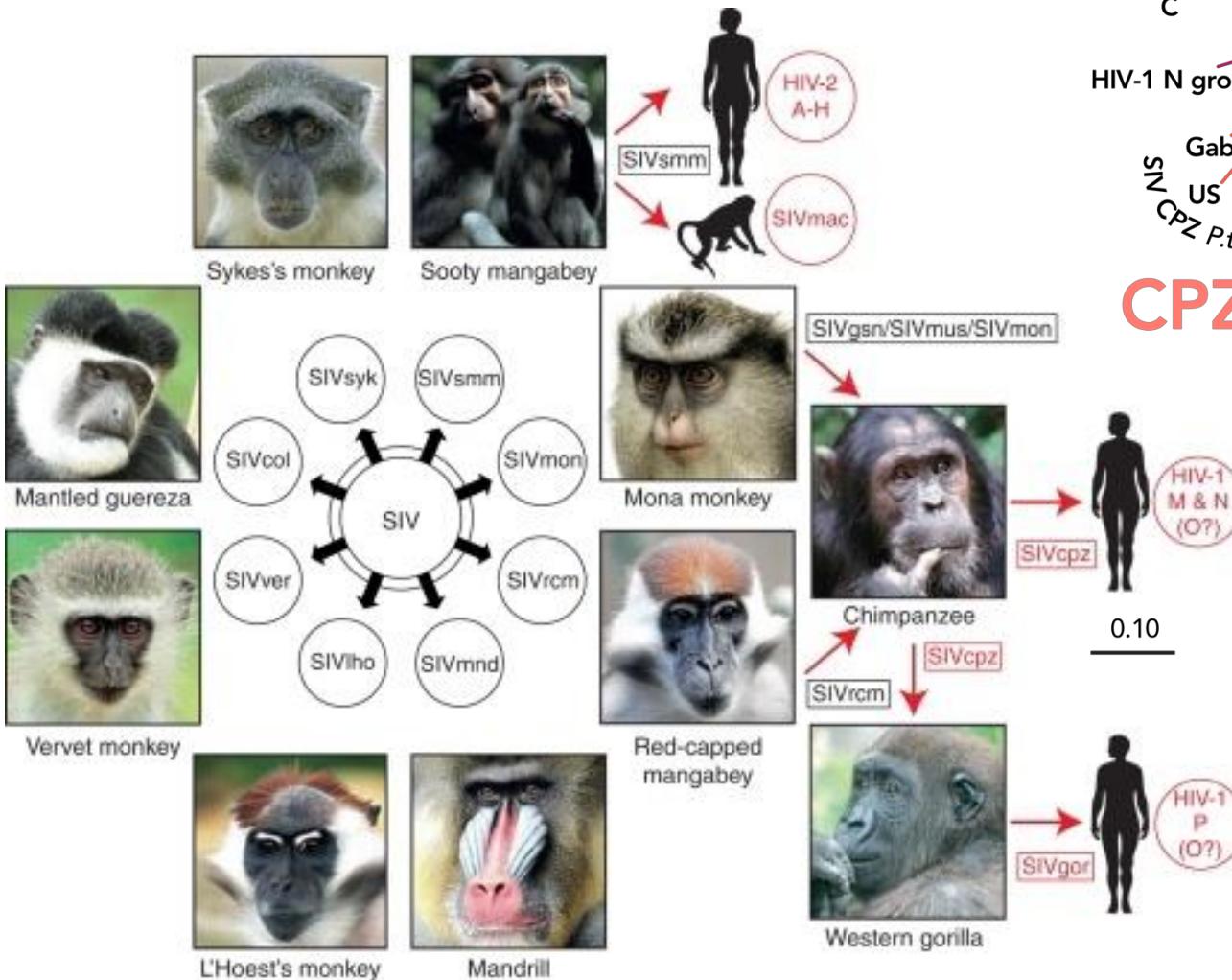
$$R_0 < 1$$

$$R_0 \approx 1$$

$$R_0 > 1$$

Zoonotic pathogens can be classed according to their R_0 in humans.

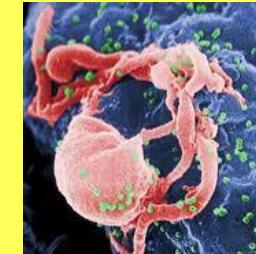
Most stage V pathogens once had an animal origin, as well!



Sharp & Hahn. 2011. *Cold Spring Harb Perspect Med.*

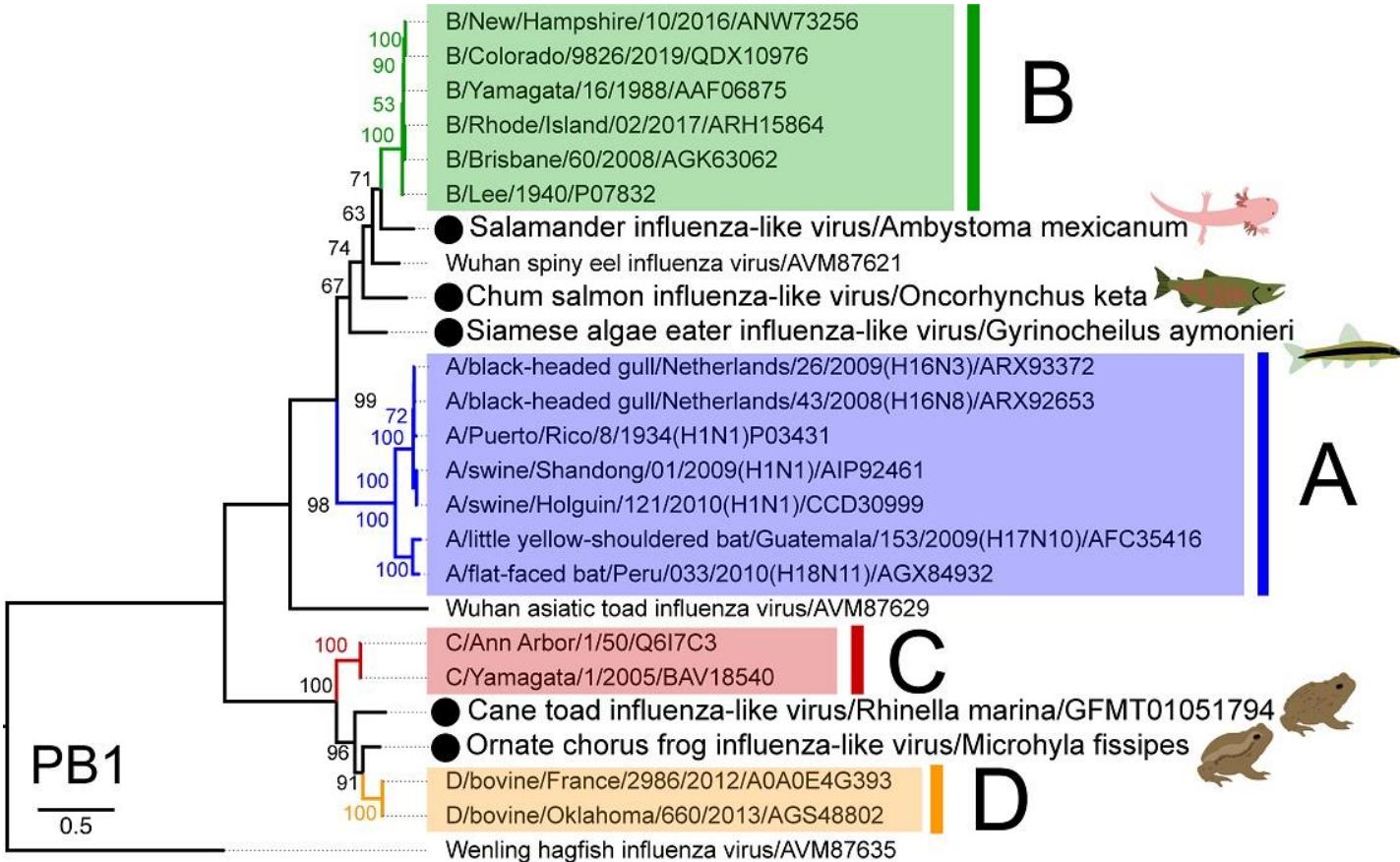
Stage V

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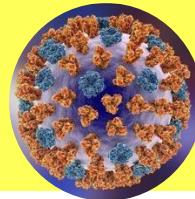
HIV

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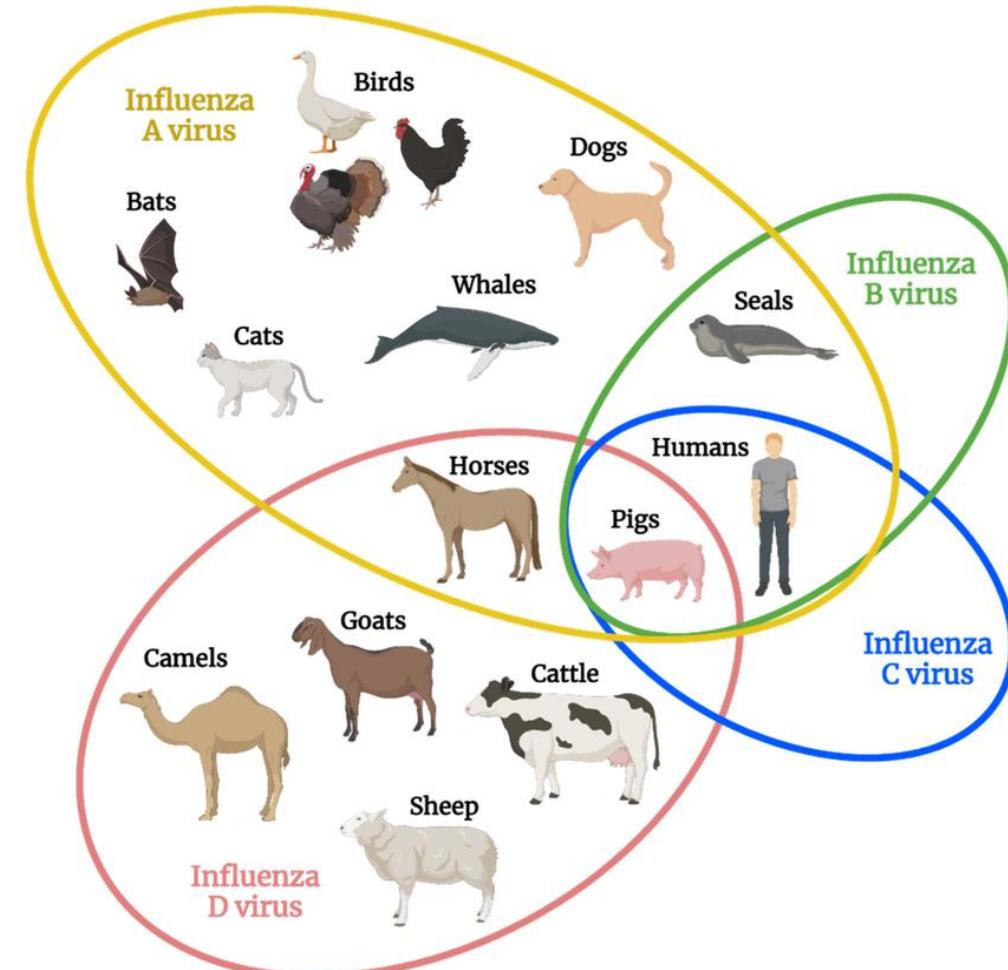


Parry et al. 2020. *Viruses*.

Stage V Transmits exclusively in humans



Influenza



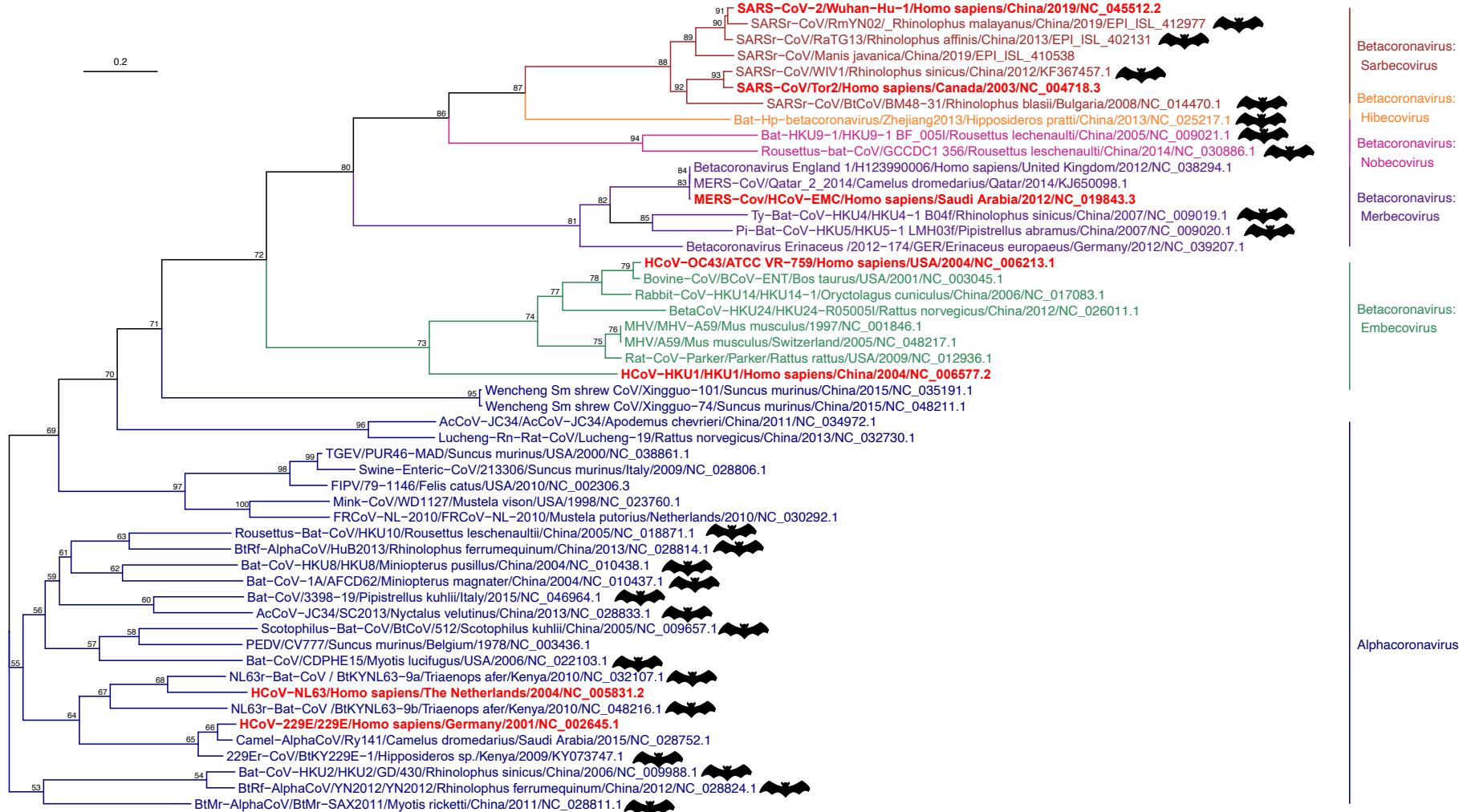
Skelton & Huber. 2022. *Viruses*.

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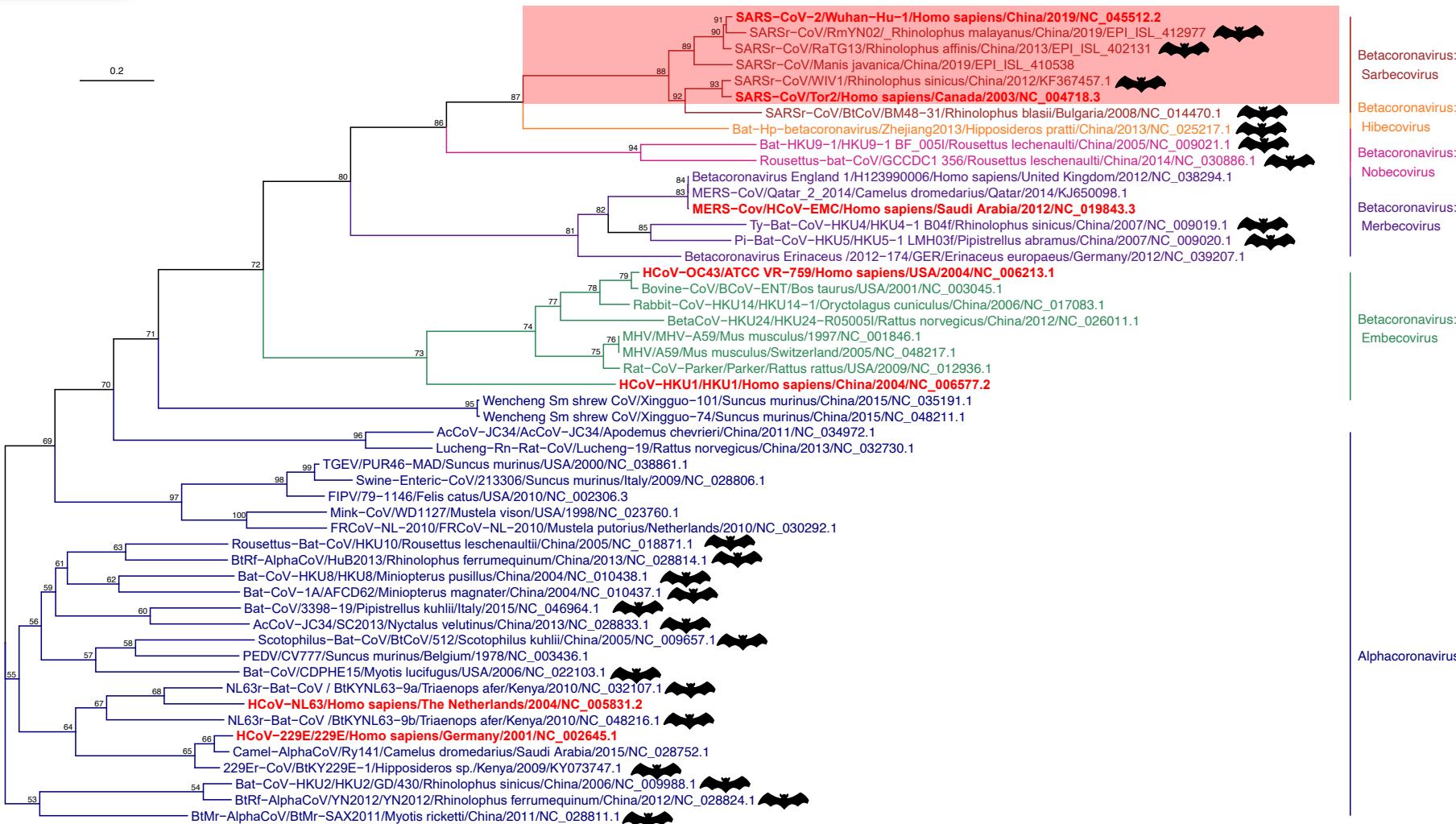


SARS-CoV-2 originates from bat-borne coronaviruses in subgenus **Sarbecovirus**

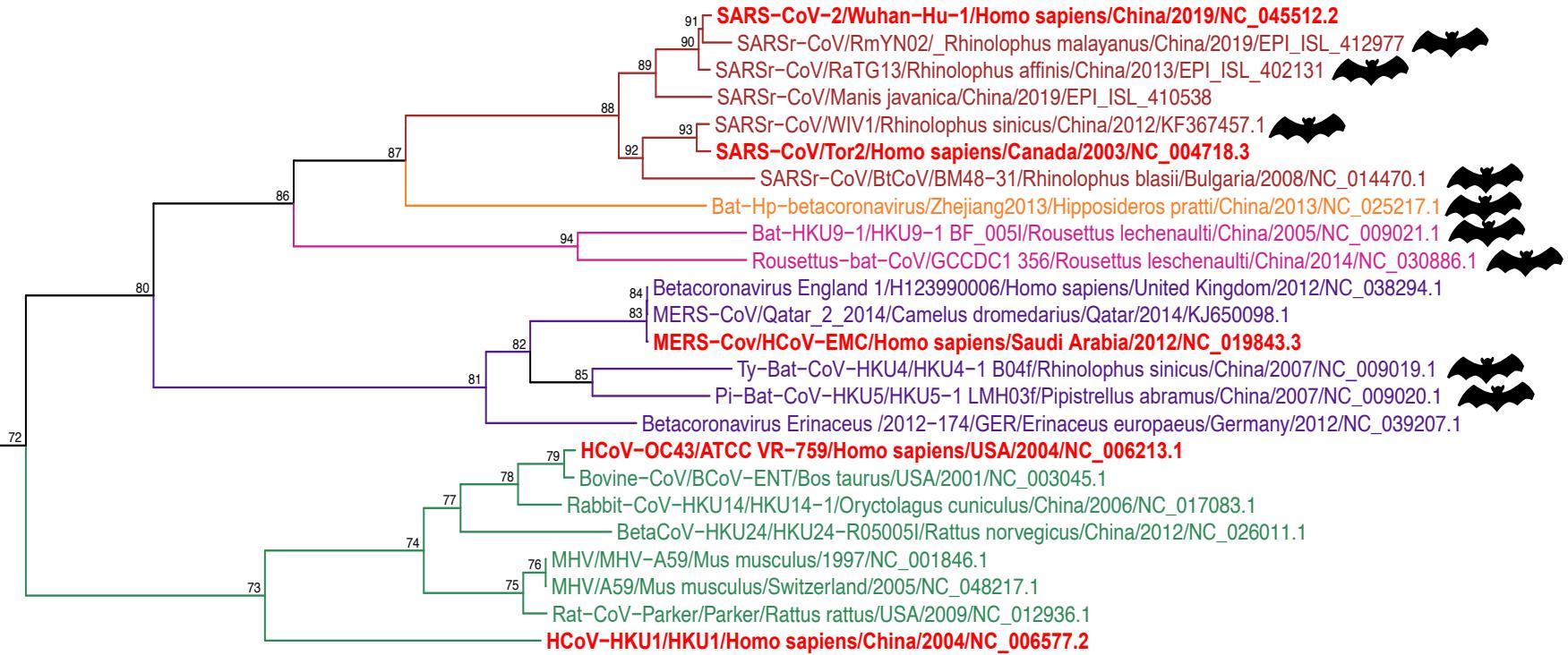




SARS-CoV-2 originates from bat-borne coronaviruses in subgenus **Sarbecovirus**



Because of **coevolution**, different animal host groups are associated with different **BetaCoV subgenera**



- | | | |
|----------------------------------|----------------------------------|--|
| Betacoronavirus:
Sarbecovirus | Rhinolophidae
bats | |
| Betacoronavirus:
Hibecovirus | Hipposideridae
bats | |
| Betacoronavirus:
Nobecovirus | Pteropodidae
bats | |
| Betacoronavirus:
Merbecovirus | Vespertilionidae
bats | |
| Betacoronavirus:
Embecovirus | Cattle and
Rodents | |

CoVs are among the most likely viruses to ‘host-switch’

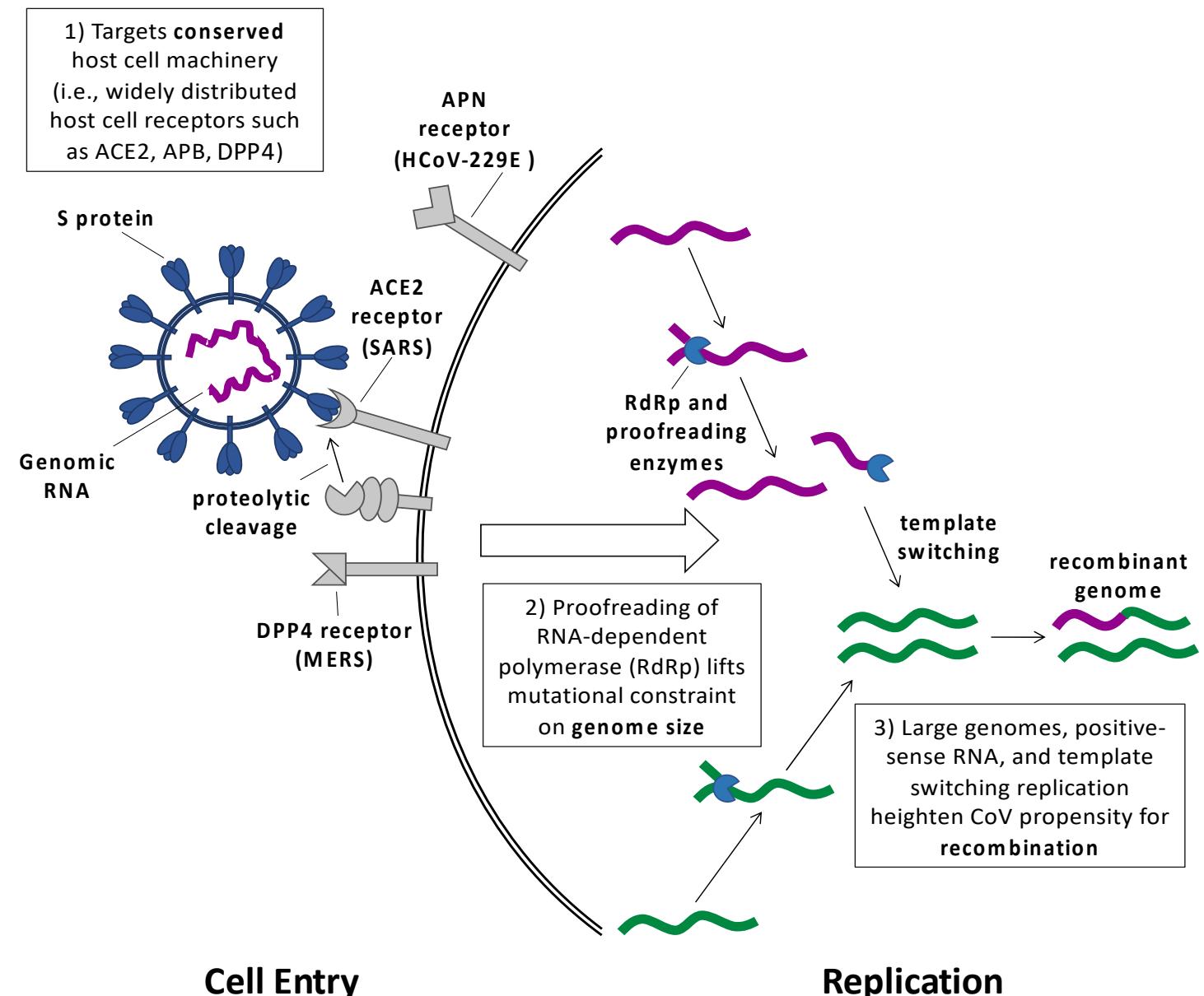
To emerge in a novel host, a virus must first **enter host cells** to hijack host cell machinery for **replication**. Barriers to cell entry create **severe bottlenecks** that limit virus host range and tropism.

Cell entry

Replication

CoVs are among the most likely viruses to ‘host-switch’

Several features of CoV biology enhance their capacity to **overcome barriers** to cross-species emergence.



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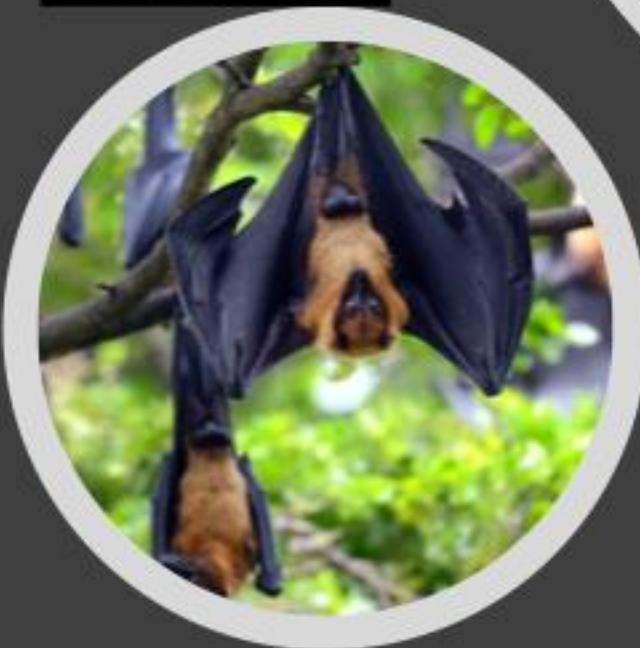
Bats are natural **reservoir hosts** for **zoonotic viruses** that cause **higher case fatality rates** in humans than do zoonoses derived from any other mammal or bird host.



henipaviruses



lyssaviruses



coronaviruses

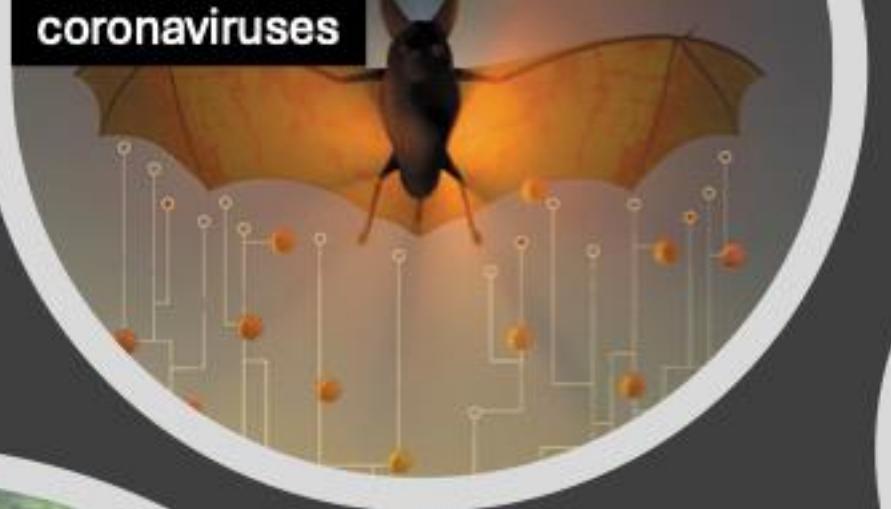


filoviruses



Sarah Guth,
Assistant Professor,
Skyline College

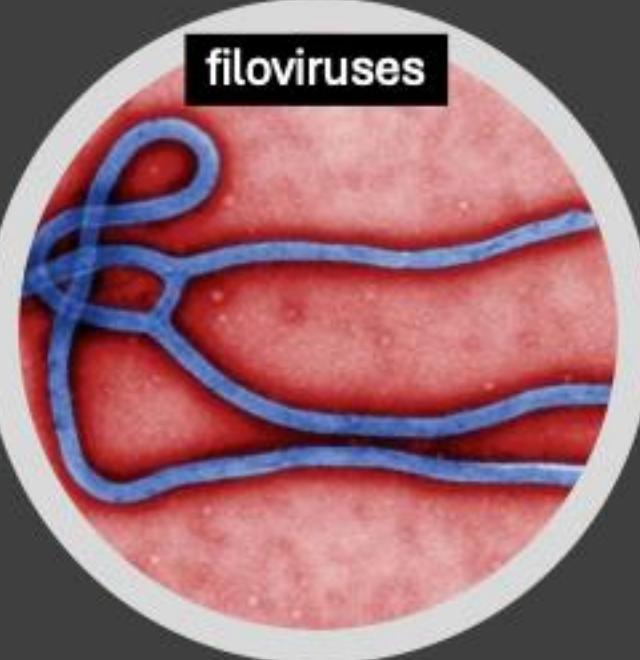
coronaviruses



henipaviruses



filoviruses



henipaviruses

Bats host otherwise virulent viruses without clinical disease.

Are **bats ‘special’ hosts for viruses?**

lyssaviruses

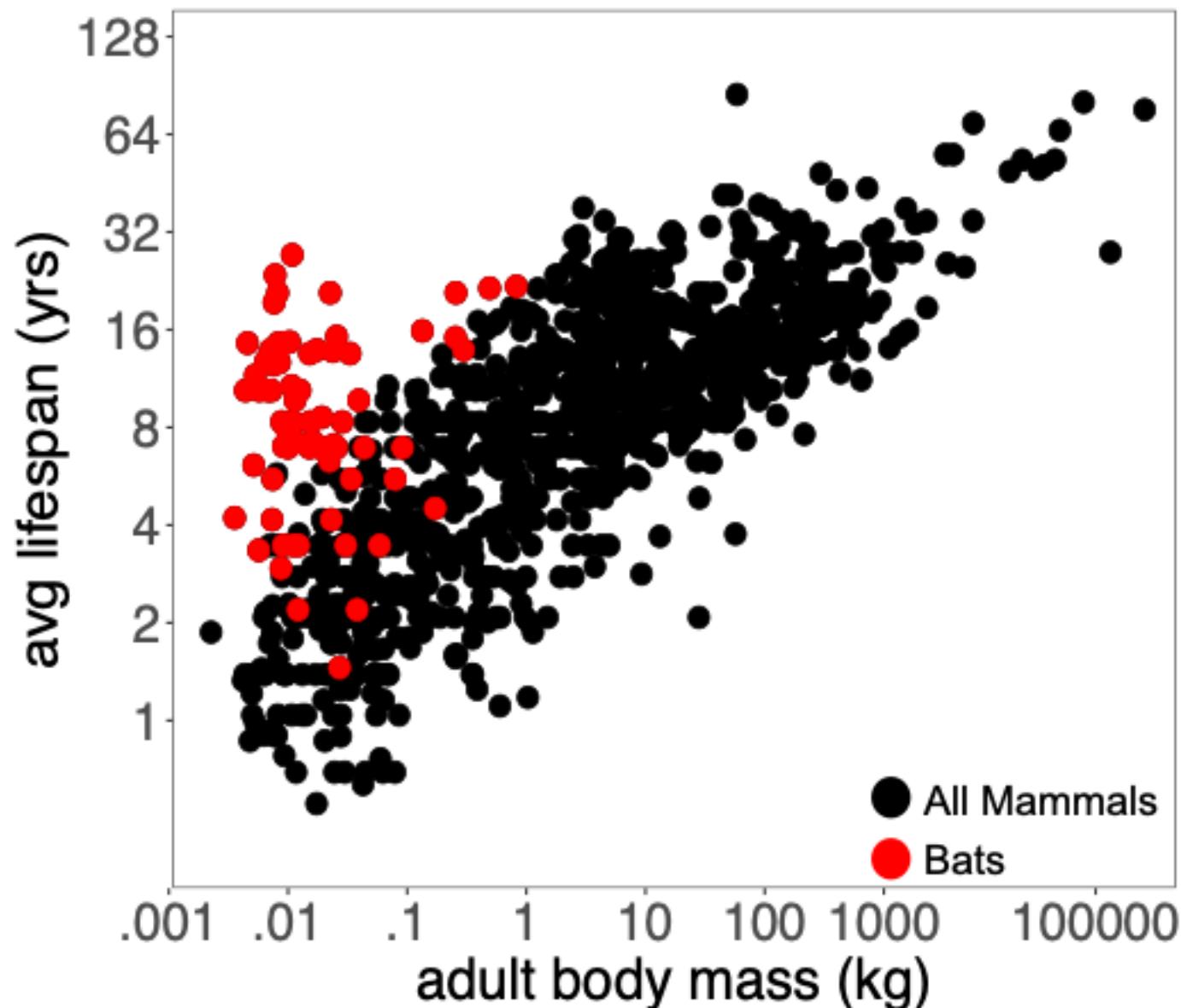


Brook & Dobson. 2015. *Trends Micro.*
Schountz et al. 2017. *Front Immunol.*

Bats are the only mammals capable of **powered flight**, the most **energetically costly** form of terrestrial locomotion.



Despite high energetic expenditures associated with flight, bats are, on average, the **longest-lived mammals per body size**.



Jones et al. 2009. *Ecology*.

Brook and Dobson 2015. *Trends in Microbiology*.

O'Shea et al. 2014. *Emerging Infectious Diseases*.

We hypothesize that unique **anti-inflammatory molecular pathways** evolved to support flight in bats have had **pleiotropic impacts** on **bat longevity, cancer resistance, and virus tolerance.**

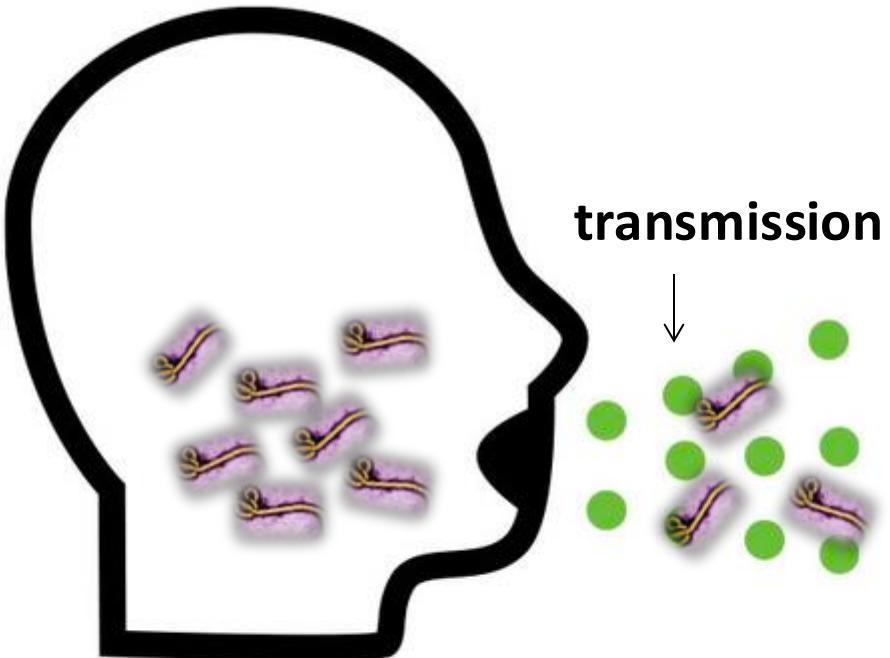


Vazquez et al. 2024. *bioRxiv*.

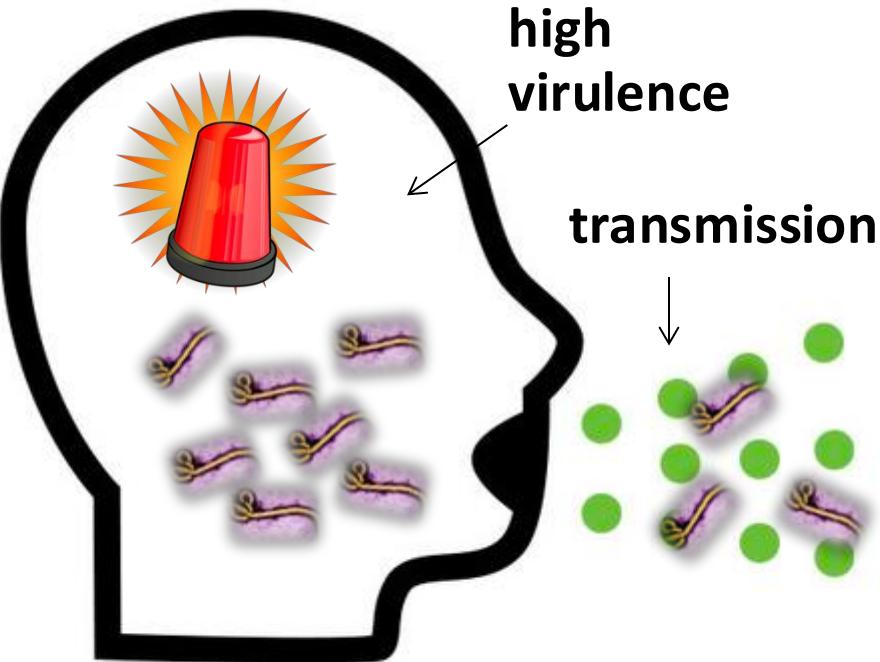
Irving et al. 2021. *Nature*

Brook and Dobson 2015. *Trends Micro.*

A virus will evolve to
maximize its capacity for
between-host infections.

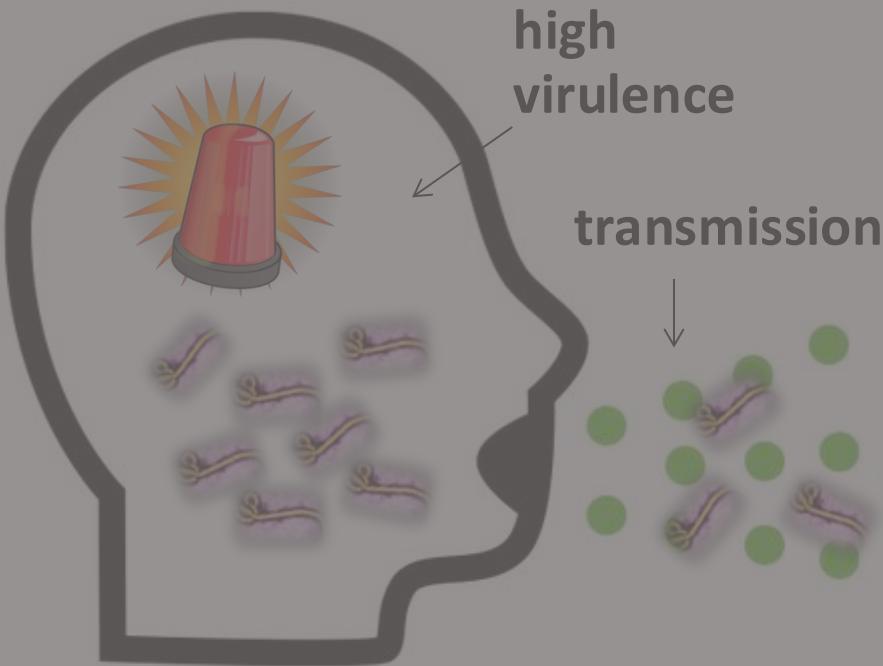


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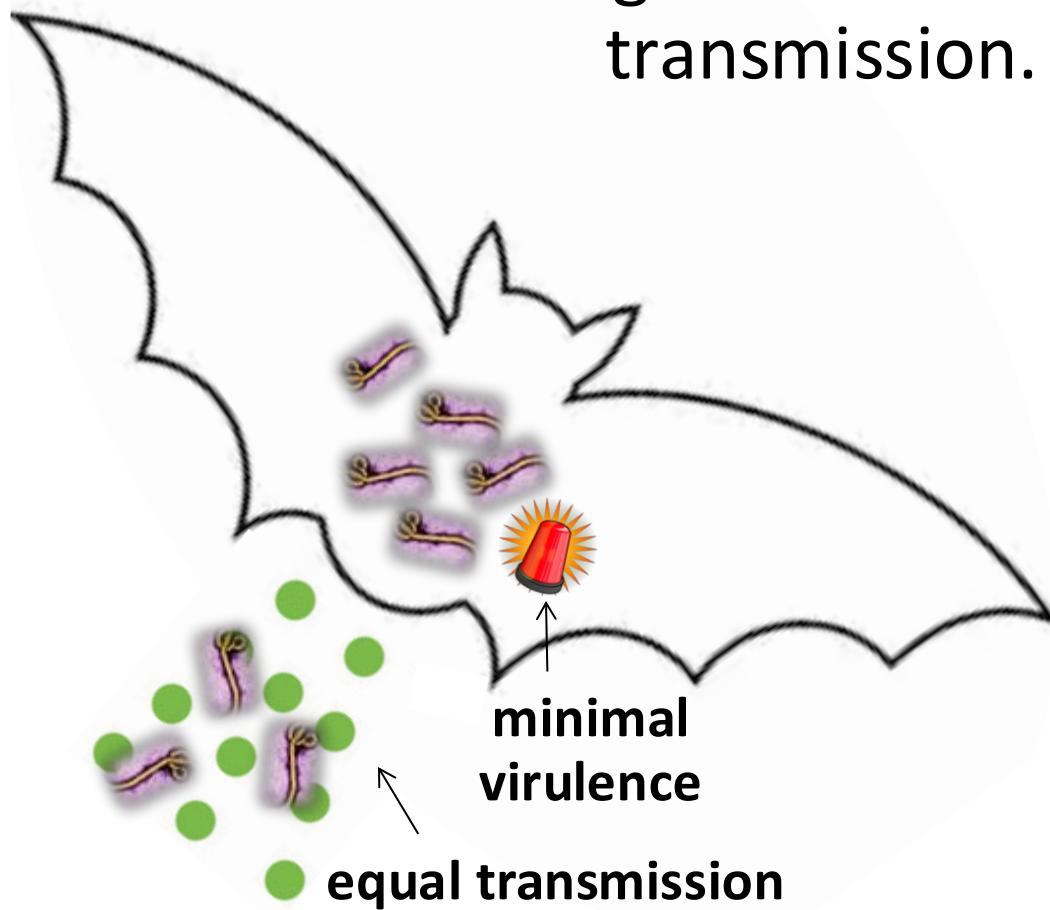
Mechanisms that promote
transmission may also cause
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A virus will evolve to **maximize** its capacity for **between-host infections**.



Mechanisms that promote **transmission** may also cause **virulence** to the host.

Bats accrue less virulence for a given level of transmission.

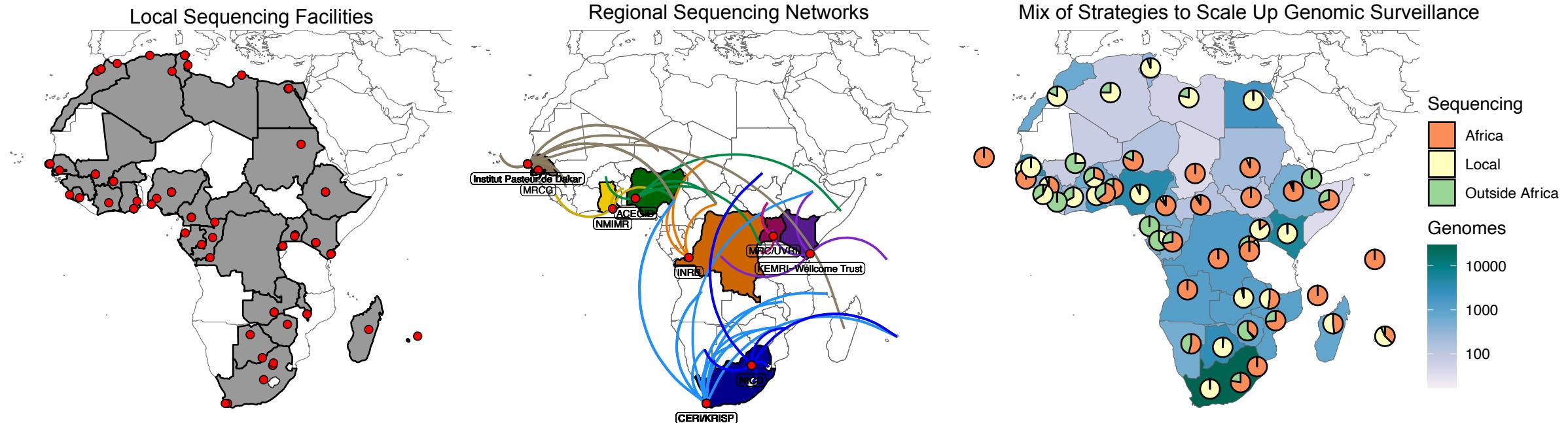


Viruses may evolve traits that cause **high virulence in non-bats**.

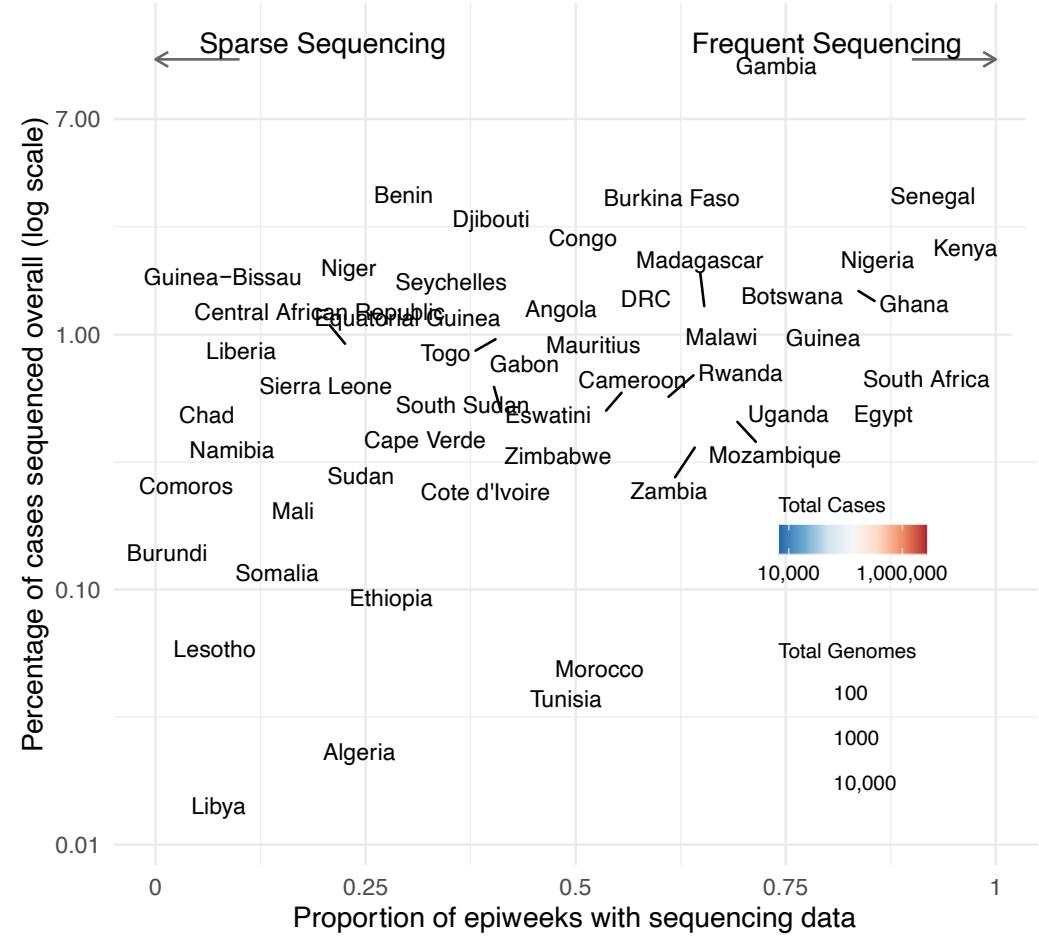
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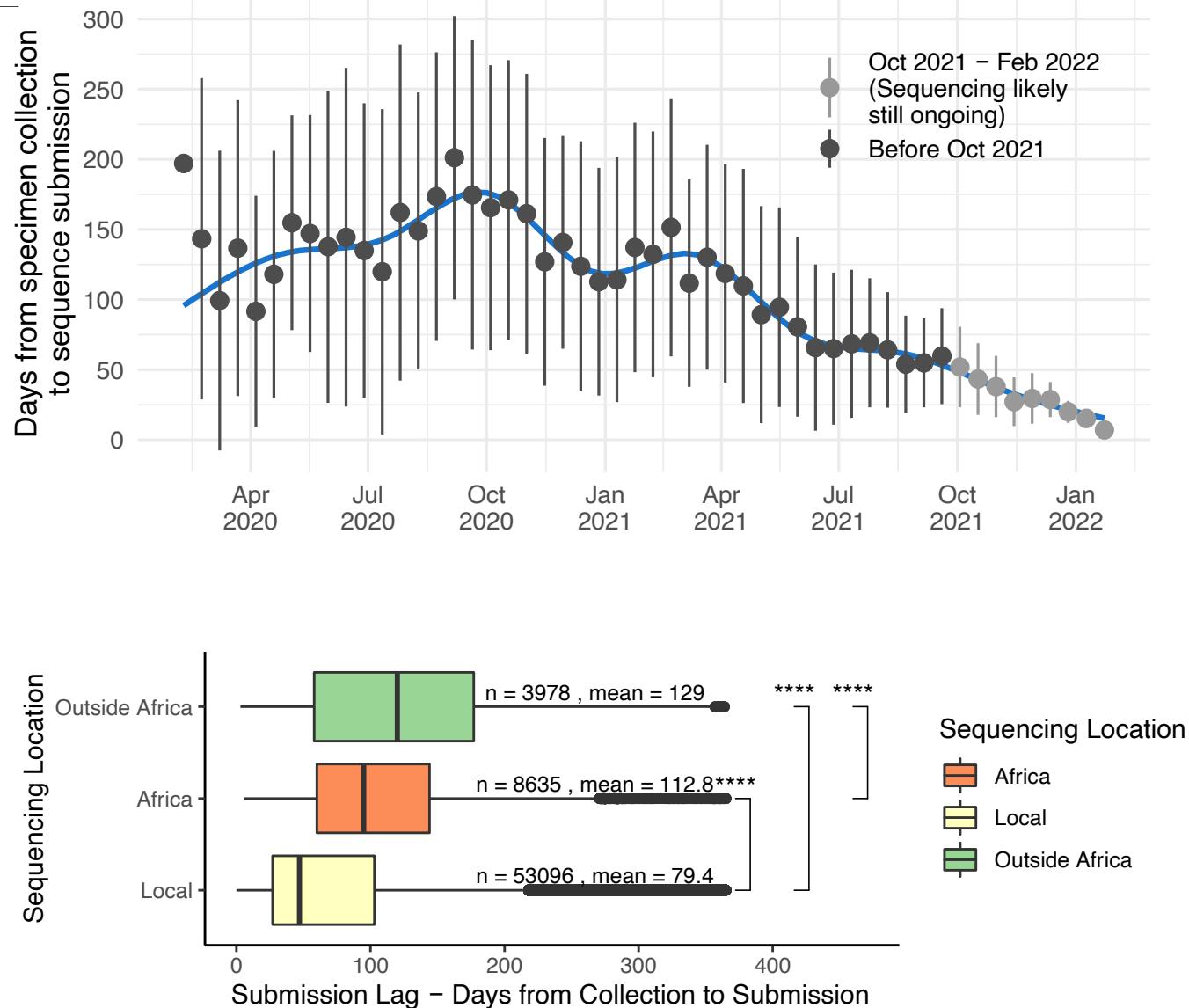
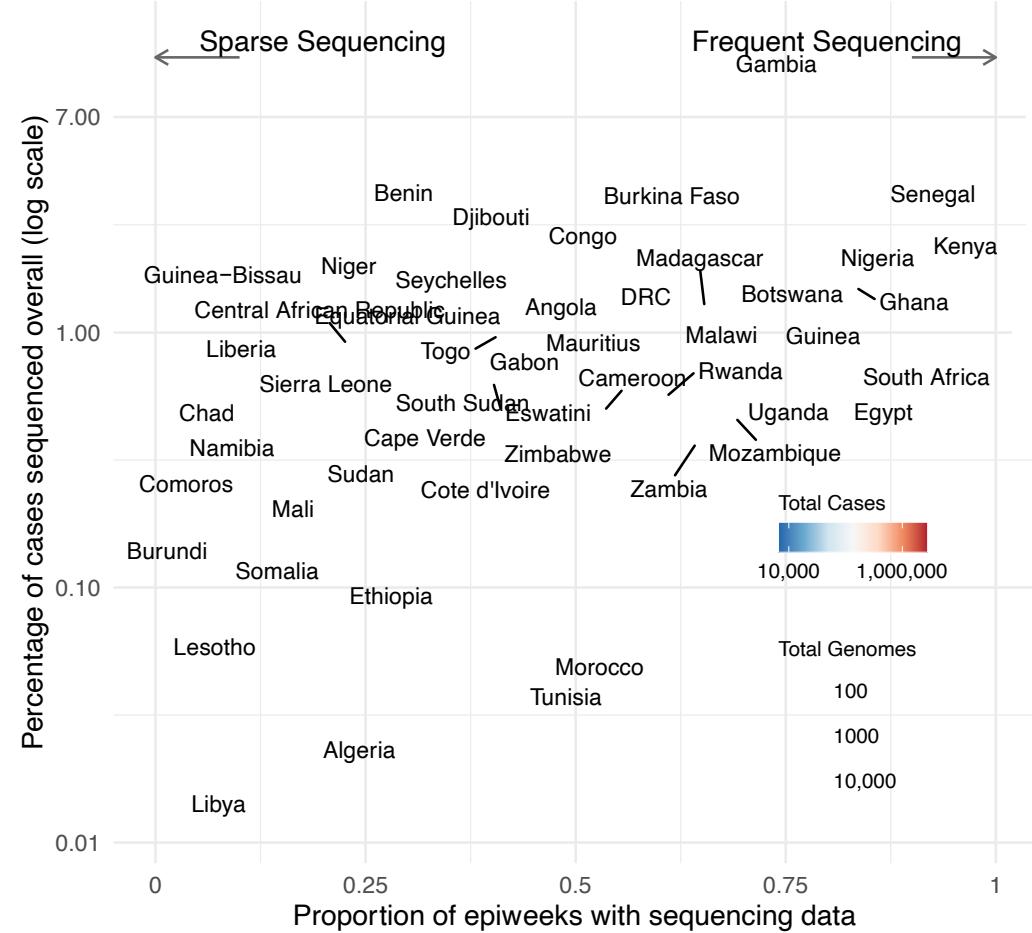
COVID-19 has hastened the expansion of pathogen genomic sequencing in Africa



In-country sequencing expanded throughout the pandemic and improved turnaround time (TAT)

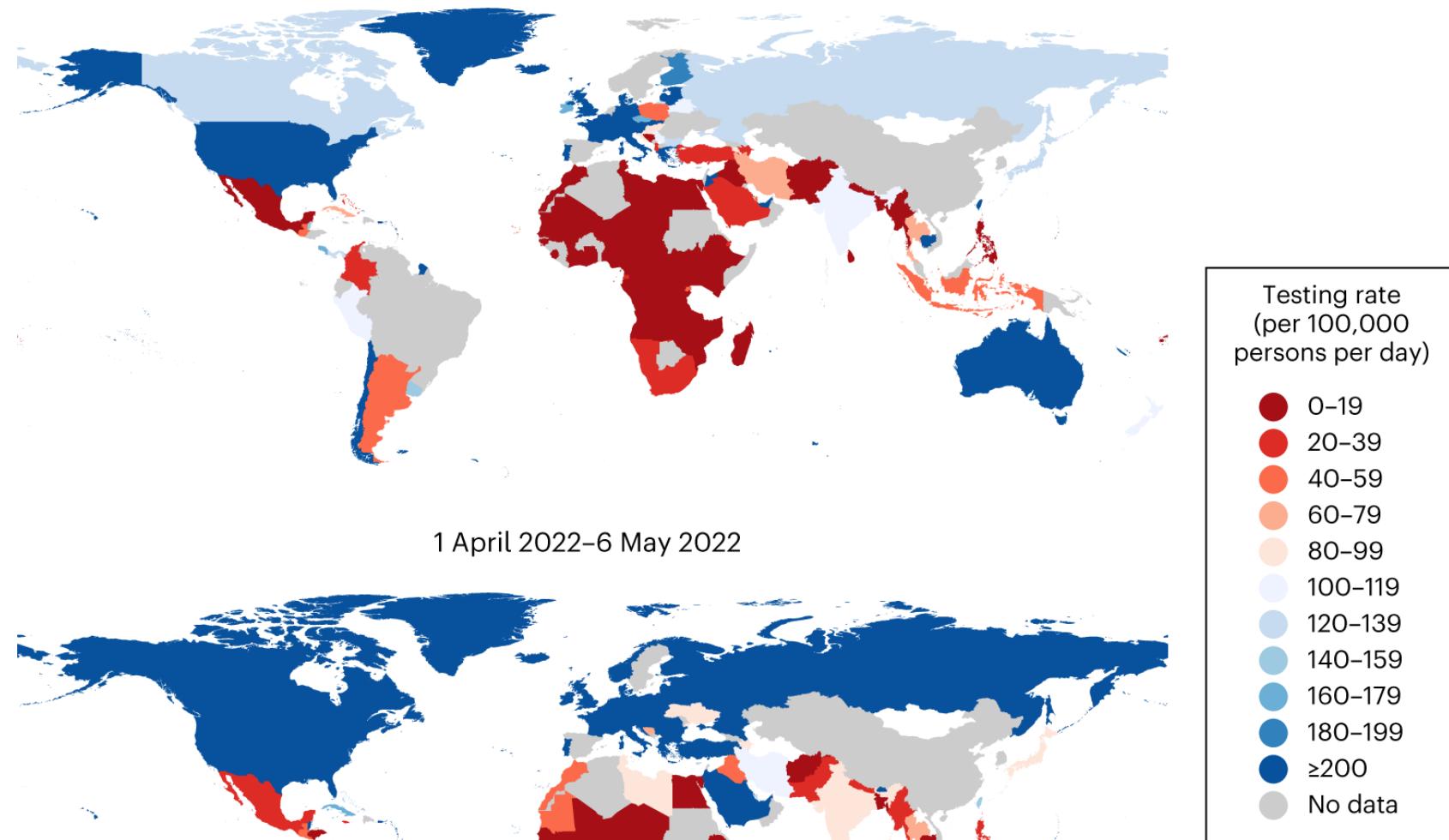


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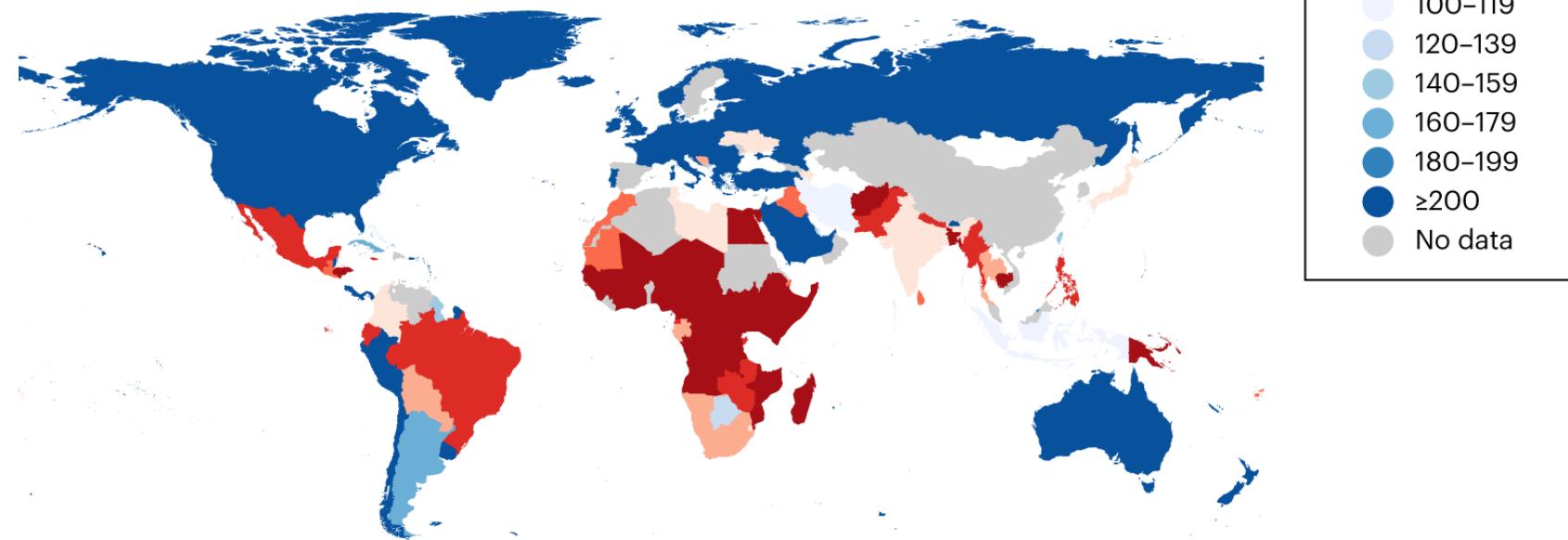


Testing rates drive sequencing rates and remain low in many LMICs as compared to HICs.

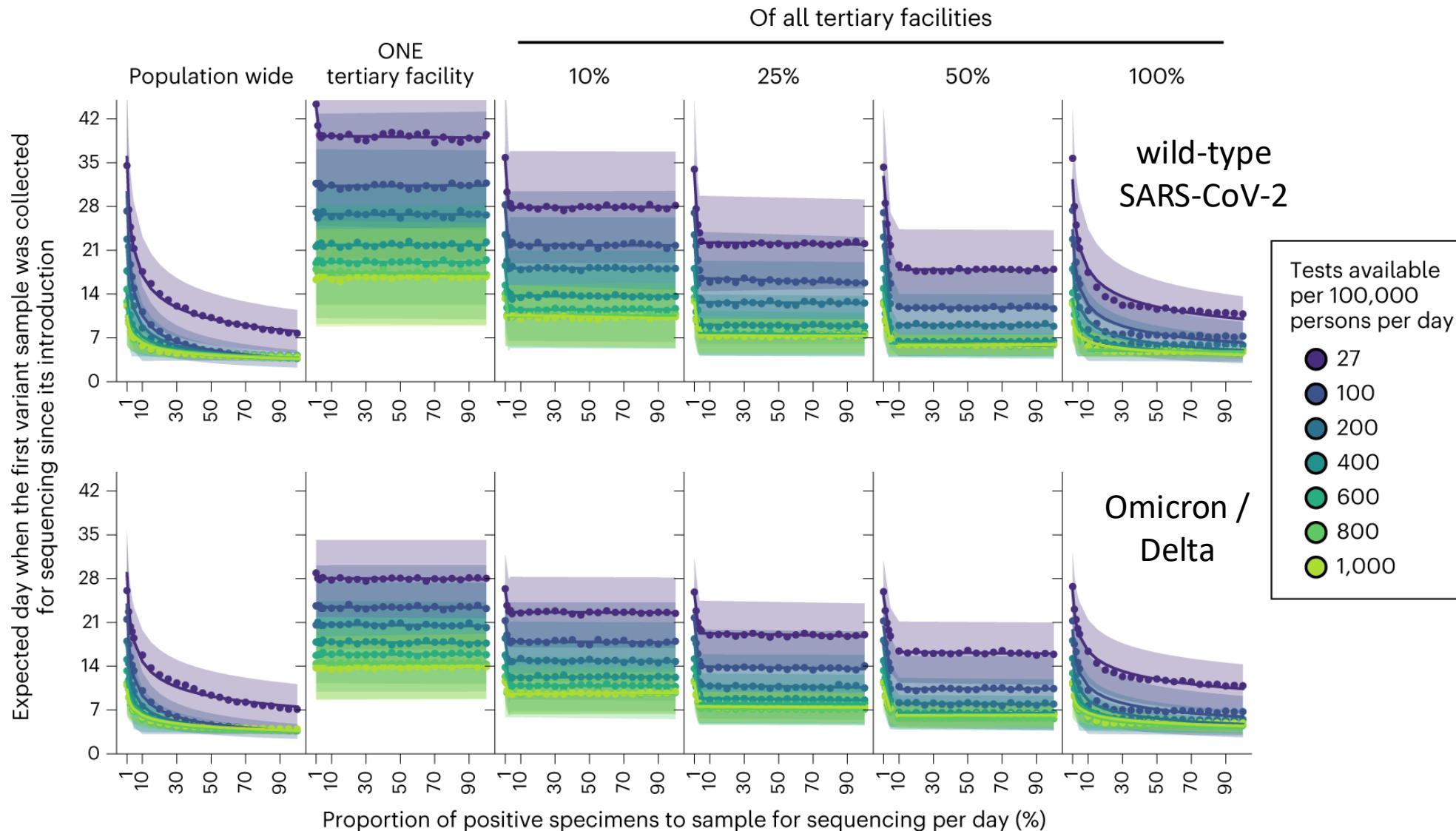
1 December 2021–31 March 2022



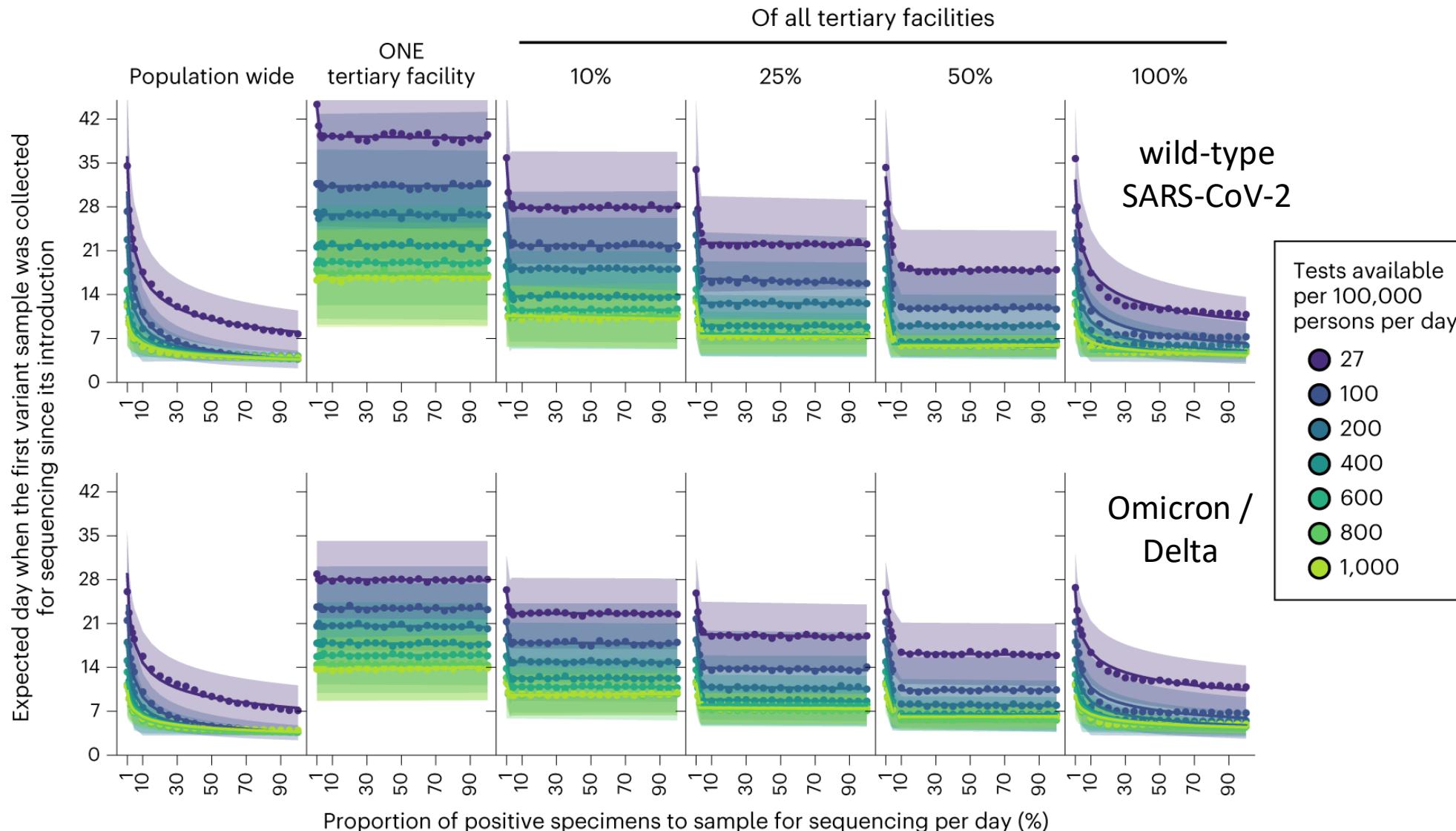
1 April 2022–6 May 2022



Testing rates and sequencing rates combine to capture the effectiveness of genomic surveillance programs.

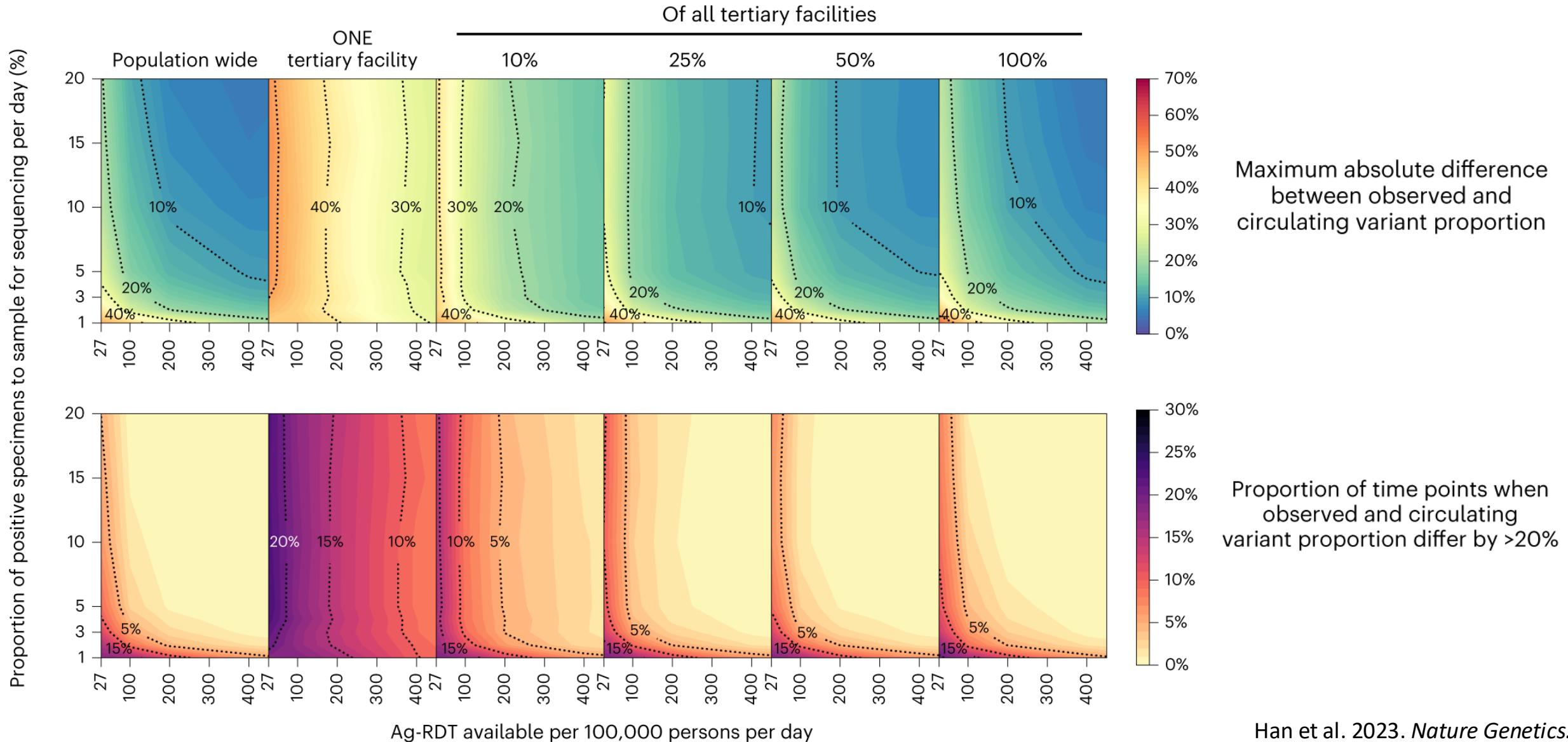


Testing rates and sequencing rates combine to capture the effectiveness of genomic surveillance programs.



*Why do
we see
differences
by variant?*

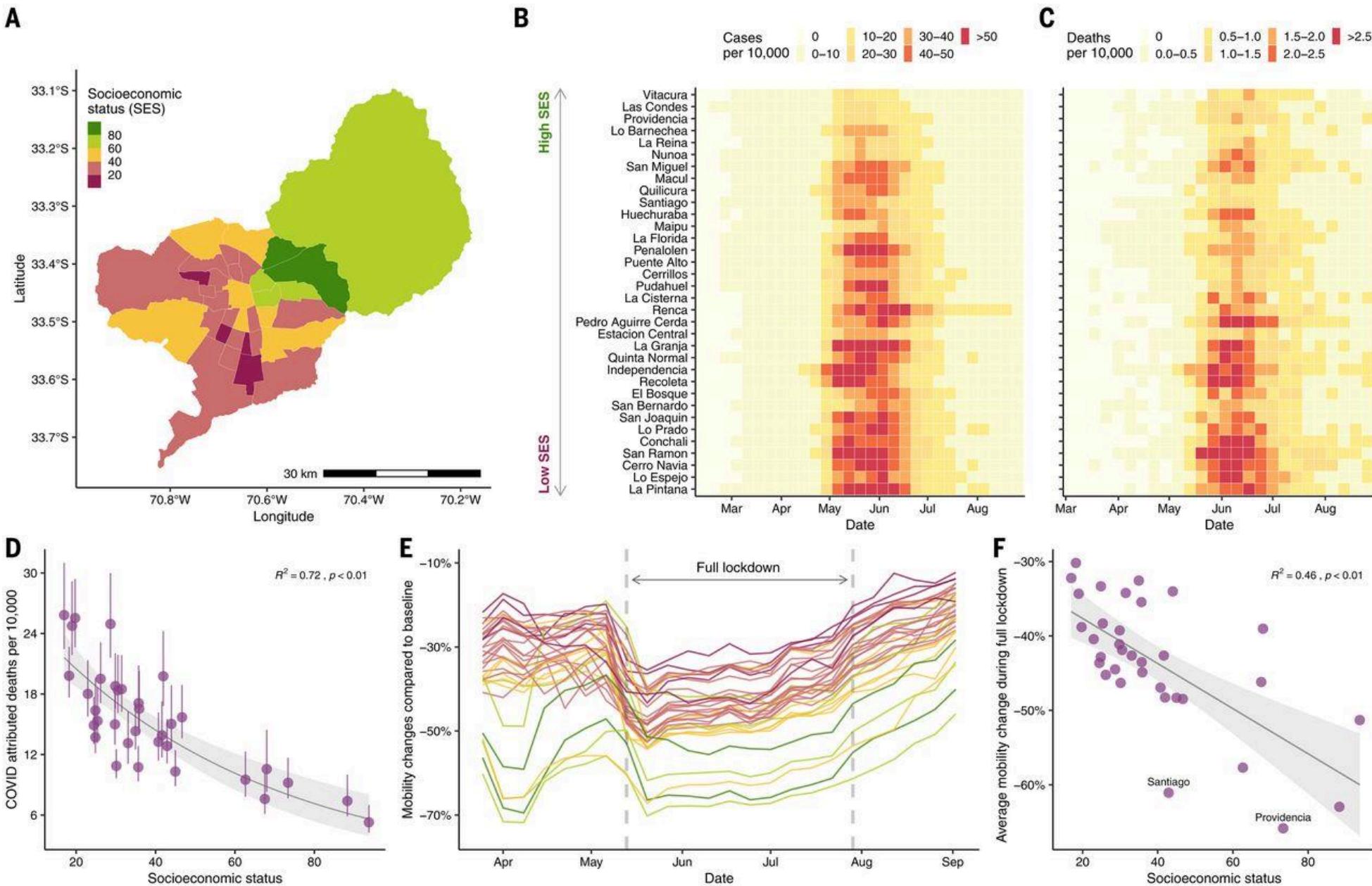
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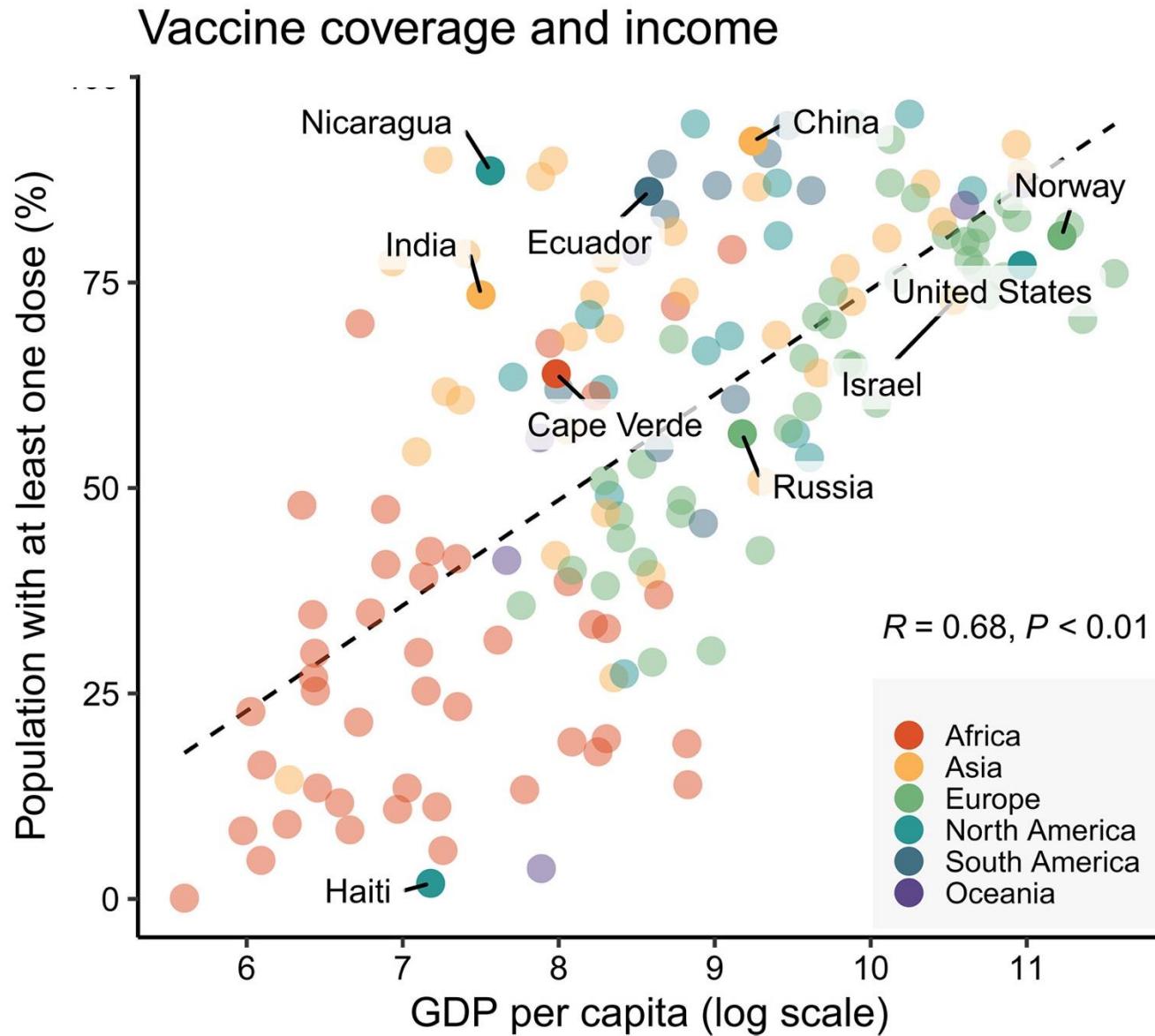
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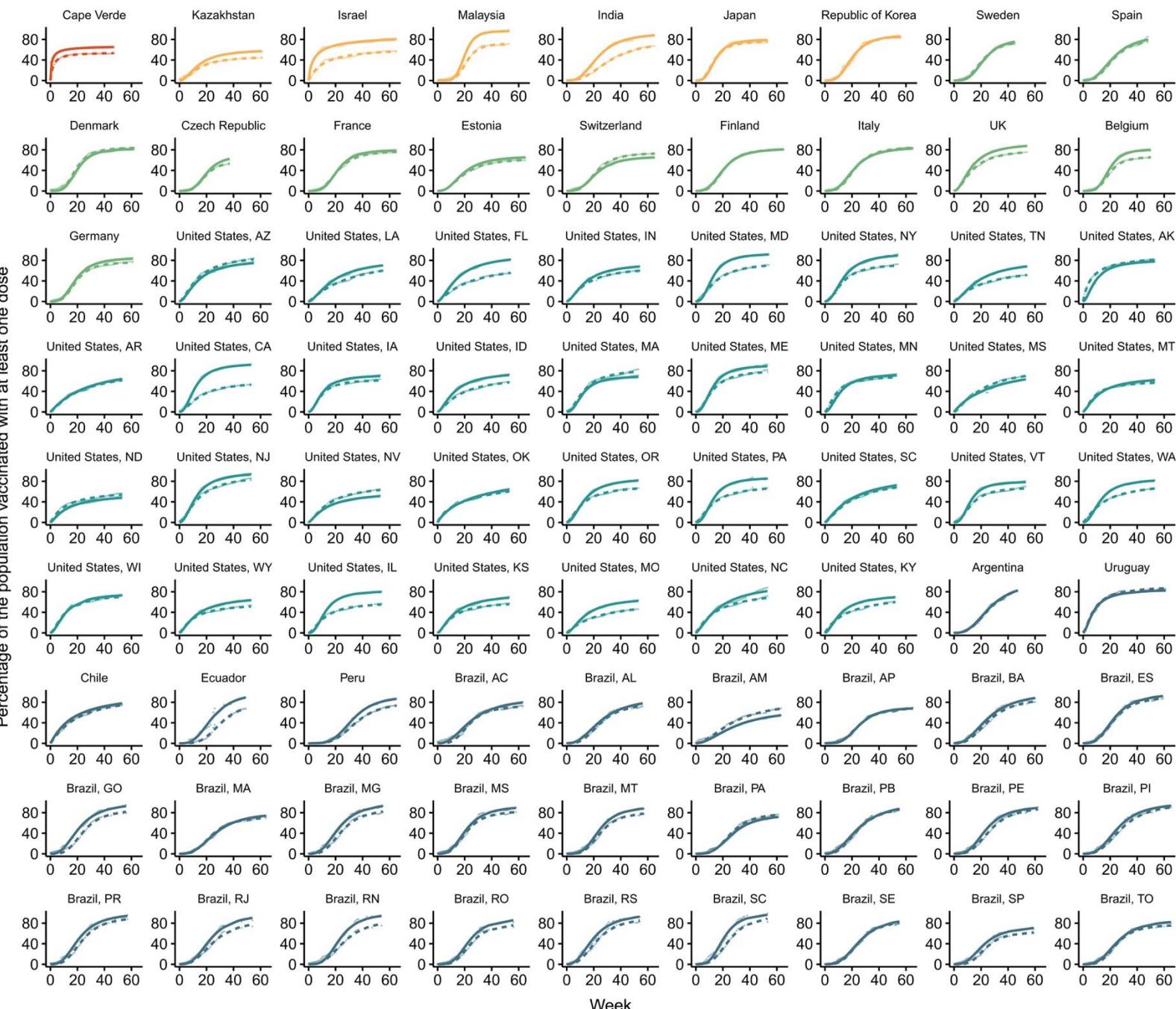
COVID-19
morbidity and
mortality was
more
pronounced in
more
vulnerable
populations
globally.



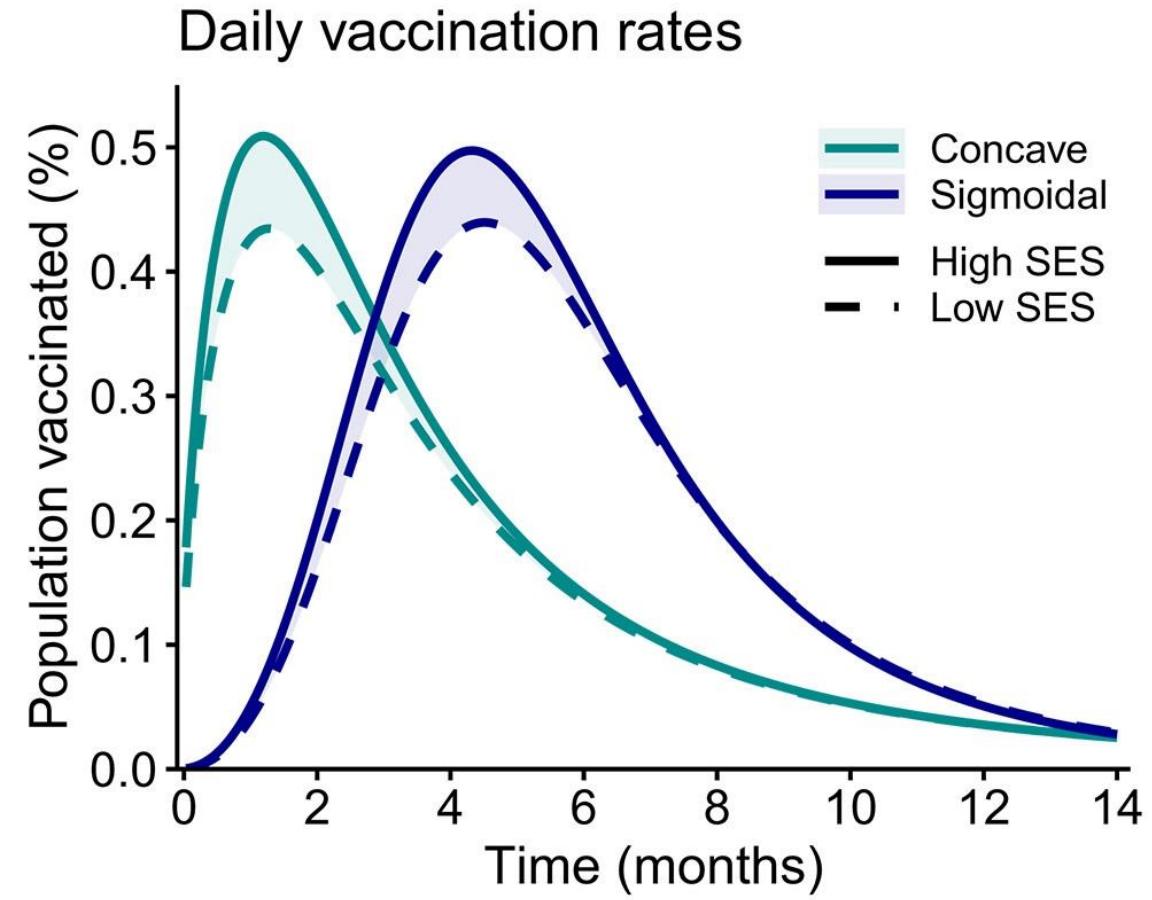
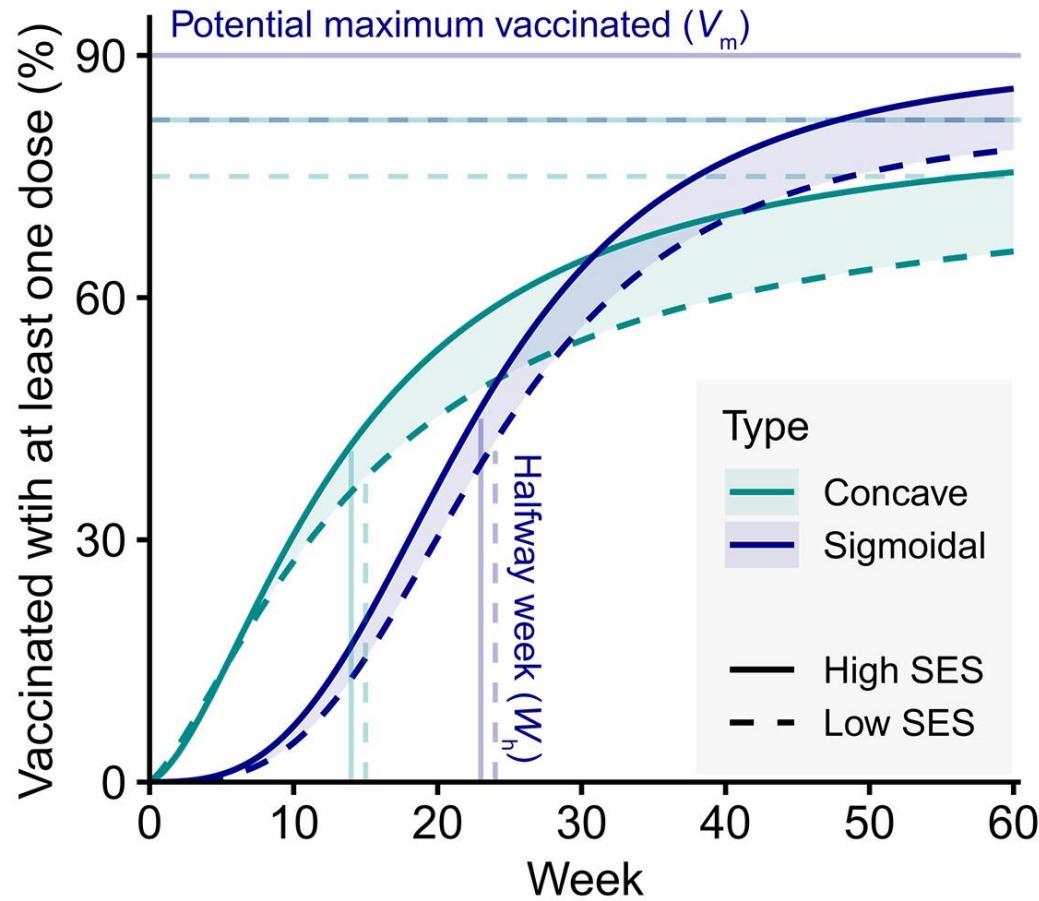
Global vaccination rates track GDP



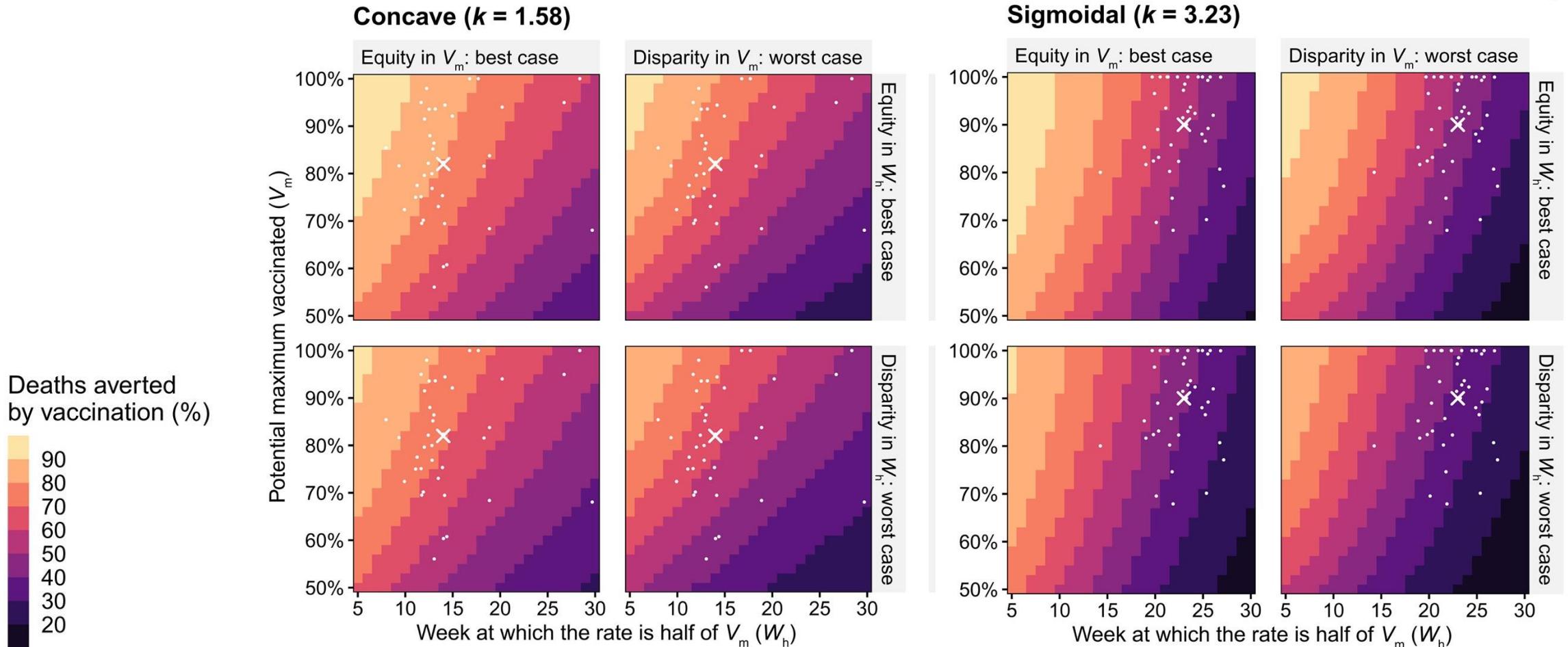
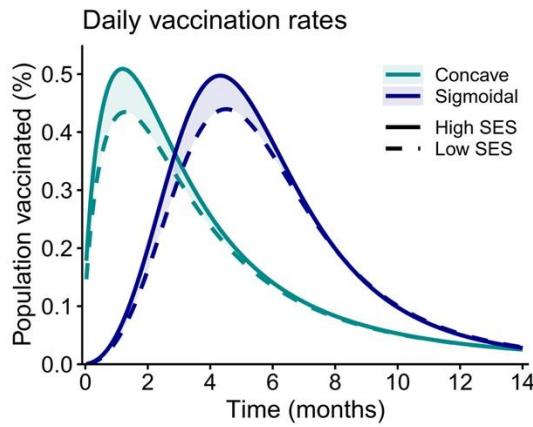
Global COVID-19 vaccine roll-out



Two types of vaccination strategy identified



Faster responses (concave strategy) mitigate disparities and avert deaths



Consequences of vaccine stockpiling for epidemic dynamics

