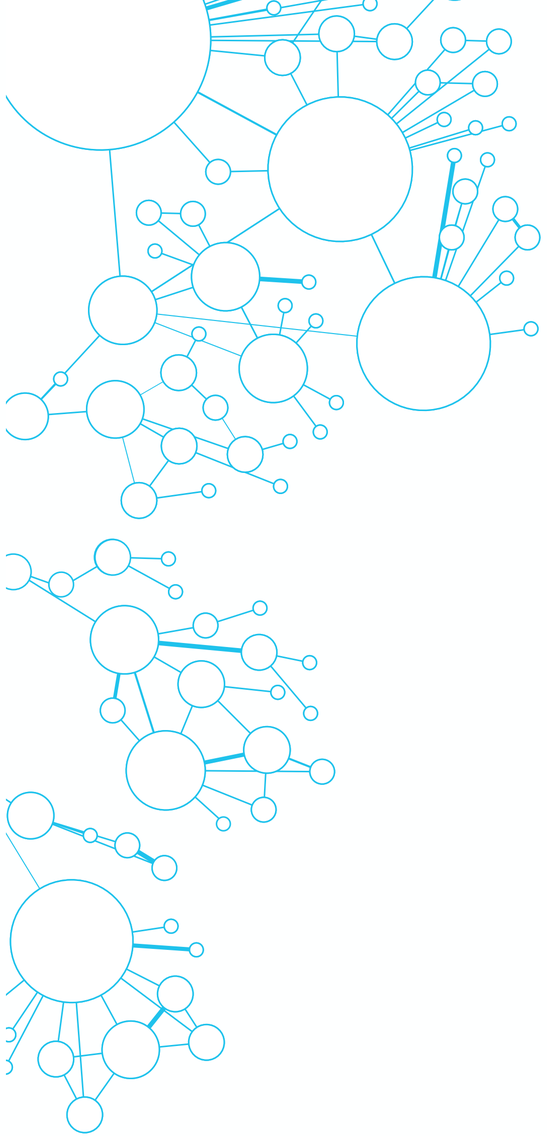

Northeastern

Global modelling of transmission and mitigation measures

Alessandro Vespignani

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LABORATORY FOR THE MODELING OF BIOLOGICAL AND SOCIO-TECHNICAL SYSTEMS

@alexvespi

Controllability once in the general population (2004-2006)

- The proportion of transmission occurring prior to symptoms (or asymptomatically) is mostly determining controllability
- For flu the containment window ~60 days (from initial cluster)
- Travel restrictions can delay the spread of a pandemic flu, but they are unlikely to prevent it.

Strategies for containing an emerging influenza pandemic in Southeast Asia

Neil M. Ferguson[1,2], Derek A.T. Cummings[3], Simon Cauchemez[4], Christophe Fraser[1], Steven Riley[5], Aronrag Meeyai[1], Sopon Iamsirithaworn[6] & Donald S. Burke[3]

Nature **437**, 209–214 (2005)

Containing Pandemic Influenza at the Source

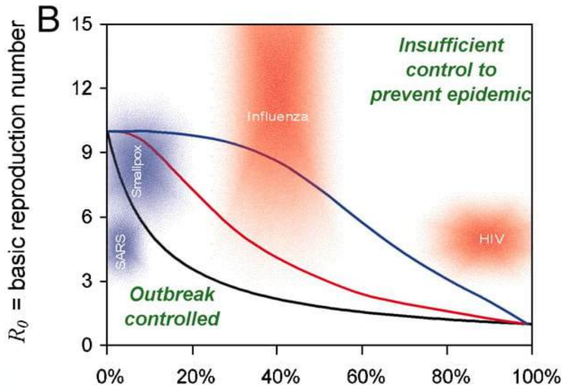
Ira M. Longini Jr.,[1]* Azhar Nizam,[1] Shufu Xu,[1] Kumnuan Ungchusak,[2] Wanna Hanshaoworakul,[2] Derek A. T. Cummings,[3] M. Elizabeth Halloran[1]

SCIENCE VOL 309 12 AUGUST 2005

Factors that make an infectious disease outbreak controllable

Christophe Fraser*†, Steven Riley*, Roy M. Anderson, and Neil M. Ferguson

PNAS | **April 20, 2004** | vol. 101 |



θ = proportion of infections that occur prior to symptoms or by asymptomatic infection.

Will travel restrictions control the international spread of pandemic influenza?

T Déirdre Hollingsworth, Neil M Ferguson & Roy M Anderson

Nature Medicine **12**, 497–499 (2006) | Cite this article

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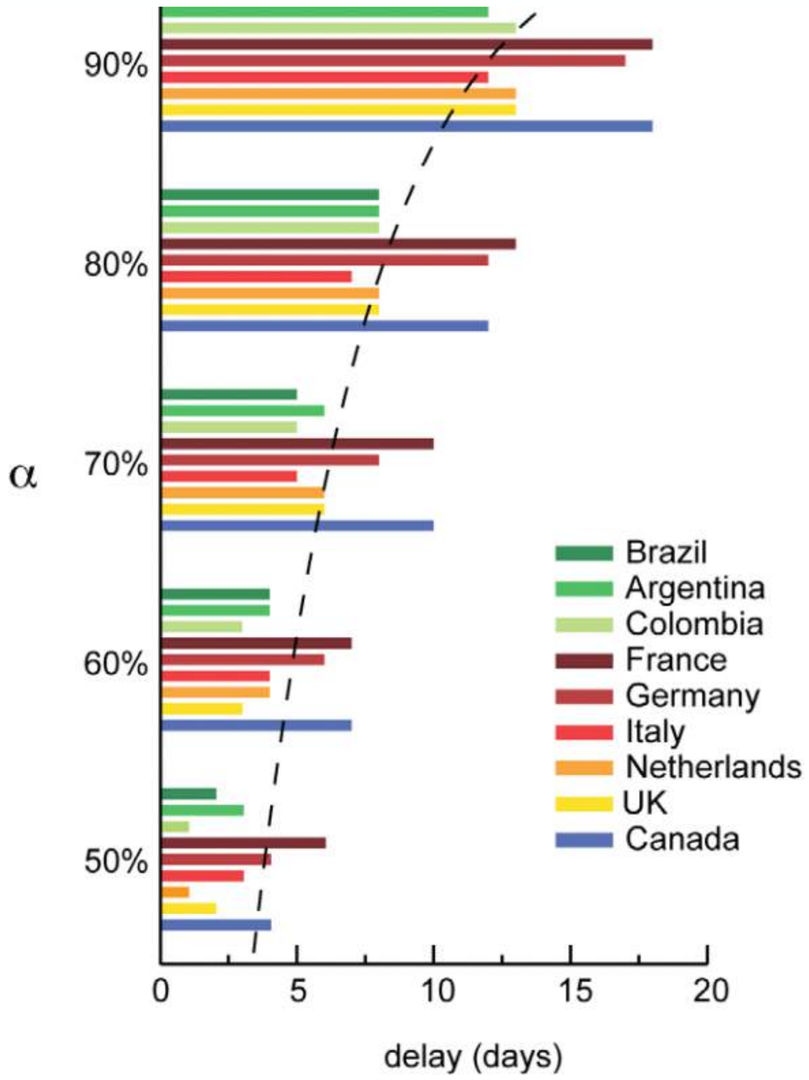
H1N1pdm targeted travel restrictions analysis



- Δt is a logarithmic function of the applied travel reduction magnitude
- Timing implementation shows very little differences

Human Mobility Networks, Travel Restrictions, and the Global Spread of 2009 H1N1 Pandemic

Paolo Bajardi[1,2☯], Chiara Poletto[1☯], Jose J. Ramasco[3], Michele Tizzoni[1,4], Vittoria Colizza[5,6,7*], Alessandro Vespignani[8,9,10*]

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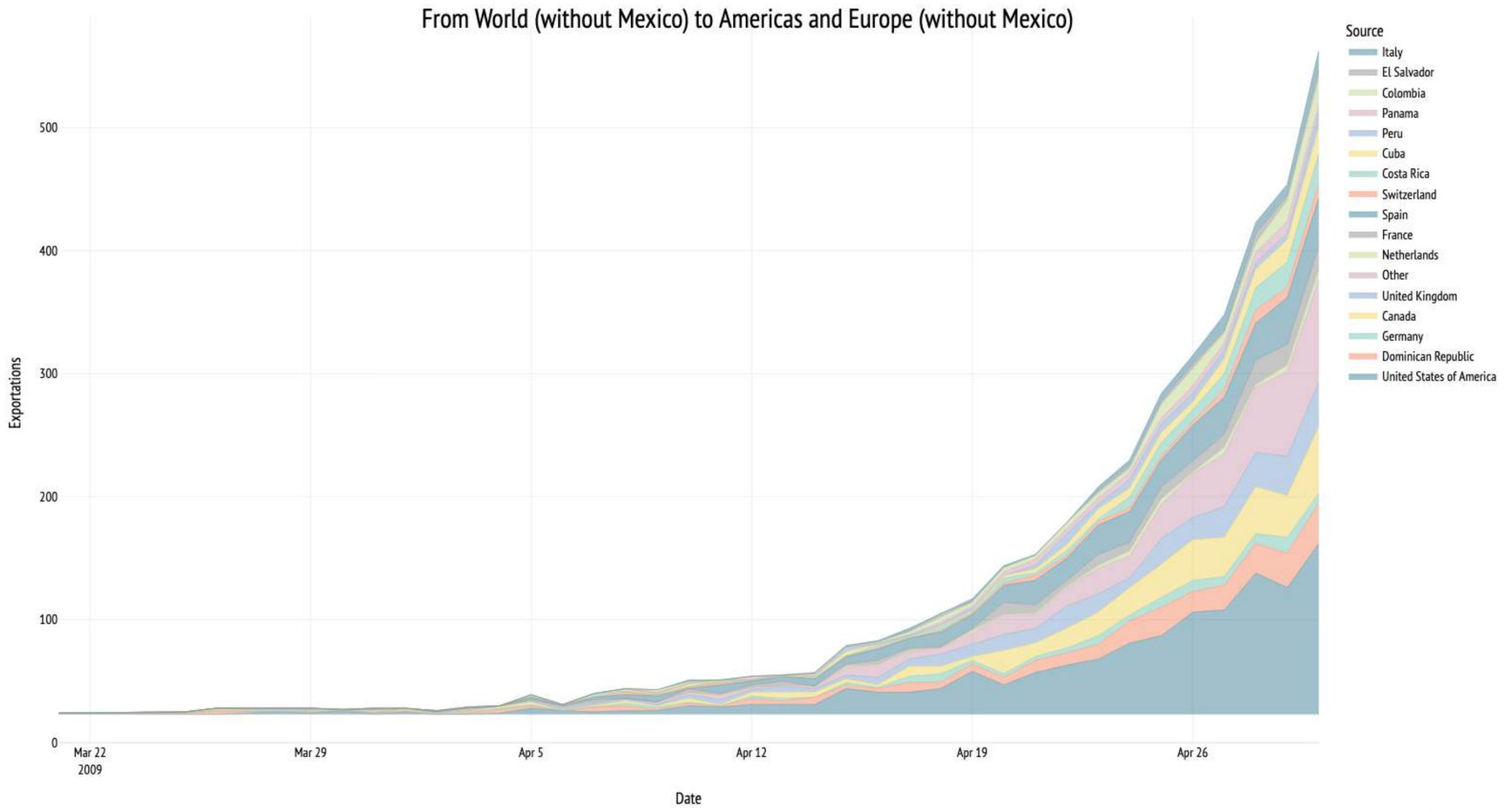
H1N1pdm non-local dynamic



Multimodeling approach to evaluating the efficacy of layering pharmaceutical and nonpharmaceutical interventions for influenza pandemics

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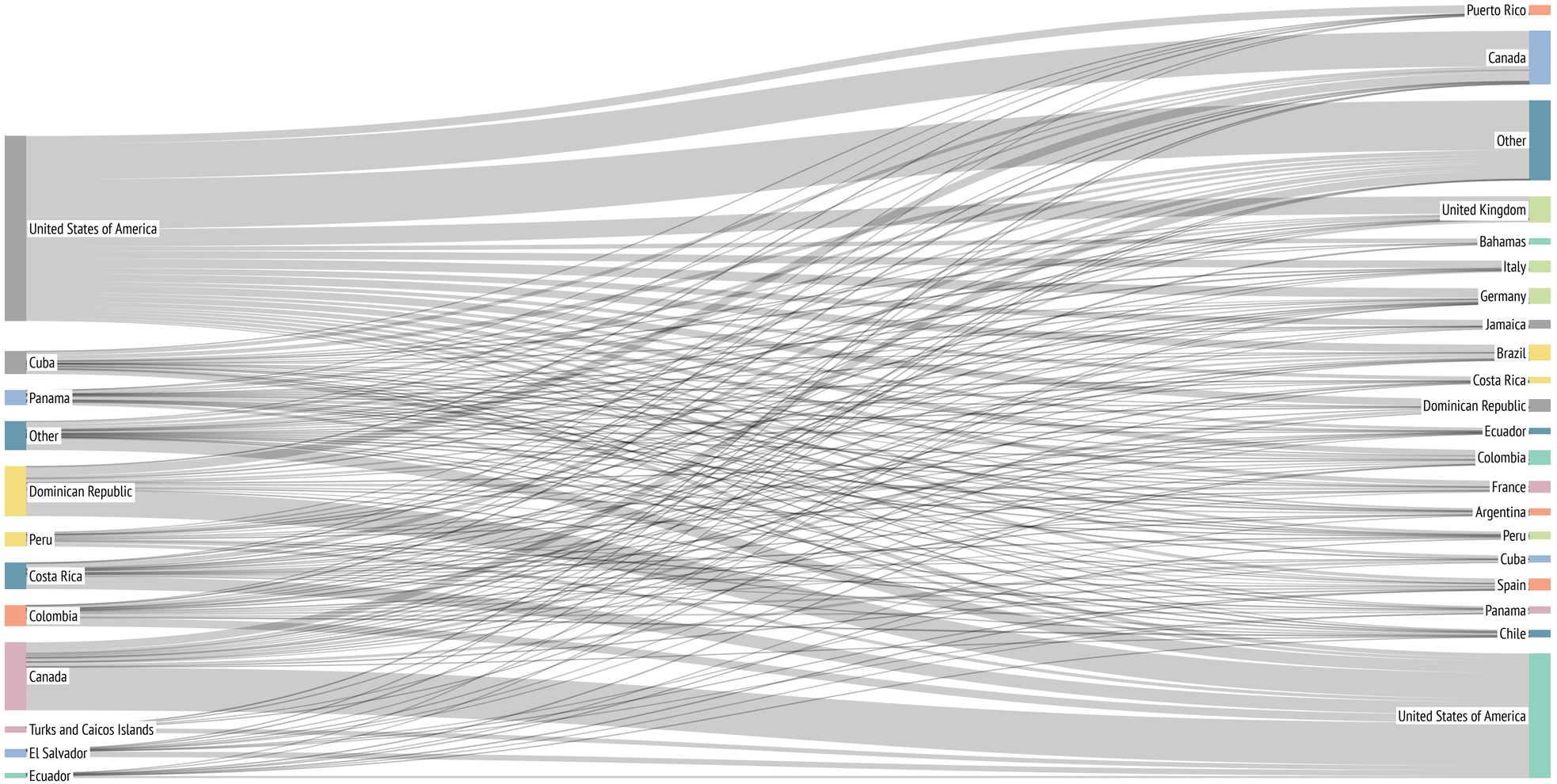
PNAS 2023 Vol. 120 No. 28 e2300590120

H1N1pdm non-local dynamic

From Americas (without Mexico) to Americas and Europe (without Mexico, April 2009)



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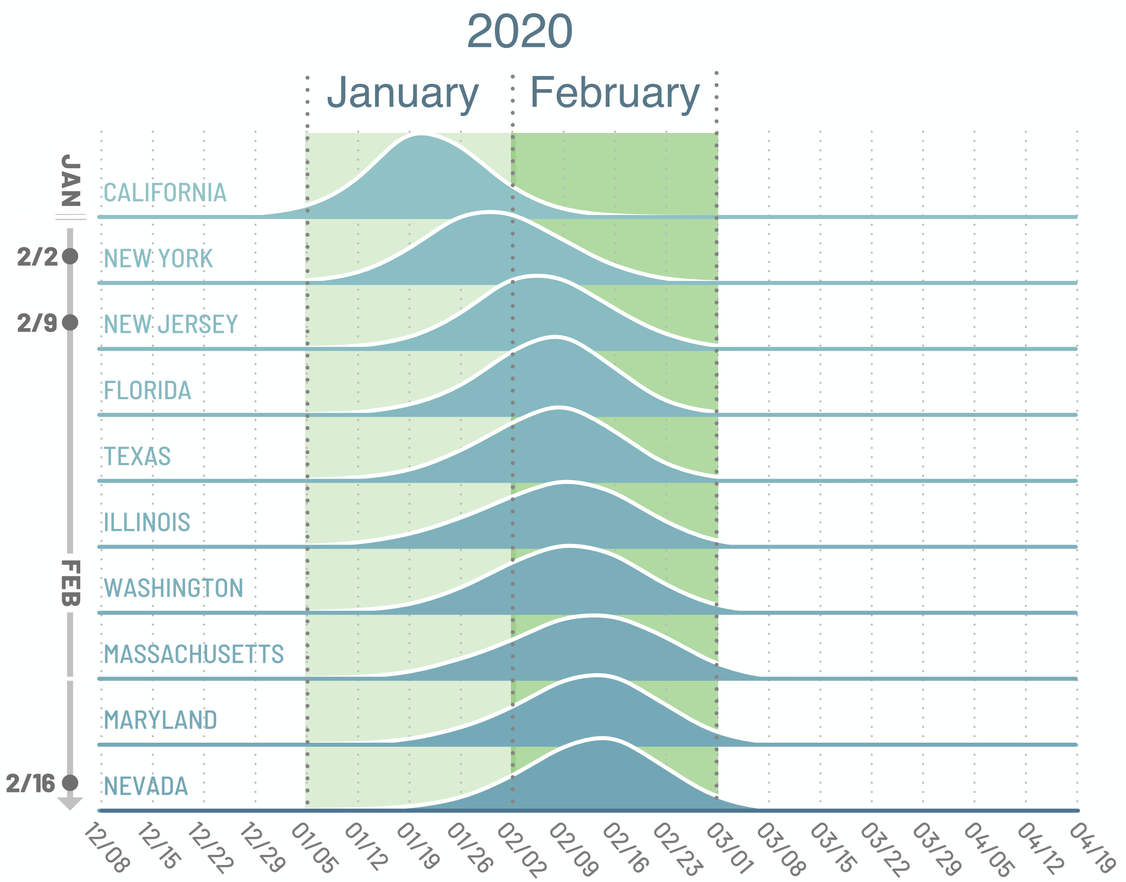
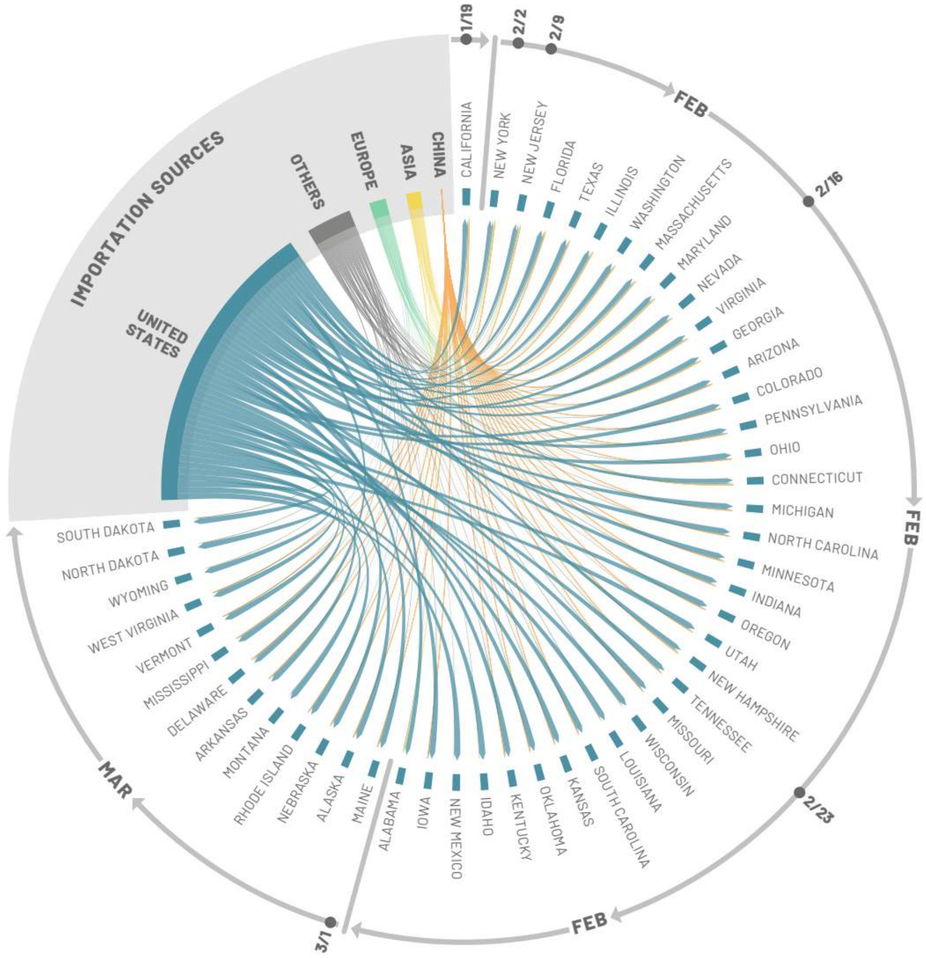
Cryptic transmission of SARS-CoV-2 and the first COVID-19 wave

Nature | Vol 600 | 2 December 2021

Jessica T. Davis[1,11], Matteo Chinazzi[1,11], Nicola Perra[1,2,11], Kunpeng Mu[1], Ana Pastore y Piontti[1], Marco Ajelli[3], Natalie E. Dean[4], Corrado Gioannini[5], Maria Litvinova[3], Stefano Merler[6], Luca Rossi[5], Kaiyuan Sun[7], Xinyue Xiong[1], Ira M. Longini Jr[8], M. Elizabeth Halloran[9,10], Cécile Viboud[7] & Alessandro Vespignani[1]✉





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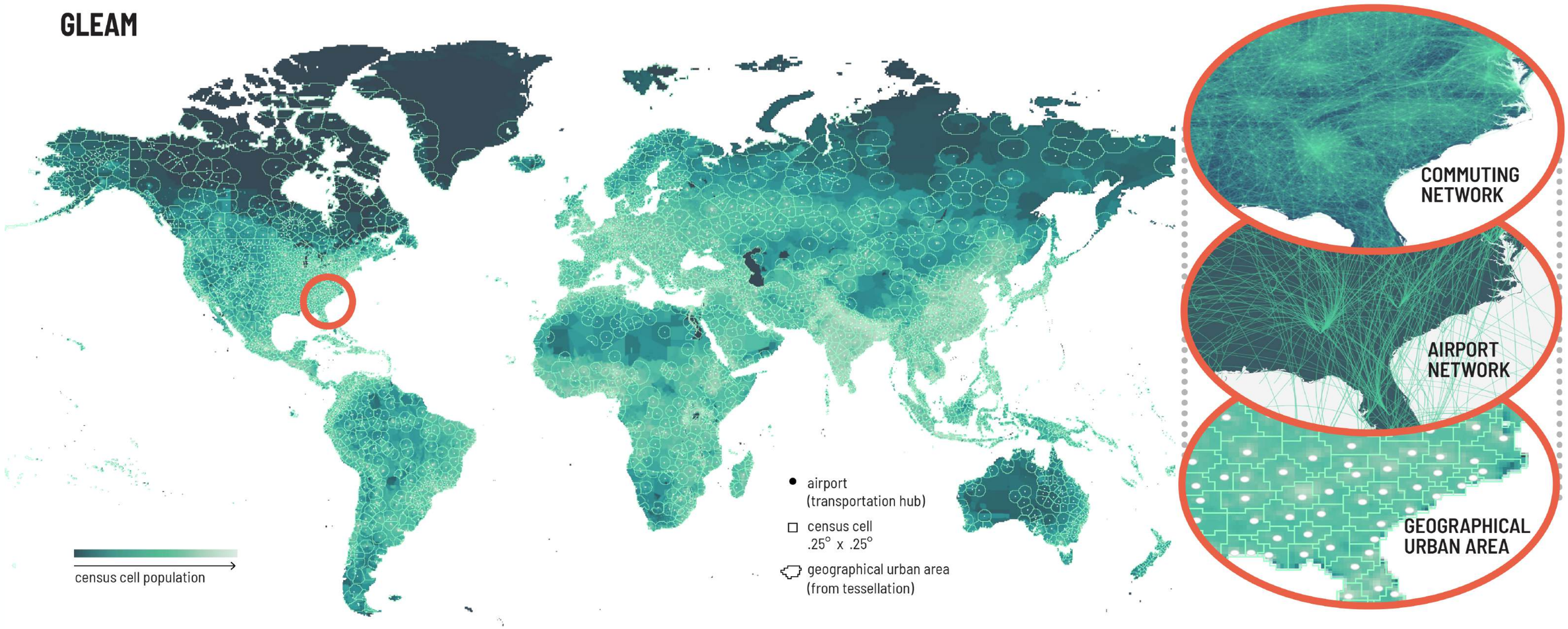
Controllability at the source “unlikely” in practice

- Generally awareness is after a few hundreds if not thousand of infections
- With Flu we should assume a relatively high level of asymptomatic transmission (including “paucisymptomatic”).

- How we can limit/delay global spreading
- What is the role of non-symptomatic transmission in international spreading?
- Targeted travel restrictions?
- Border screening?
- Travel bans?

Metapopulation modeling framework



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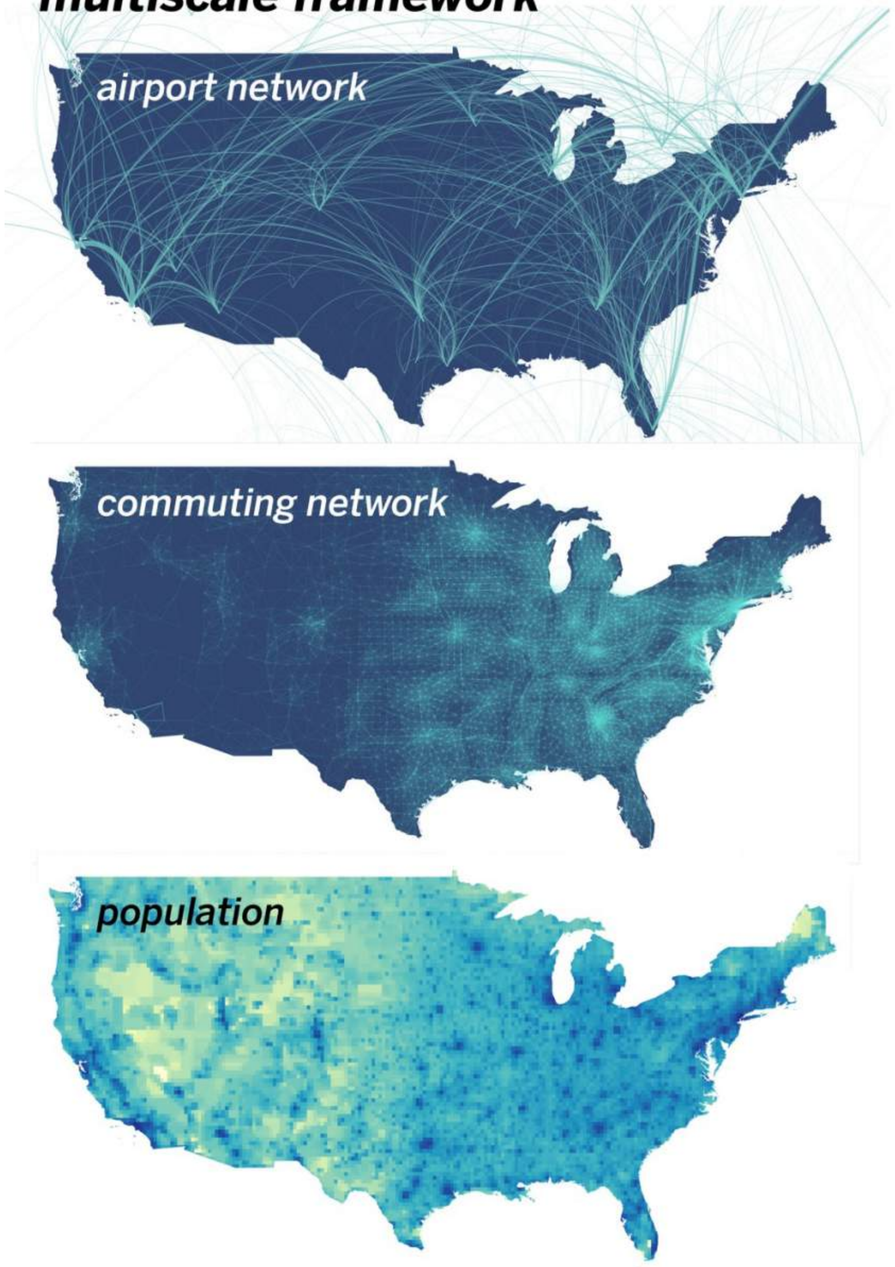
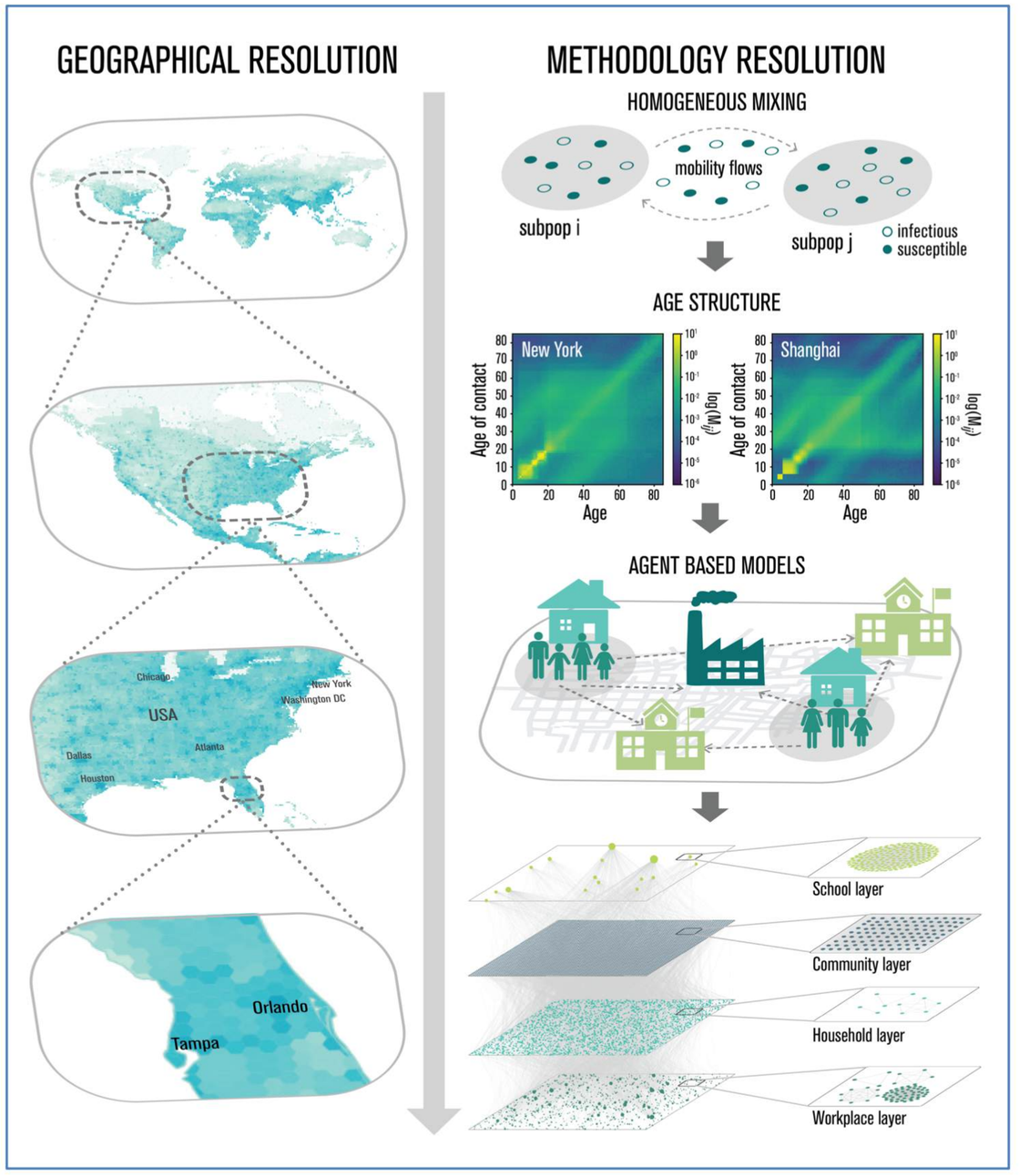
multiscale framework





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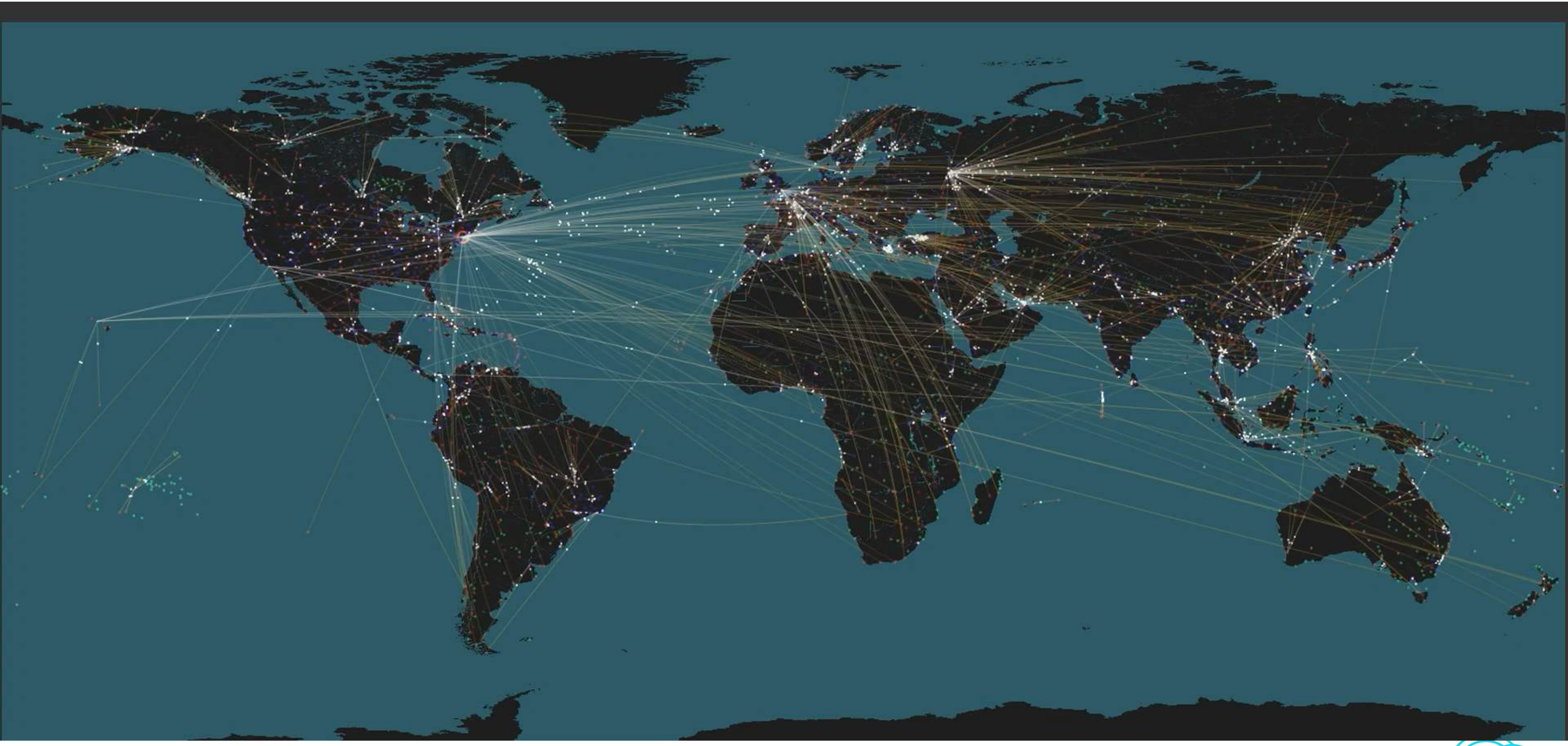

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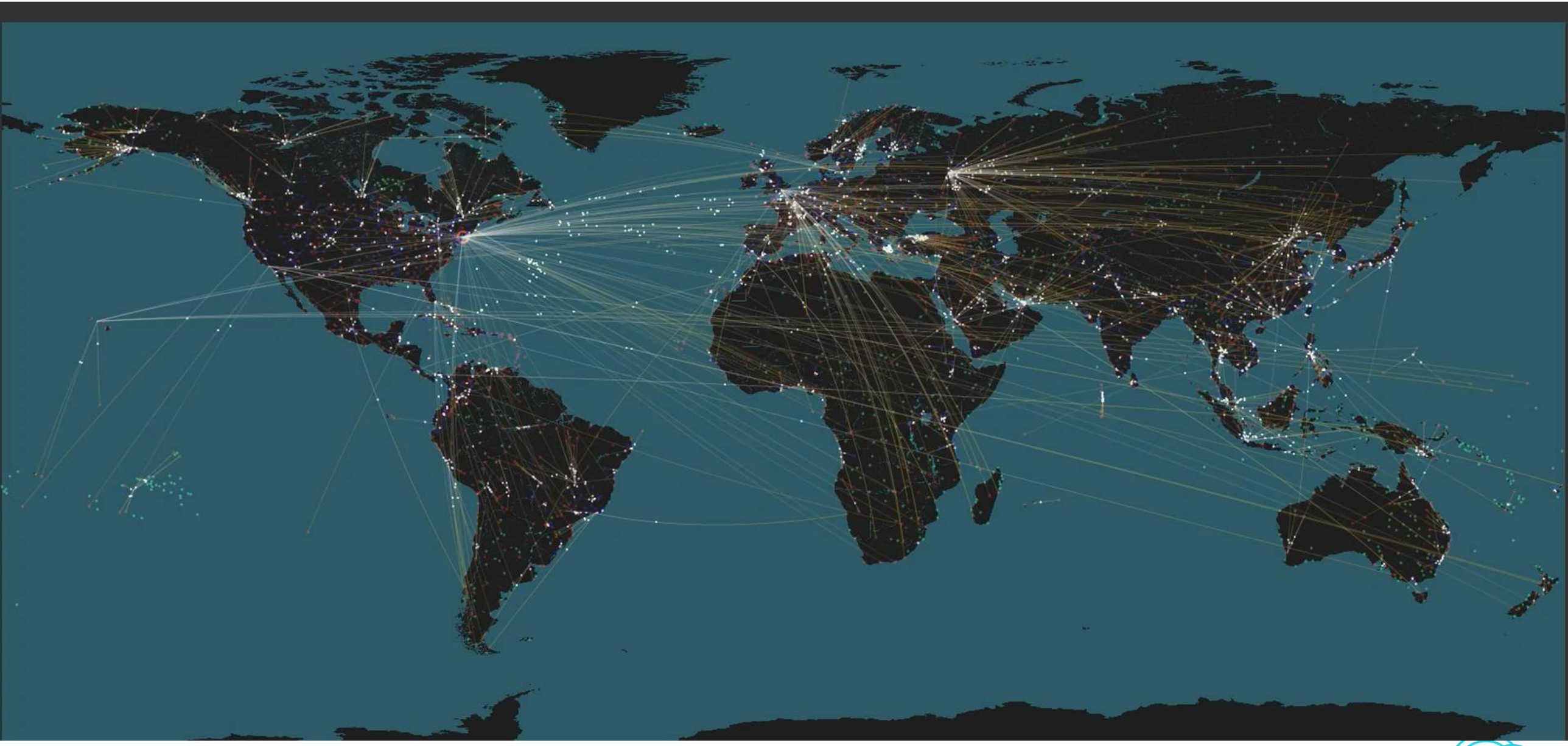

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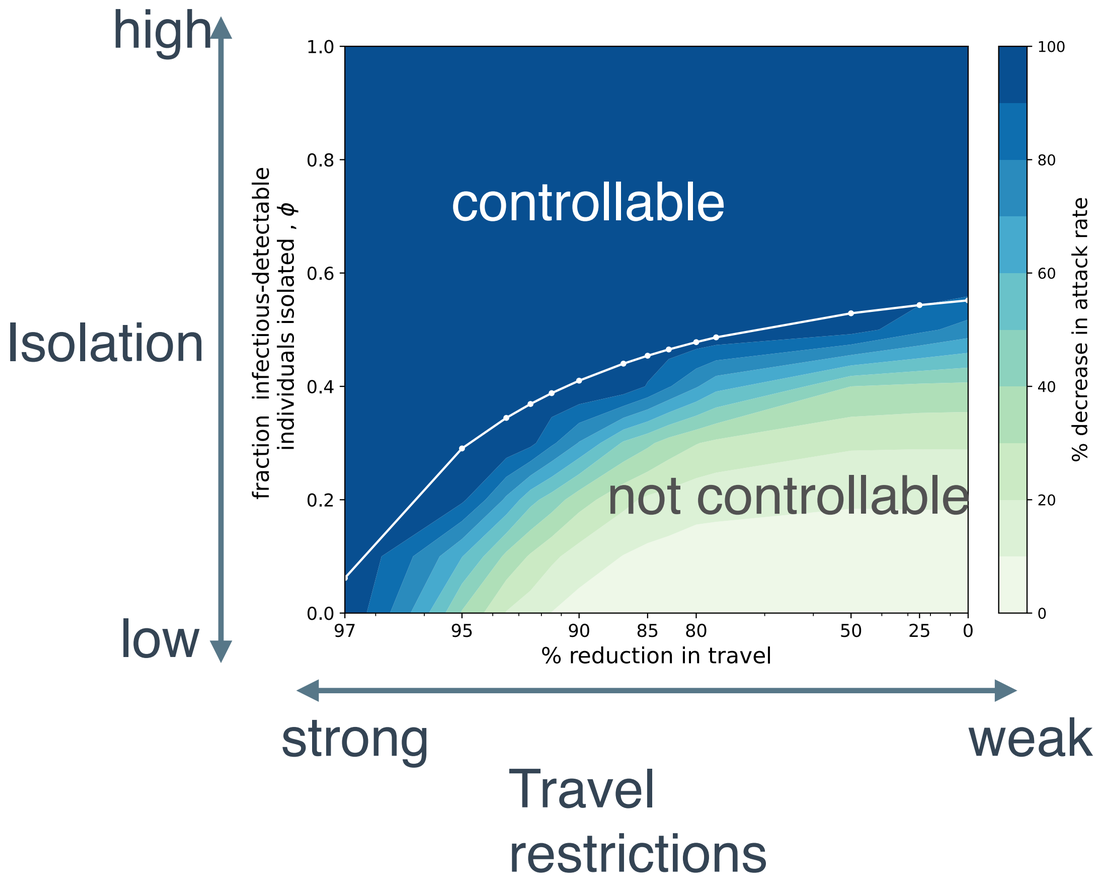
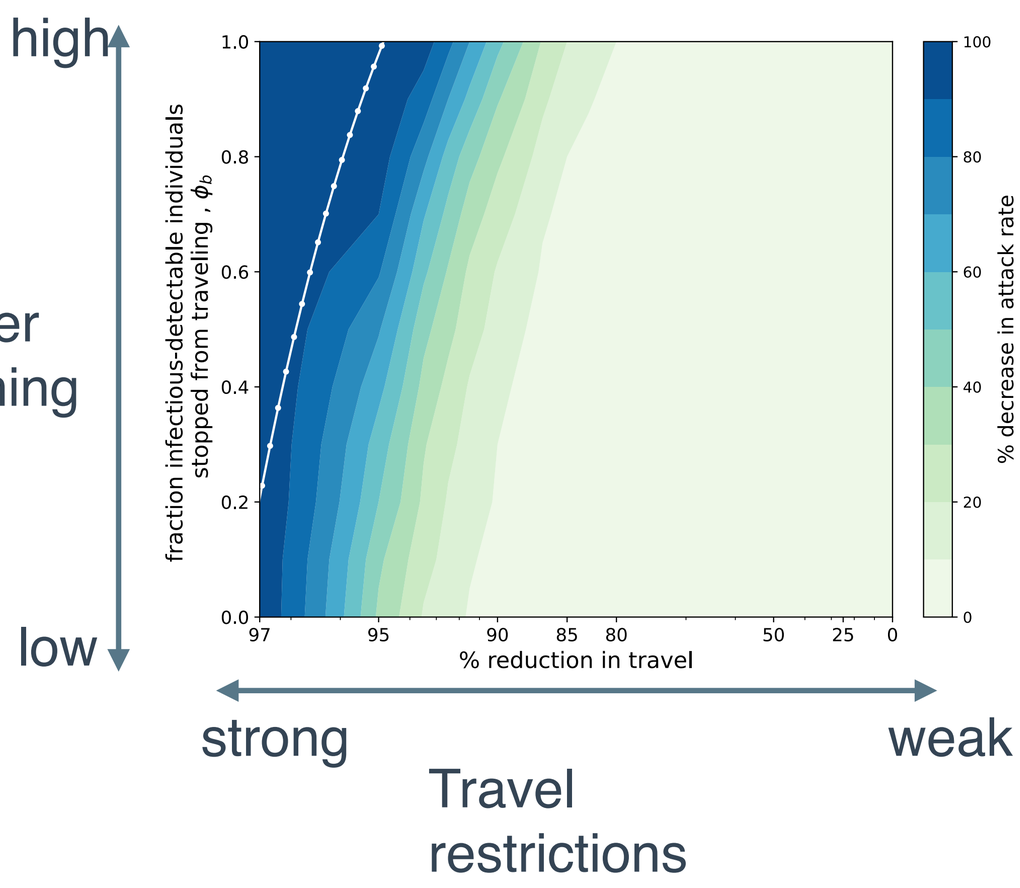
Where to put your resources…..

Clara bay, Jessica Davis 2024

Isolation & travel restrictions



Border screening & travel restrictions



Local interventions are more effective at reducing the total number of individuals infected.

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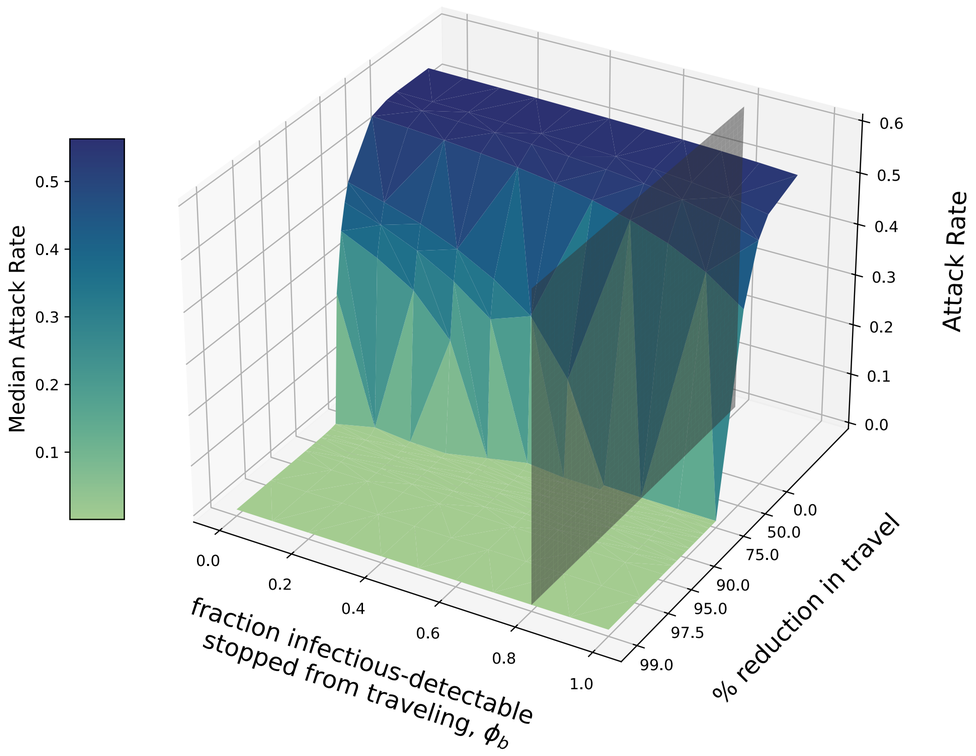
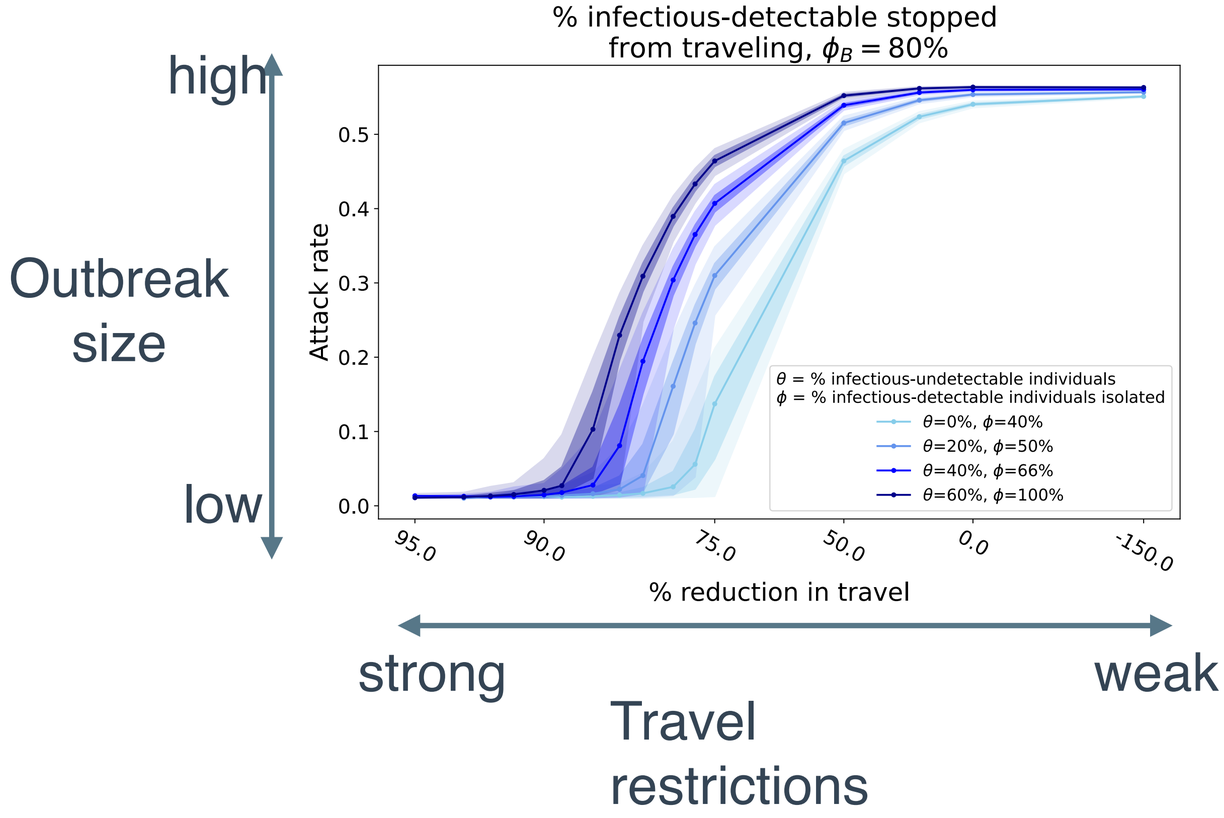
Combining interventions





Undetected cases shift threshold to a widespread global outbreak where more undetectable cases require stricter travel restrictions to control an outbreak.

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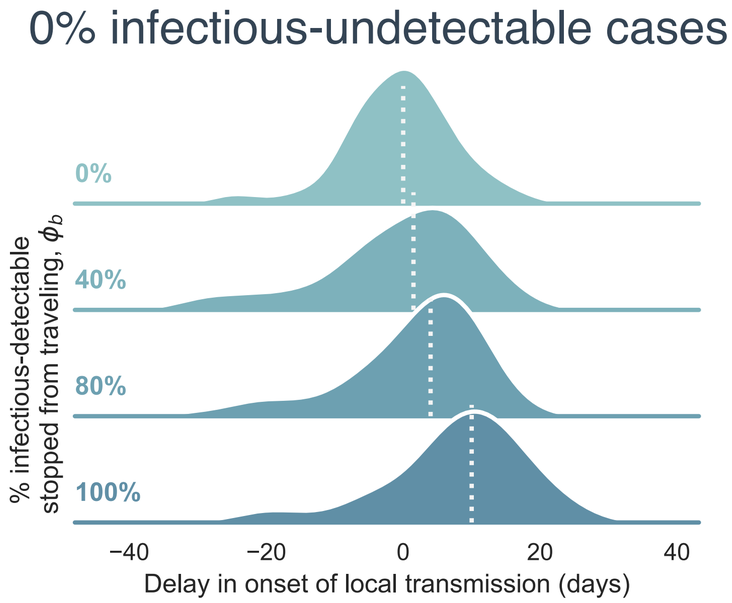
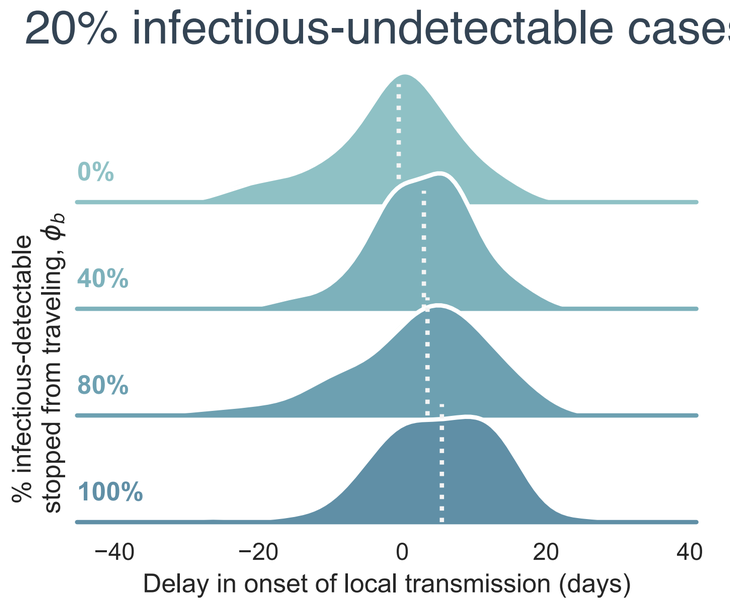
Highly effective border screening can delay the onset of local transmission by up to 10 days if there are no undetectable infections.

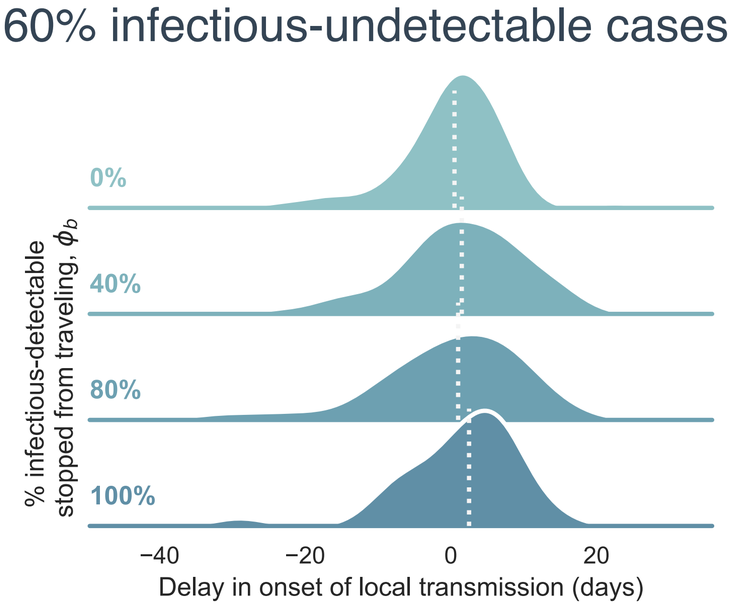
If 20% of cases are asymptomatic, this delay is reduced to 5 days.

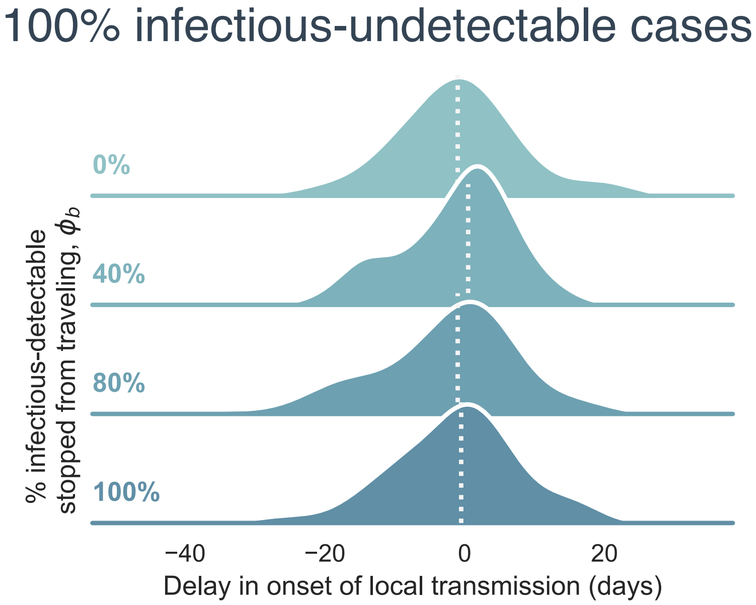
Border screening is ineffective for high levels of undetectable infections.

Onset of local transmission: time when 10 new transmission events occur in a

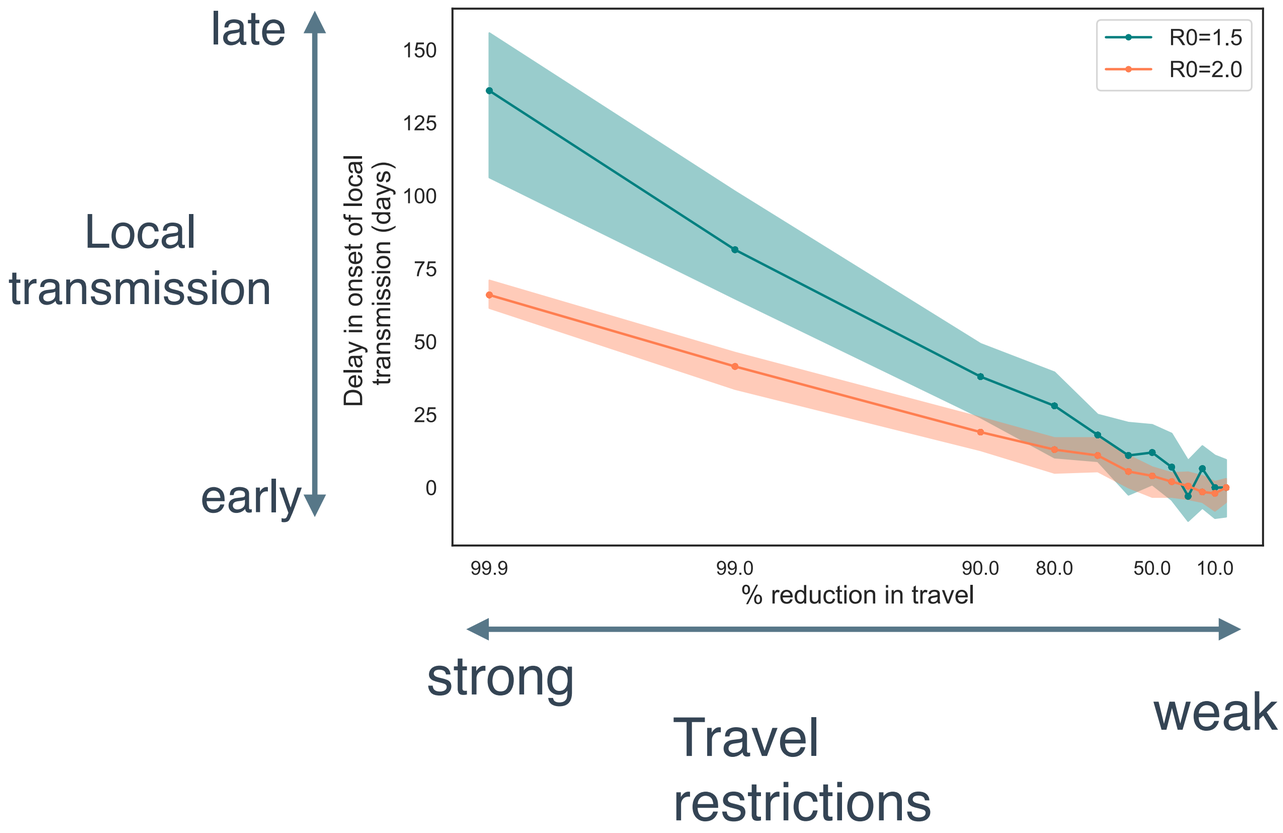








Timing of local transmission onset



Travel restrictions must be highly effective to reduce the number of cases, especially for higher R0.

Travel restrictions delay the onset of local transmission in a logarithmic manner.

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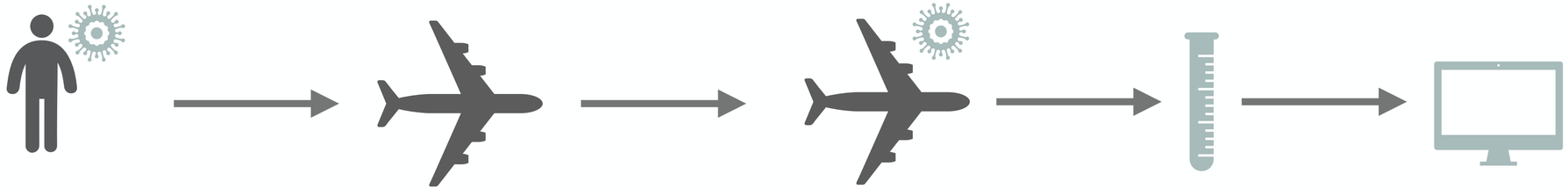
Modeling platform simulating the detection of specific pathogens among international travelers on arrival (nasal swab) or through wastewater surveillance (WWS) during outbreaks or epidemics.



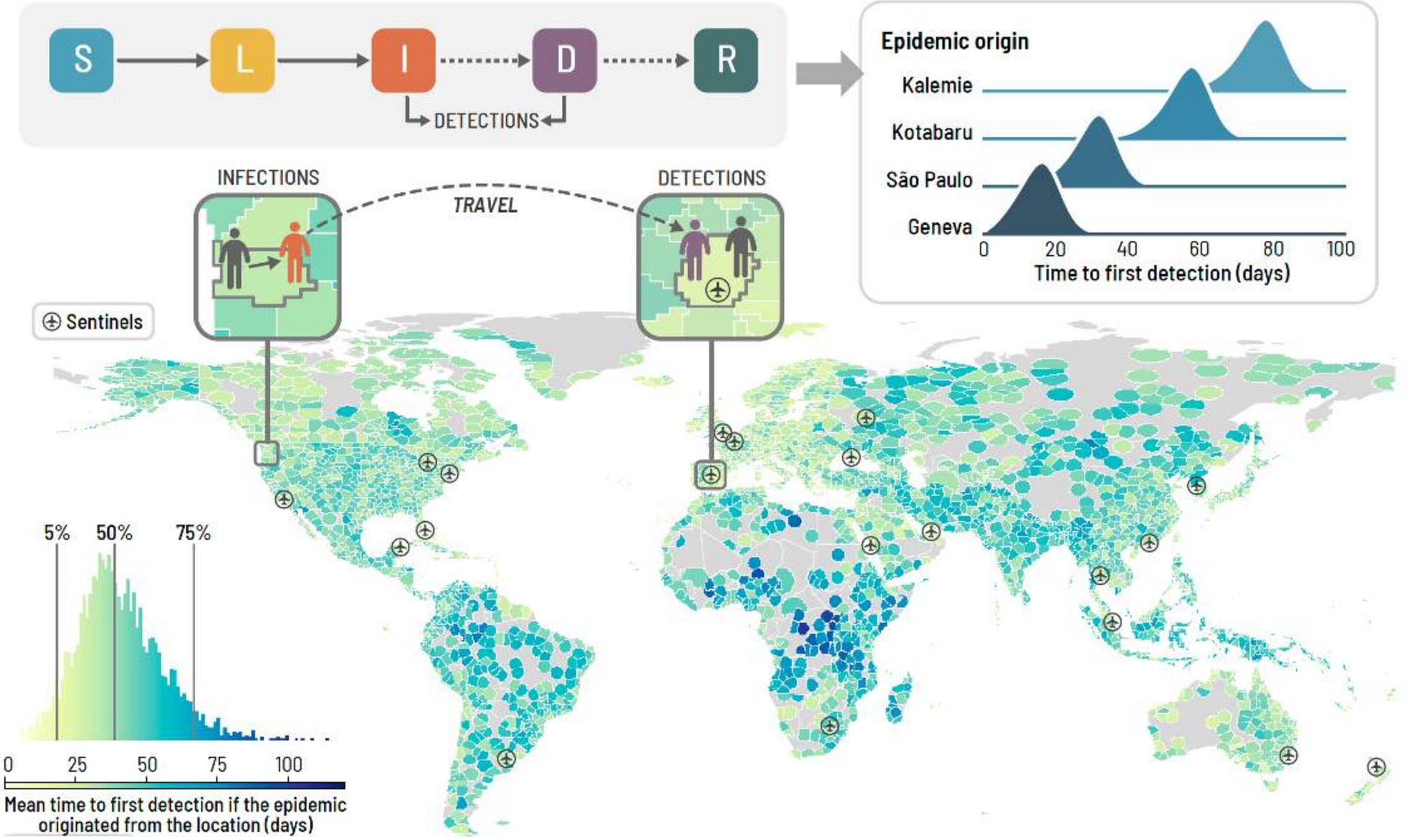
Collaborators&Stakeholders:

- Northeastern
- Concentric Ginkgo Bioworks
- Indiana University
- CDC Division of Global Migration Health
- BMGF
- University of Vermont

Optimization and performance analytics of global aircraft-based wastewater surveillance networks

Guillaume St-Onge, Jessica T. Davis, Laurent Hébert-Dufresne, Antoine Allard, Alessandra Urbinati, Samuel V. Scarpino, Matteo Chinazzi, Alessandro Vespignani

doi: https://doi.org/10.1101/2024.08.02.24311418


S
L
I
D
R
DETECTIONS
Epidemic origin
Kalemie
Kotabaru
São Paulo
Geneva
0
20
40
60
80
100
Time to first detection (days)
INFECTIONS
TRAVEL
DETECTIONS
Sentinels
5%
50%
75%
0
25
50
75
100
Mean time to first detection if the epidemic originated from the location (days)

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Modeling platform for Travel-Based Genomic and Wastewater Outbreak surveillance

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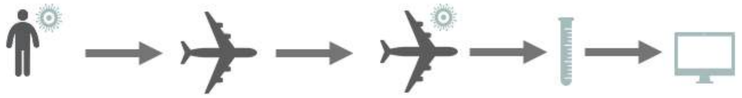
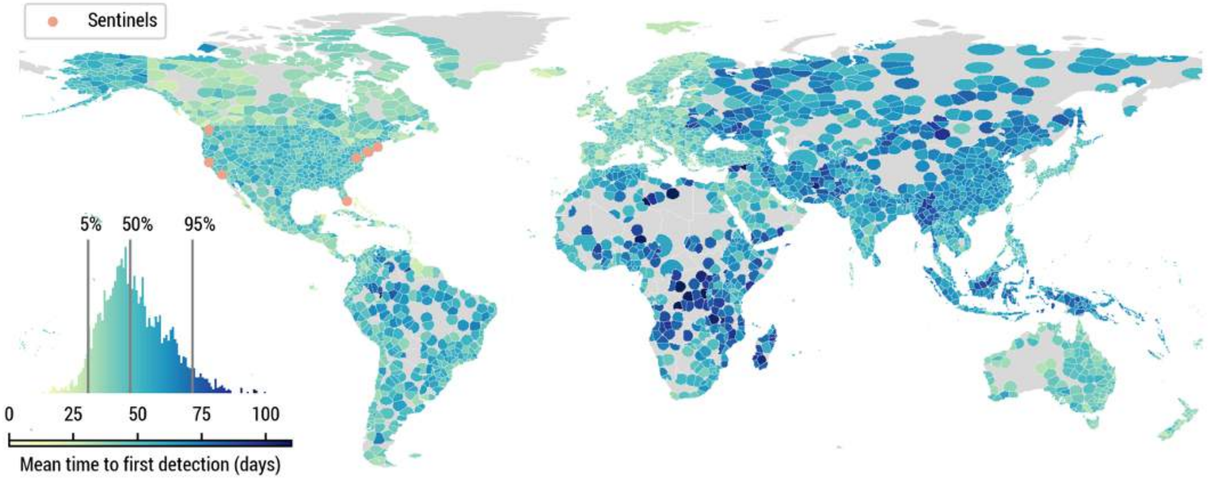
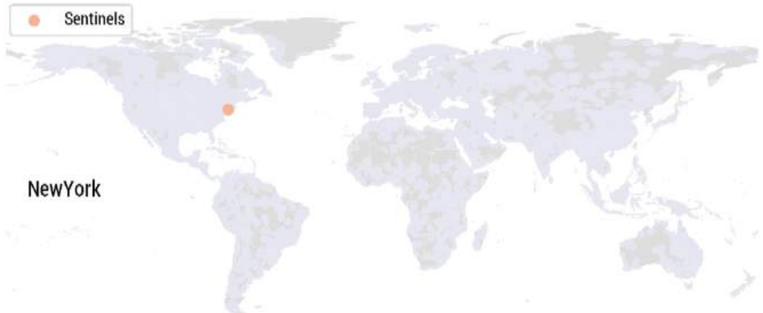


Modeling objectives

- Which airports in the US?
- Which international flight routes?
- Performance analysis
- Adaptive strategies



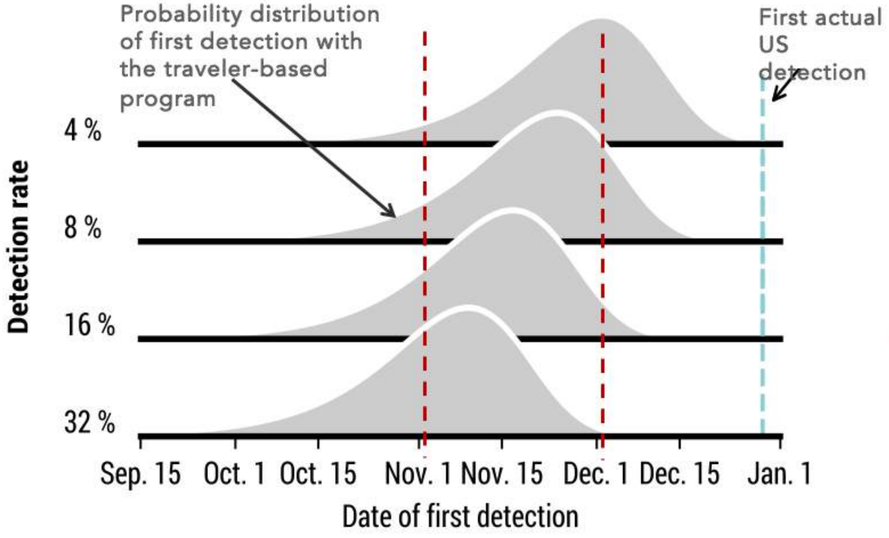
Optimization: top 10 sentinel locations in the US



NewYork
LosAngeles
Miami
SanFrancisco
Baltimore
Chicago
Boston
Houston
Orlando
Seattle

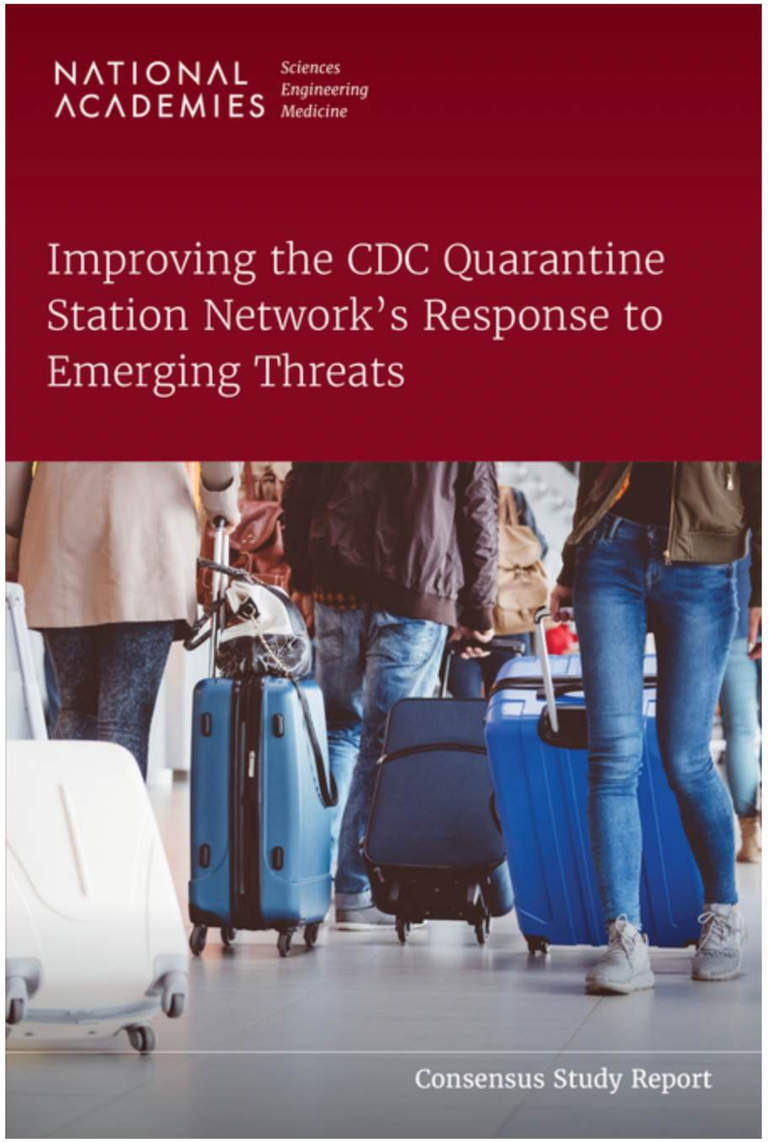
- Darker color = higher reduction of the mean time to first detection

B.1.1.7 (Alpha variant) counterfactual



- Increase in reproduction number ~40%
- UK origin during the week of September 13–19, 2020
- Detection 1 to 2 month before actual detection

- Containment and monitoring for H5N1 should happen now when we have a smoking gun (poultry/cattle farming).
- More rapid modeling with specific information on the outbreak (seasonality, starting dates, intervention capacities)- SMH Insighnet effort.
- Developing a realistic playbook considering a large catalog of possible scenarios



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