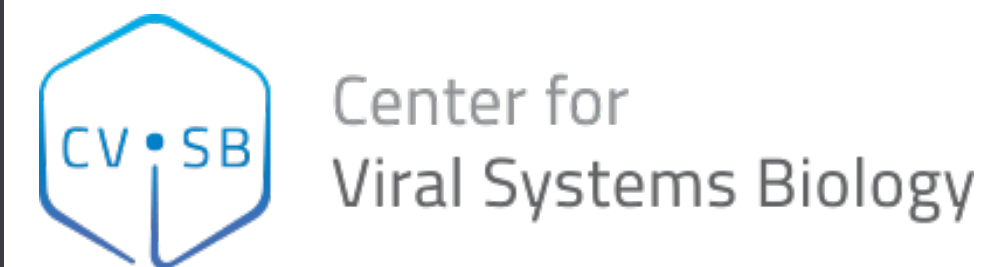
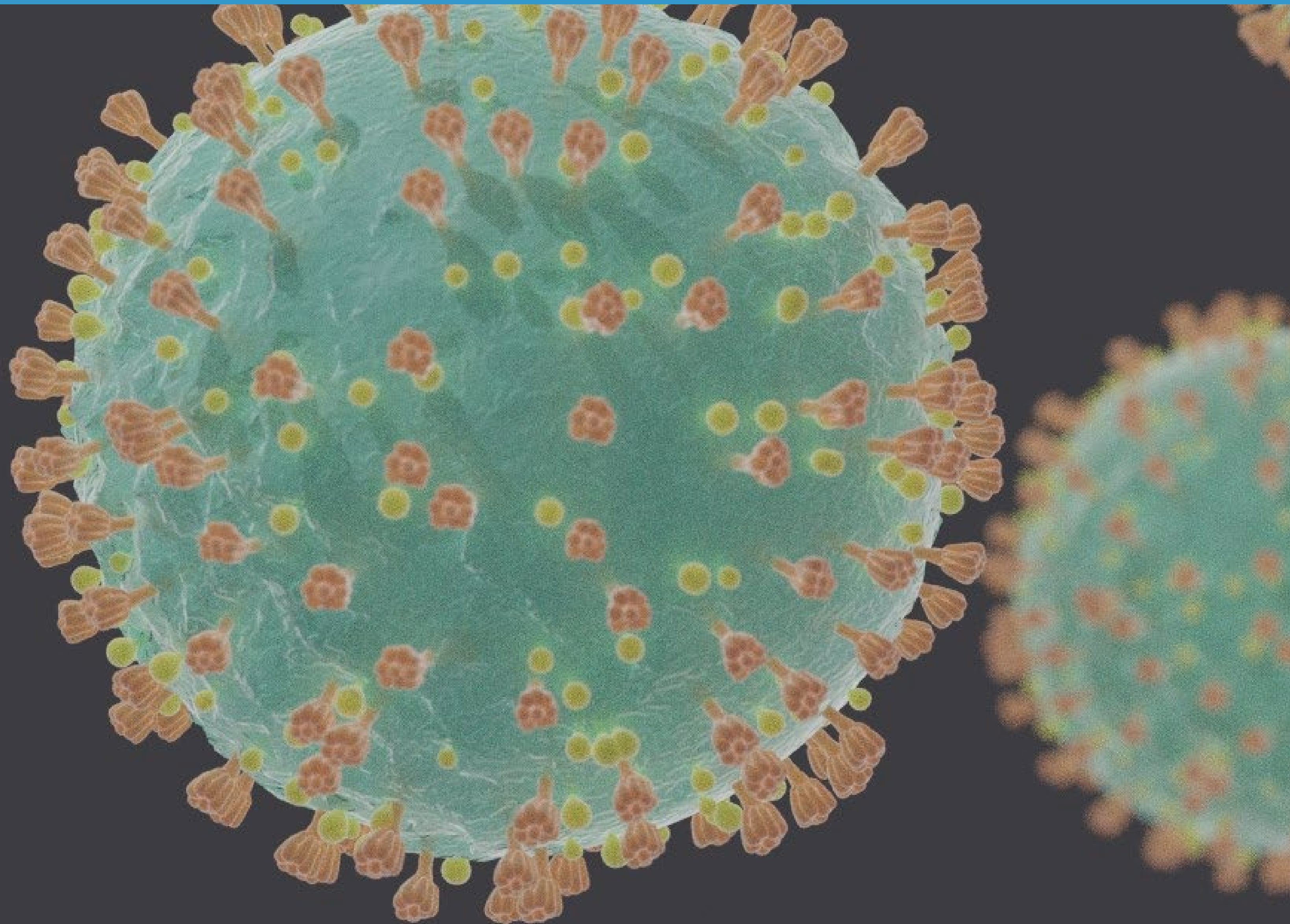


Outbreaky'omics



Surveillance

Emergence

Detection

Epidemic > Endemic

What is out there?

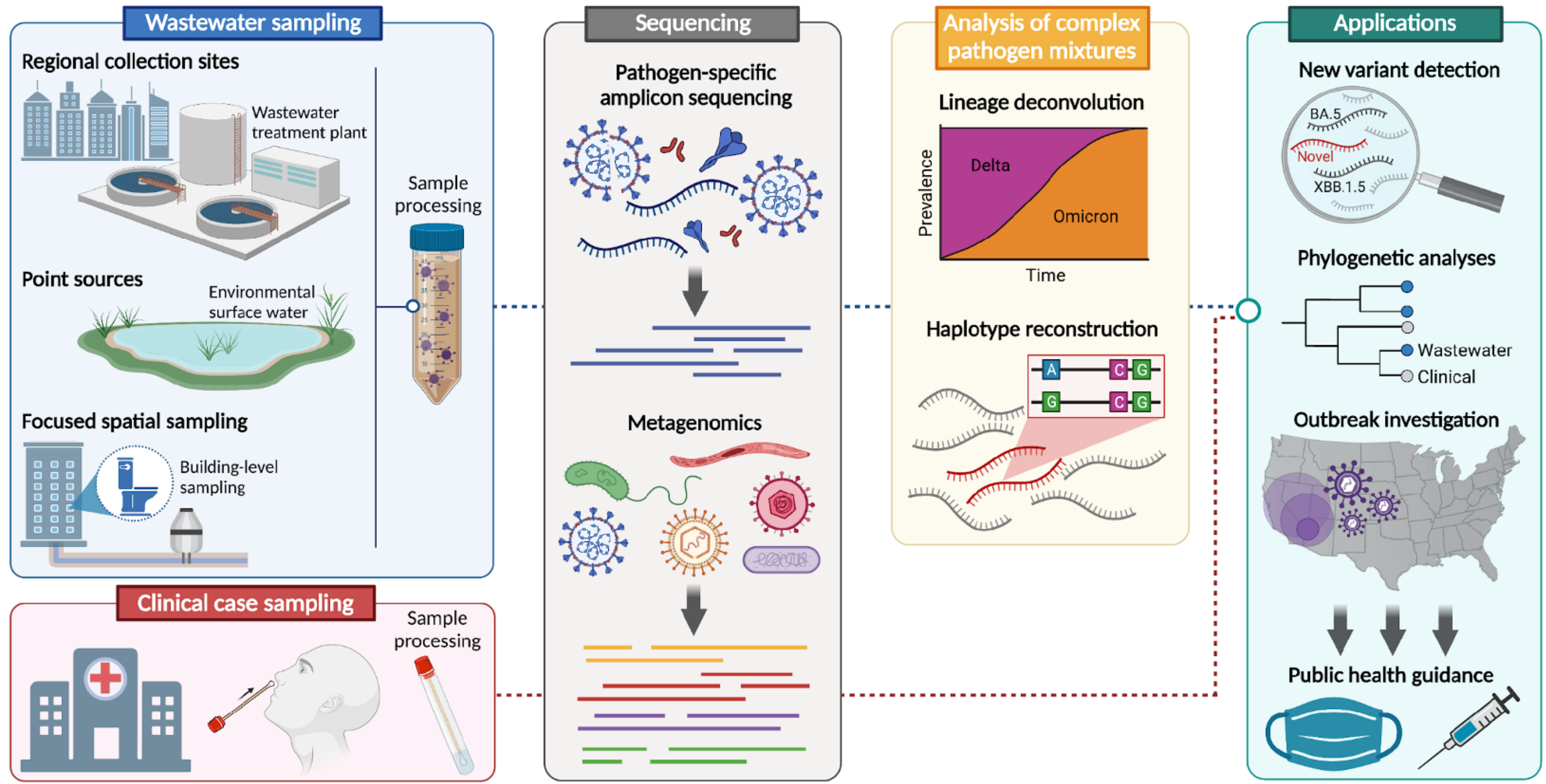
Active vs Passive Surveillance

Expected

Unexpected

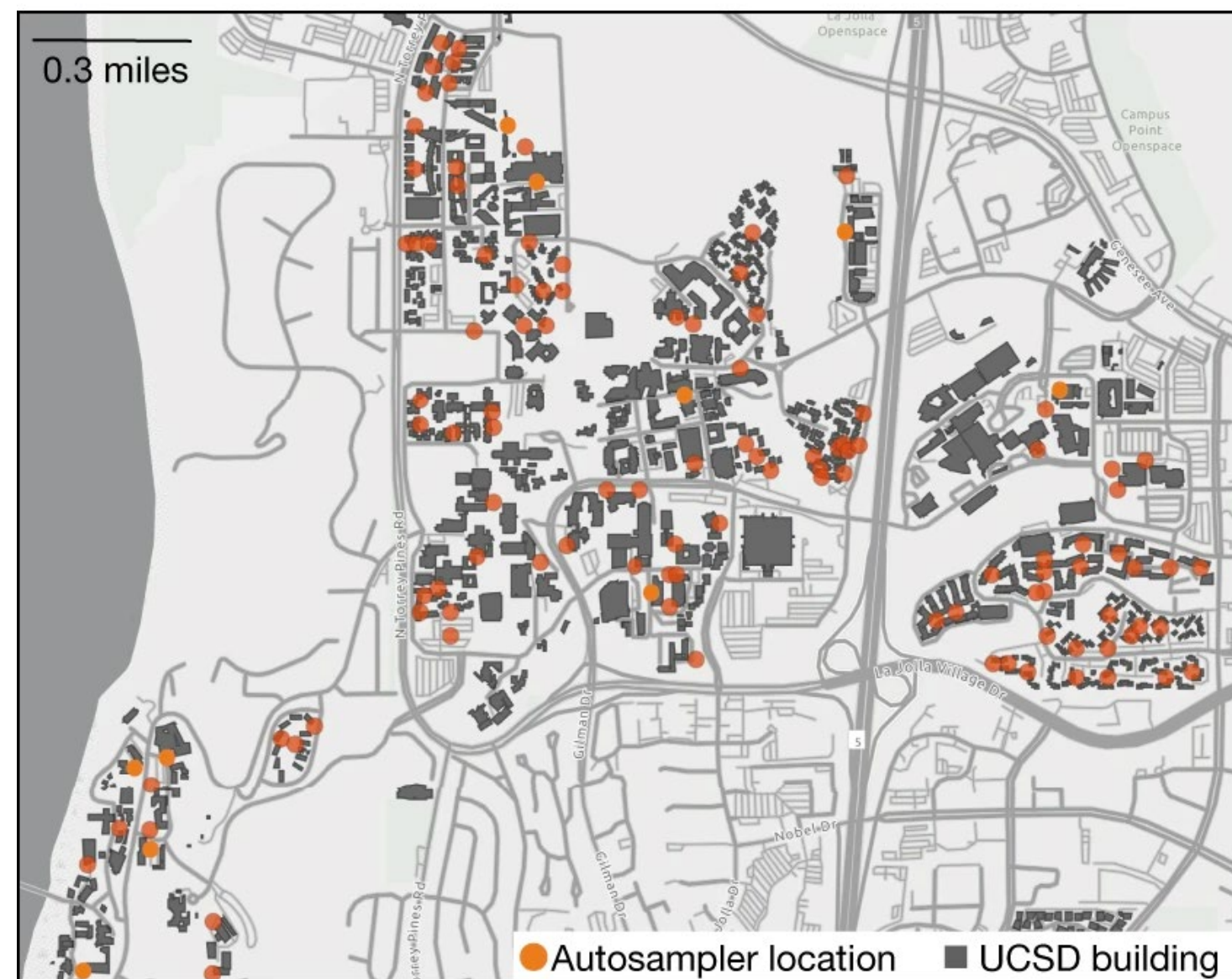
Novel

💩 the future!



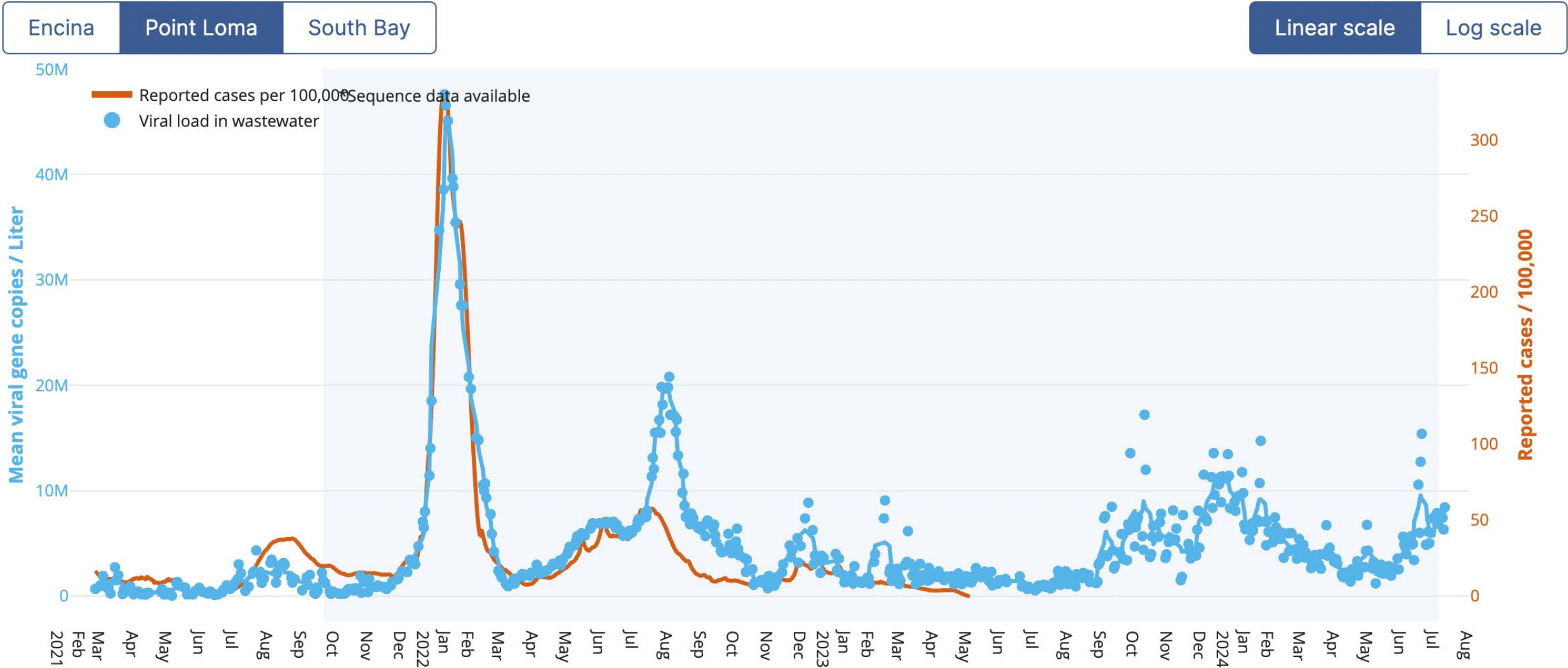
Passive surveillance
that is
Active

What is possible in San Diego should also be possible anywhere else



Barnes et al., Nature Communications 2023
Yousif et al., Nature Communications 2023
Levy et al., Science 2023
Karthikeyan et al., Nature 2022

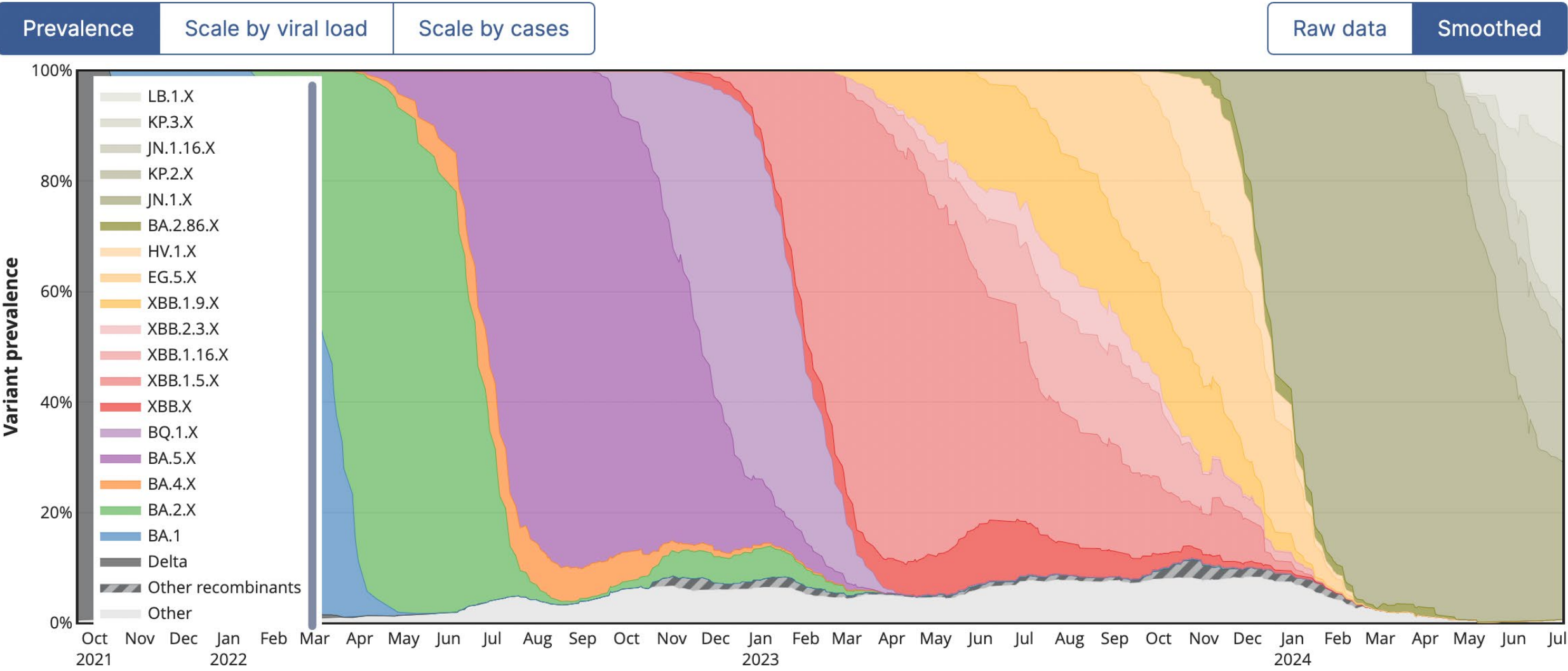
Real-time monitoring of viral dynamics | San Diego



Lineage	Growth Advantage	Bootstrap 95% CI
KP.3.X	11.7%	[6.07% , 19.90%]
KP.2.X	2.8%	[-3.69% , 9.61%]
LB.1.X	1.9%	[-26.94% , 26.40%]
JN.1.11.X	-3.0%	[-14.35% , 5.76%]
JN.1.16.X	-4.8%	[-17.57% , 11.75%]
KQ.1.X	-12.4%	[-249.77% , -6.18%]
JN.1.7.X	-26.0%	[-164.21% , -16.11%]
JN.1.X	-129.2%	[-215.28% , 34.53%]

Updated at July 15 @ 06:33 PM PDT

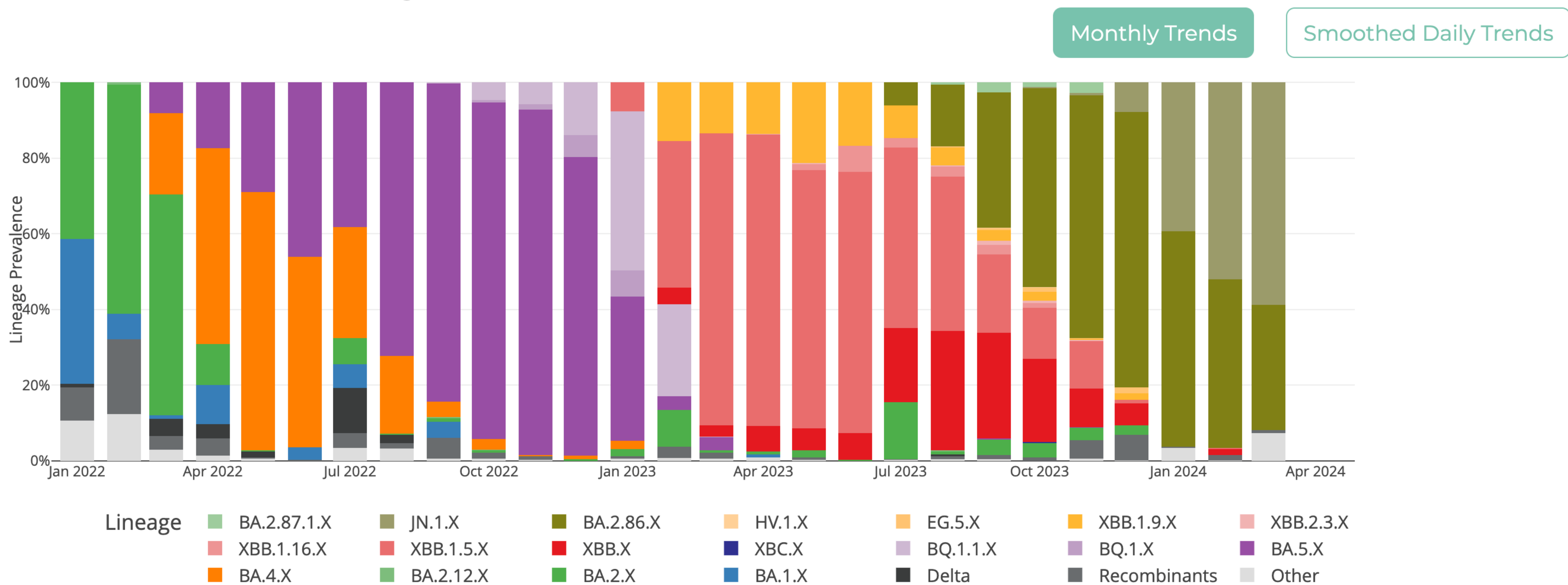
Wastewater lineages



Real-time monitoring of viral dynamics | South Africa



Lineage Prevalence Observed via Wastewater



Participating Institutions

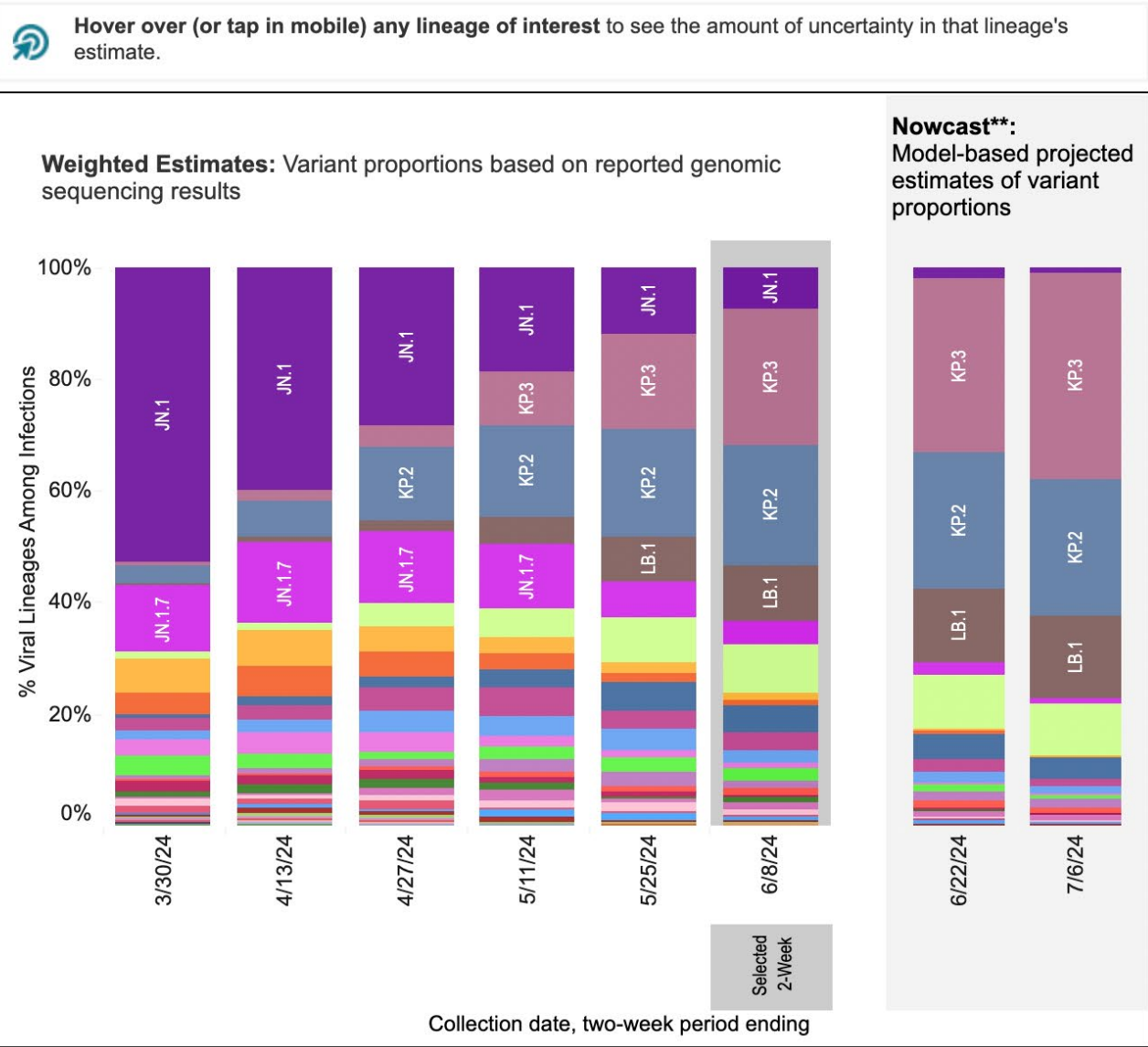


Real-time monitoring of viral dynamics | United States



COVID Data Tracker

Weighted Estimates in United States for 2-Week Periods in 3/17/2024 – 7/6/2024



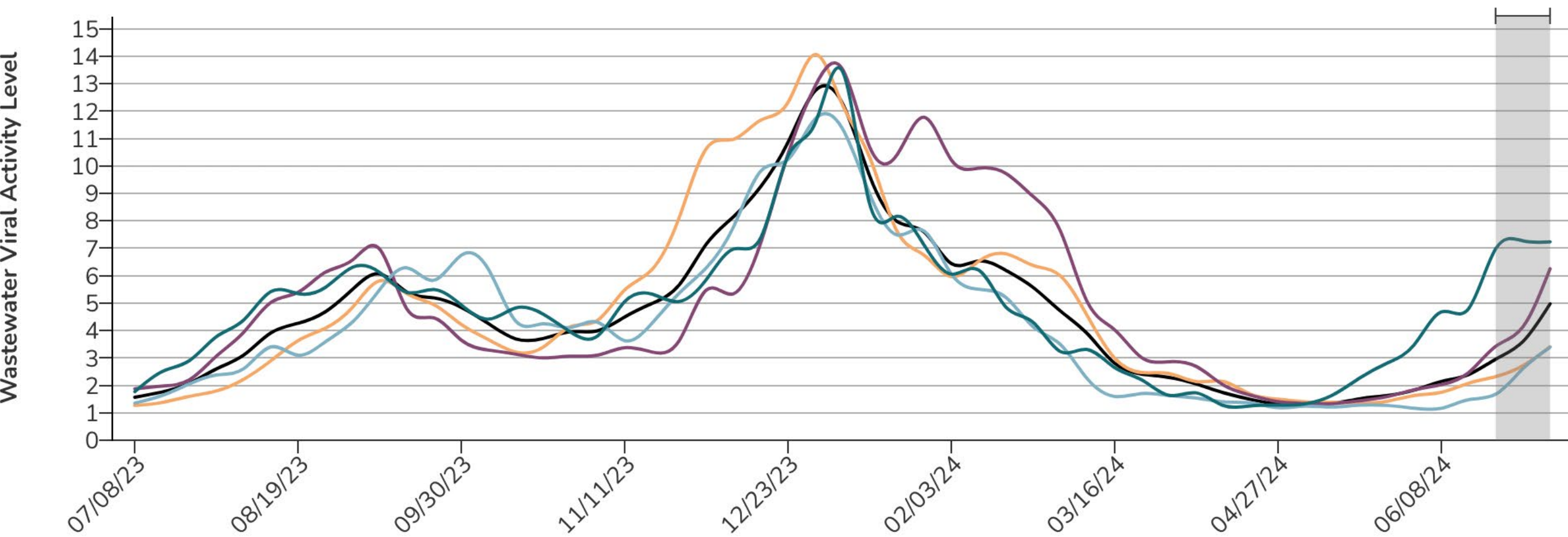
Weighted Estimates in United States for 5/26/2024 – 6/8/2024

USA				
WHO label	Lineage #	%Total	95%CI	
Omicron	KP.3	24.5%	18.4-31.6%	
	KP.2	21.5%	17.5-25.9%	
	LB.1	10.0%	5.2-17.0%	
	KP.1.1	8.9%	4.6-15.2%	
	JN.1	7.4%	4.8-10.9%	
	JN.1.16.1	4.8%	2.5-8.2%	
	JN.1.7	† 4.0%	1.7-7.9%	
	JN.1.16	3.1%	1.6-5.4%	
	JN.1.18	2.2%	1.2-3.7%	
	JN.1.11.1	2.1%	1.1-3.7%	
	XDV.1	† 1.4%	0.2-5.0%	
	KP.4.1	† 1.3%	0.4-3.4%	
	JN.1.13.1	† 1.2%	0.3-3.0%	
	KS.1	† 1.1%	0.4-2.6%	
	KQ.1	† 1.1%	0.1-3.7%	
	JN.1.8.1	† 1.0%	0.3-2.4%	
	JN.1.32	† 0.8%	0.0-4.4%	
	KW.1.1	† 0.8%	0.2-2.2%	
	XDP	† 0.6%	0.1-1.8%	
	KV.2	† 0.3%	0.0-1.2%	
	JN.1.4.3	† 0.3%	0.0-1.5%	
	BA.2	† 0.0%	0.0-0.4%	

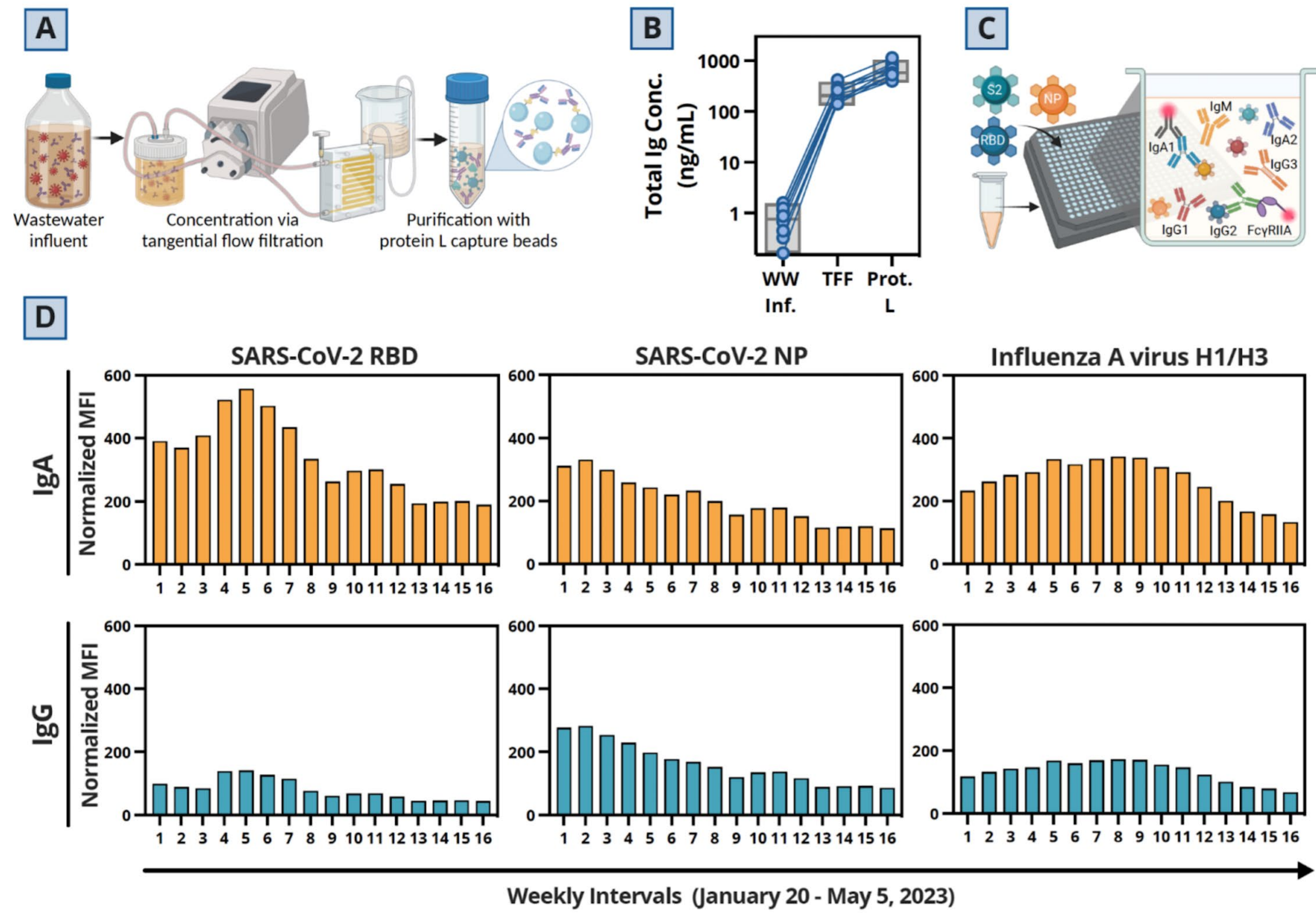


National Wastewater Surveillance System (NWSS)

1 Year

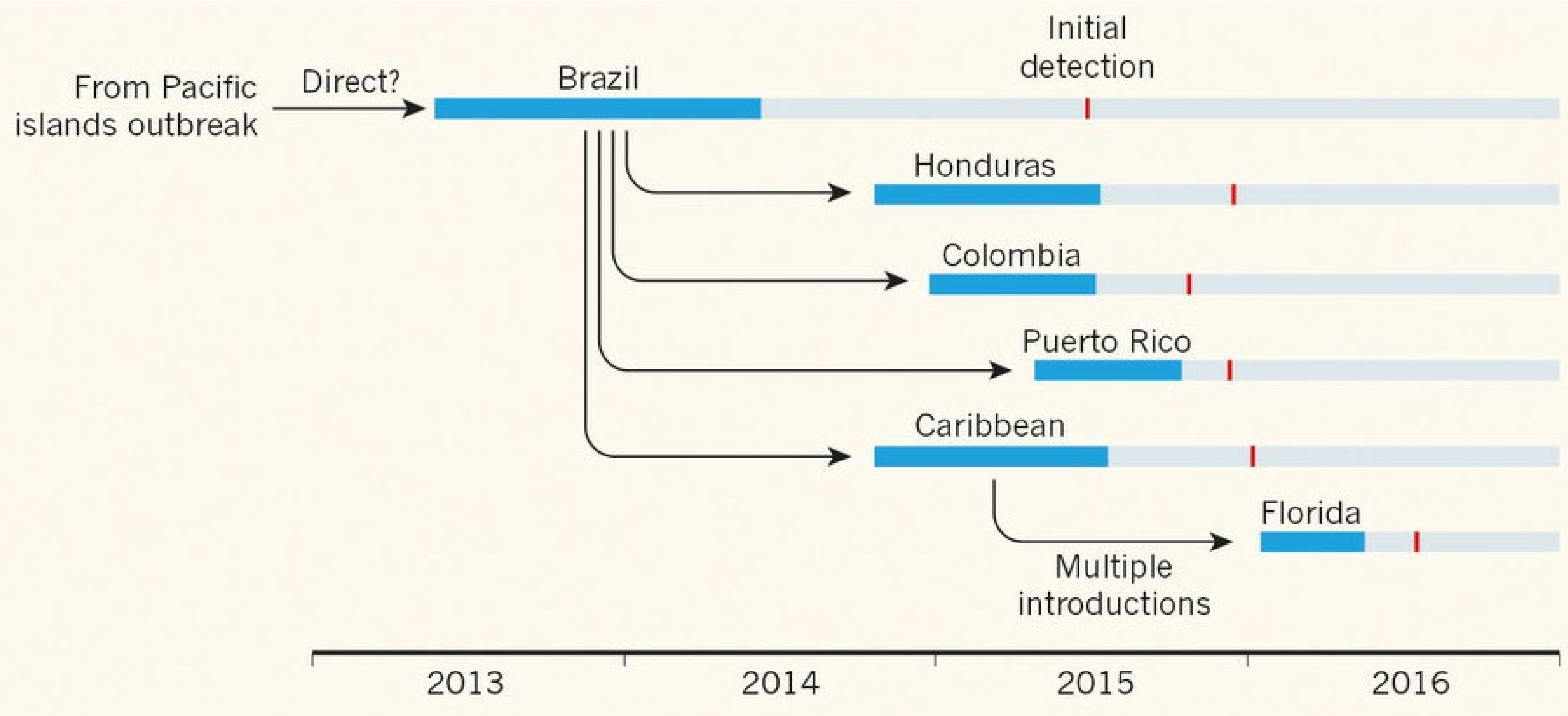


Profiling population-wide immunity using 🦌



Shortening surveillance gaps

Surveillance Gaps are widespread | Zika example



Genomic epidemiology reveals multiple introductions of Zika virus into the United States

[Nathan D. Grubaugh](#), [Jason T. Ladner](#), [Moritz U. G. Kraemer](#), [Gytis Dudas](#), [Amanda L. Tan](#), [Karthik Gangavarapu](#), [Michael R. Wiley](#), [Stephen White](#), [Julien Thézé](#), [Diogo M. Magnani](#), [Karla Prieto](#), [Daniel Reyes](#), [Andrea M. Bingham](#), [Lauren M. Paul](#), [Refugio Robles-Sikisaka](#), [Glenn Oliveira](#), [Darryl Pronty](#), [Carolyn M. Barcellona](#), [Hayden C. Metsky](#), [Mary Lynn Baniecki](#), [Kayla G. Barnes](#), [Bridget Chak](#), [Catherine A. Freije](#), [Adrianne Gladden-Young](#), ... [Kristian G. Andersen](#) ✉

[+ Show authors](#)

[Nature](#) **546**, 401–405 (2017) | [Cite this article](#)

Zika virus evolution and spread in the Americas

[Hayden C. Metsky](#), [Christian B. Matranga](#), [Shirlee Wohl](#), [Stephen F. Schaffner](#), [Catherine A. Freije](#), [Sarah M. Winnicki](#), [Kendra West](#), [James Qu](#), [Mary Lynn Baniecki](#), [Adrianne Gladden-Young](#), [Aaron E. Lin](#), [Christopher H. Tomkins-Tinch](#), [Simon H. Ye](#), [Daniel J. Park](#), [Cynthia Y. Luo](#), [Kayla G. Barnes](#), [Rickey R. Shah](#), [Bridget Chak](#), [Giselle Barbosa-Lima](#), [Edson Delatorre](#), [Yasmine R. Vieira](#), [Lauren M. Paul](#), [Amanda L. Tan](#), [Carolyn M. Barcellona](#), ... [Pardis C. Sabeti](#)

[+ Show authors](#)

[Nature](#) **546**, 411–415 (2017) | [Cite this article](#)

Establishment and cryptic transmission of Zika virus in Brazil and the Americas

[N. R. Faria](#), [J. Quick](#), [I.M. Claro](#), [J. Thézé](#), [J. G. de Jesus](#), [M. Giovanetti](#), [M. U. G. Kraemer](#), [S. C. Hill](#), [A. Black](#), [A. C. da Costa](#), [L. C. Franco](#), [S. P. Silva](#), [C.-H. Wu](#), [J. Raghvani](#), [S. Cauchemez](#), [L. du Plessis](#), [M. P. Verotti](#), [W. K. de Oliveira](#), [E. H. Carmo](#), [G. E. Coelho](#), [A. C. F. S. Santelli](#), [L. C. Vinhal](#), [C. M. Henriques](#), [J. T. Simpson](#), ... [O. G. Pybus](#) ✉

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[Nature](#) **546**, 406–410 (2017) | [Cite this article](#)

Surveillance Gaps lead to cryptic transmissions

Ebola, West Africa: ~3 months (unexpected, new region)

Zika, Brazil: ~1.5 years (unexpected, new region)

Zika, United States: ~3 months (expected)

Mpox, Nigeria: ~2 years (unexpected, human-to-human transmission)

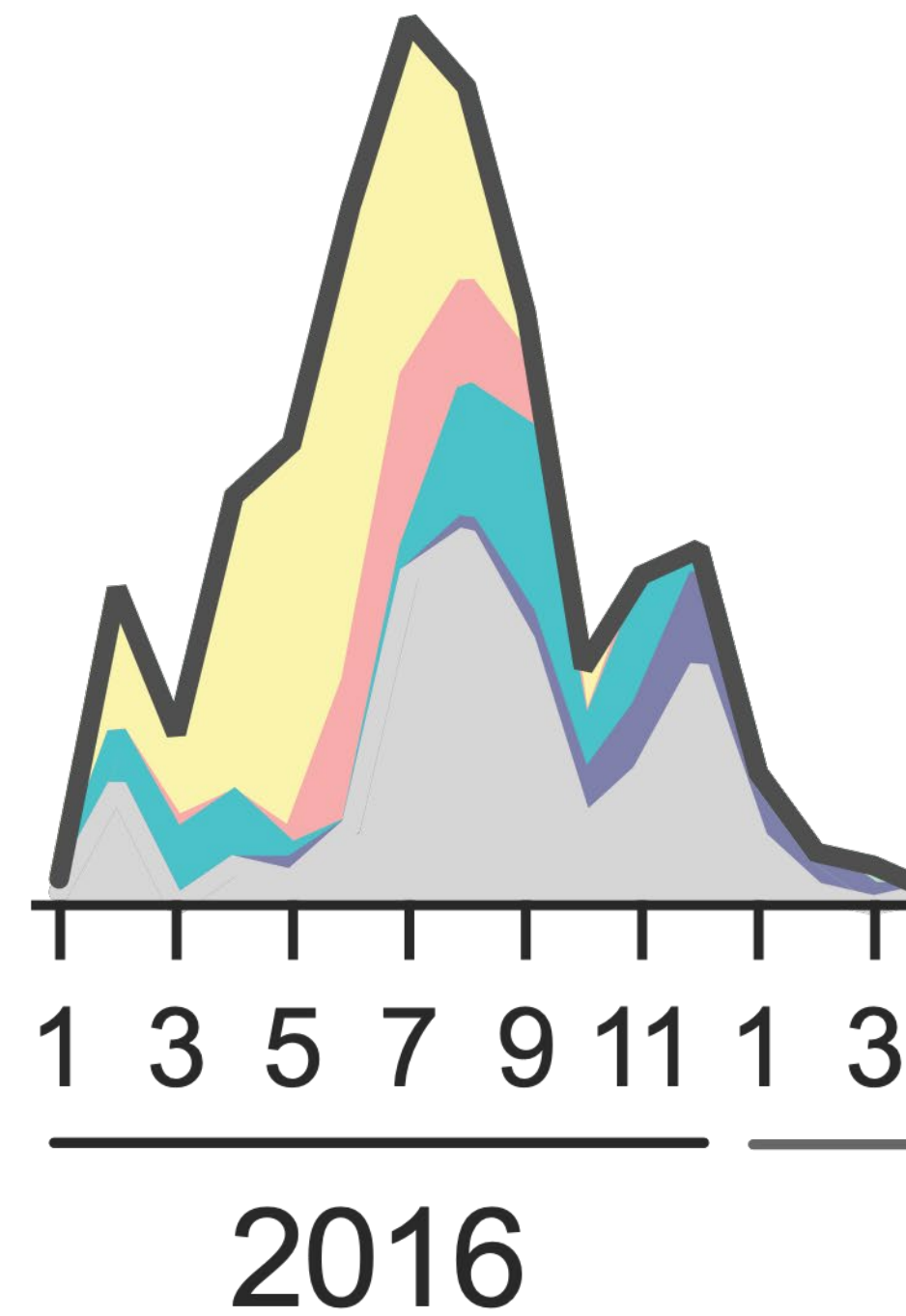
H5N1, United States: ~3 months (should have been expected)

SARS-CoV-2, China: ~1 month (novel)

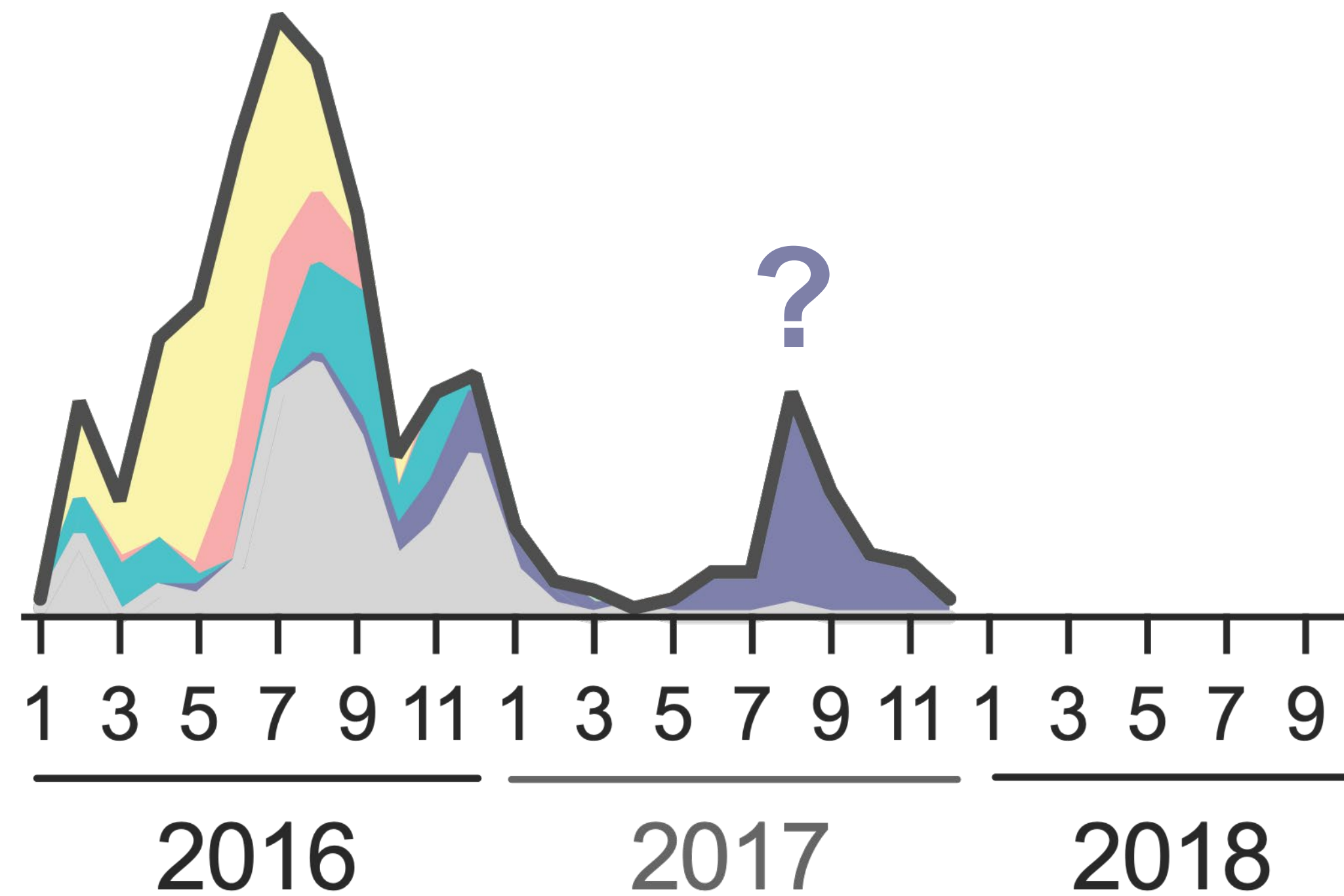
SARS-CoV-2, United States: ~1 month (expected)

SARS-CoV-2 variants, South Africa: ~a few weeks (semi-novel)

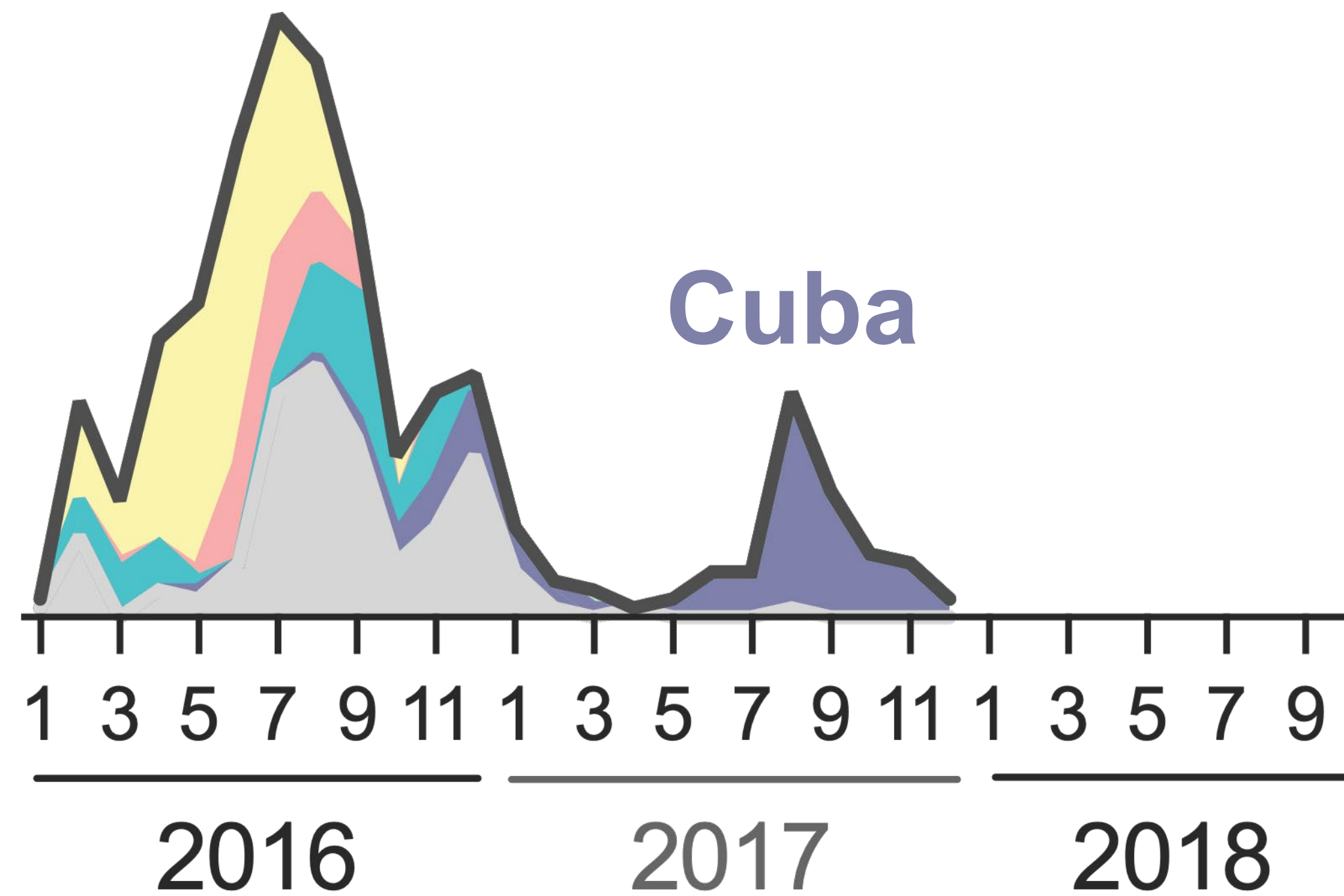
Detecting outbreaks that we don't know about (travel surveillance)



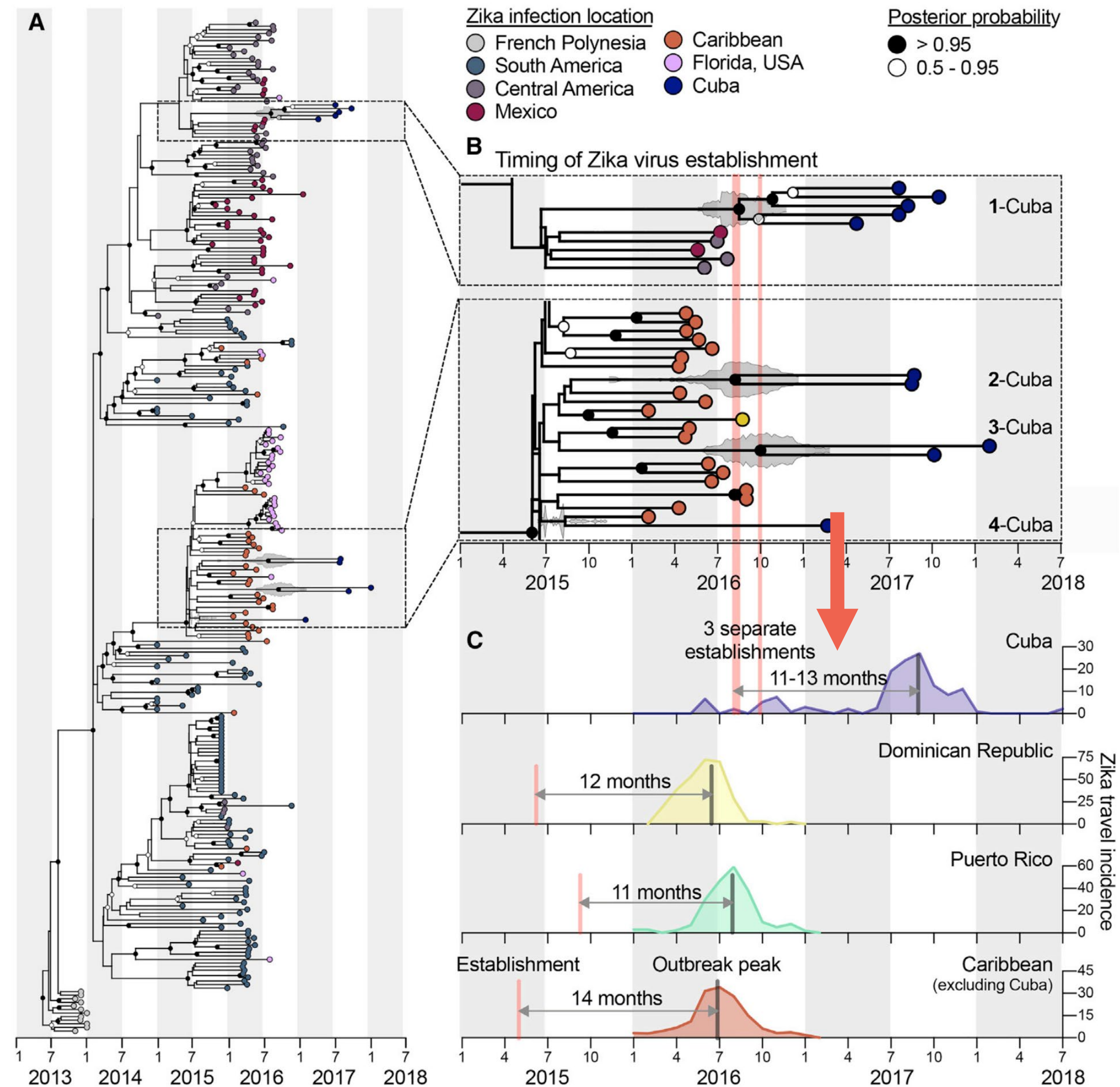
Detecting outbreaks that we don't know about (travel surveillance)



Detecting outbreaks that we don't know about (travel surveillance)



Outbreak in Cuba was delayed by exactly a year



Understanding emergence



武汉华南海鲜批发市场

WUHAN HUANAN HAIXIAN PIFA SHICHANG

停车场 (P) →

杨智辉大闸蟹

杨智辉大闸蟹

孙氏泥鳅鳙鱼

金祥龙虾螃蟹

舒氏水产商行

宋氏甲鱼泥鳅

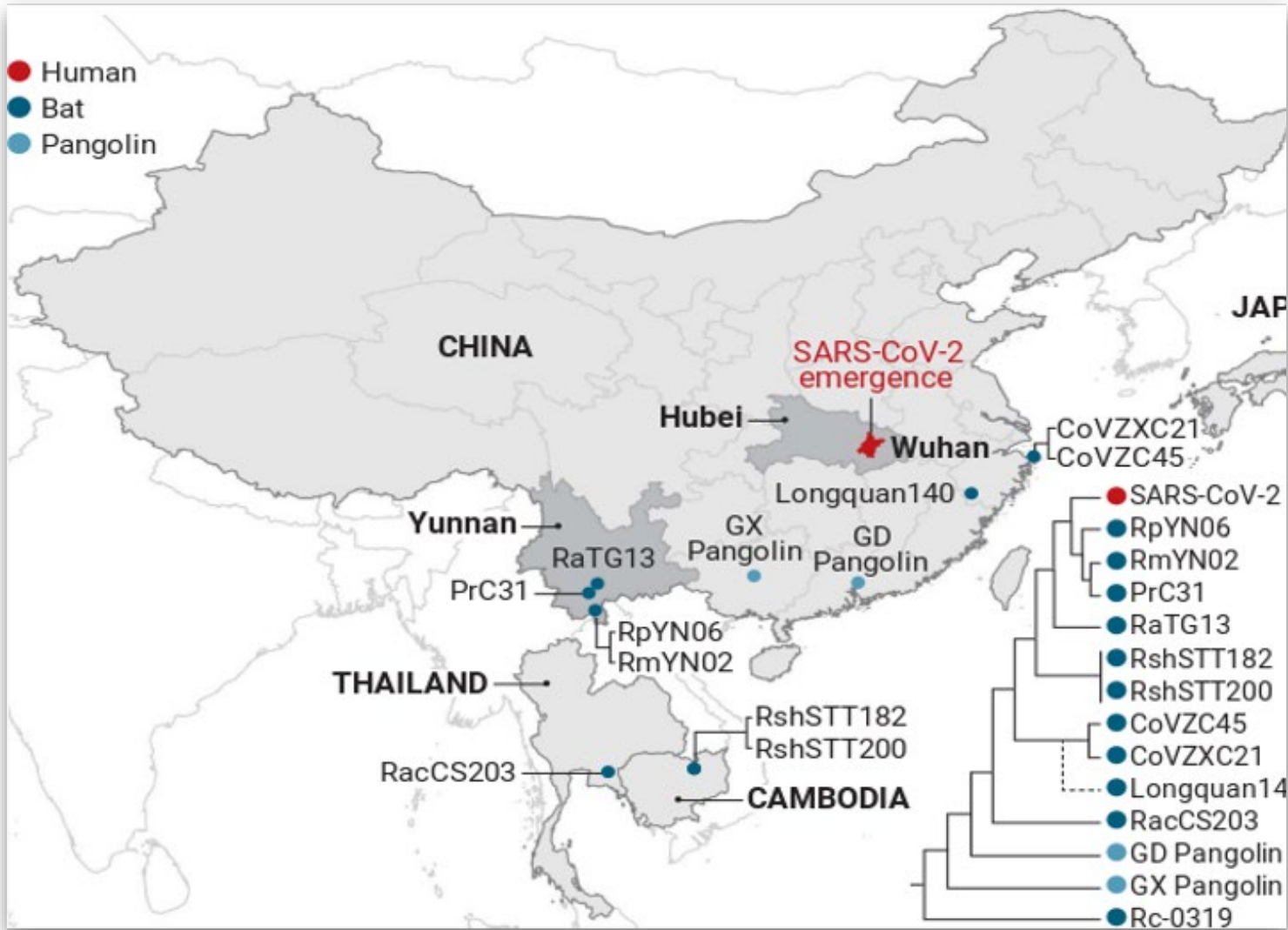
永红

华南海鲜市场停车收费标准

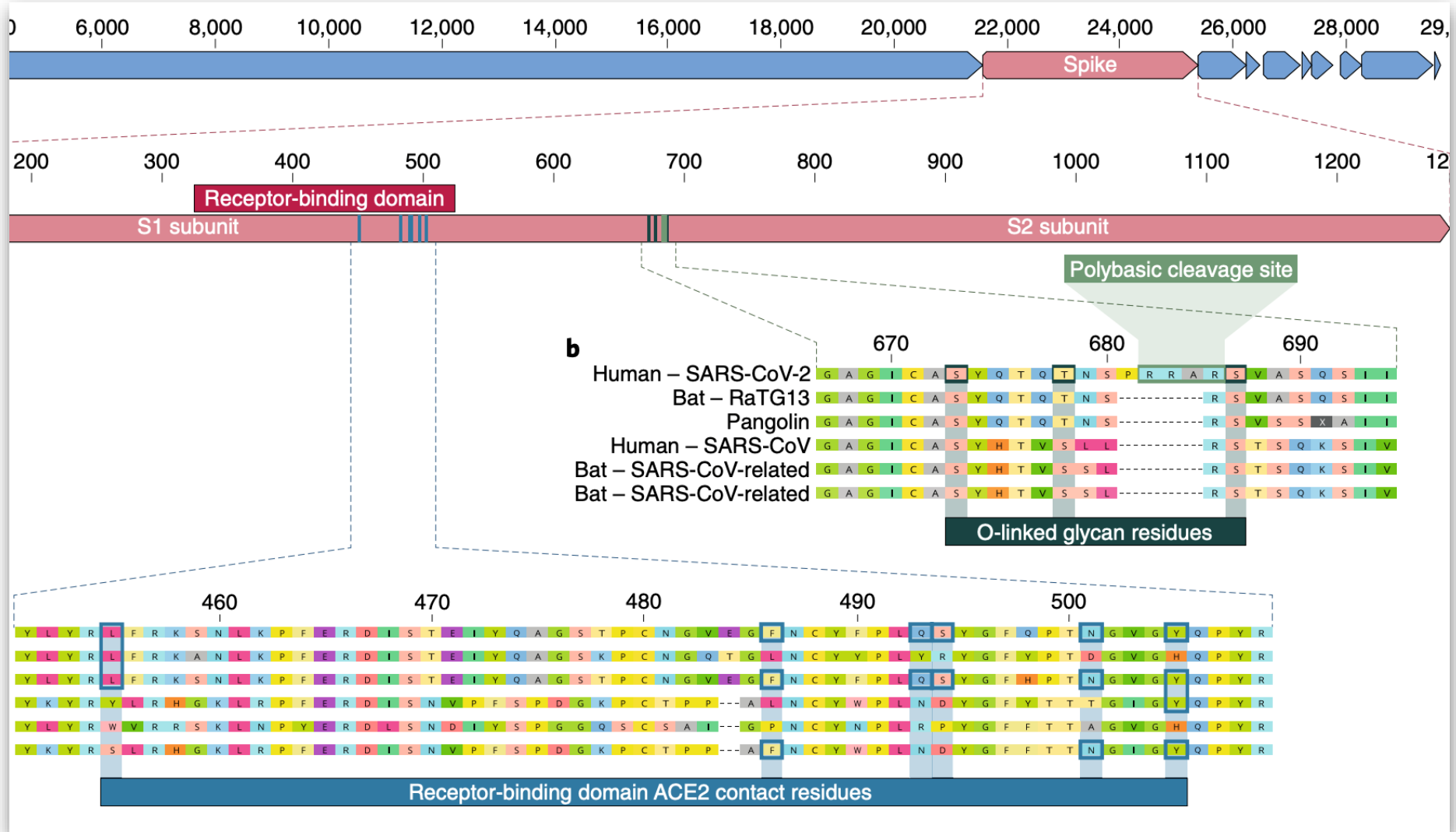
车型	收费标准
小车	5元/小时
中巴车、面包车、金杯车	10元/小时
小型货车 (中巴车、依维柯)	20元/天/次
冷藏货车	50元/天/次
大型货车	100元/天/次
特种货车	150元/天/次
特殊大货车	200元/天/次

备注：1. 节假日及活动期间，收费标准另有规定。2. 场内设有监控摄像头，请自觉遵守交通规则。

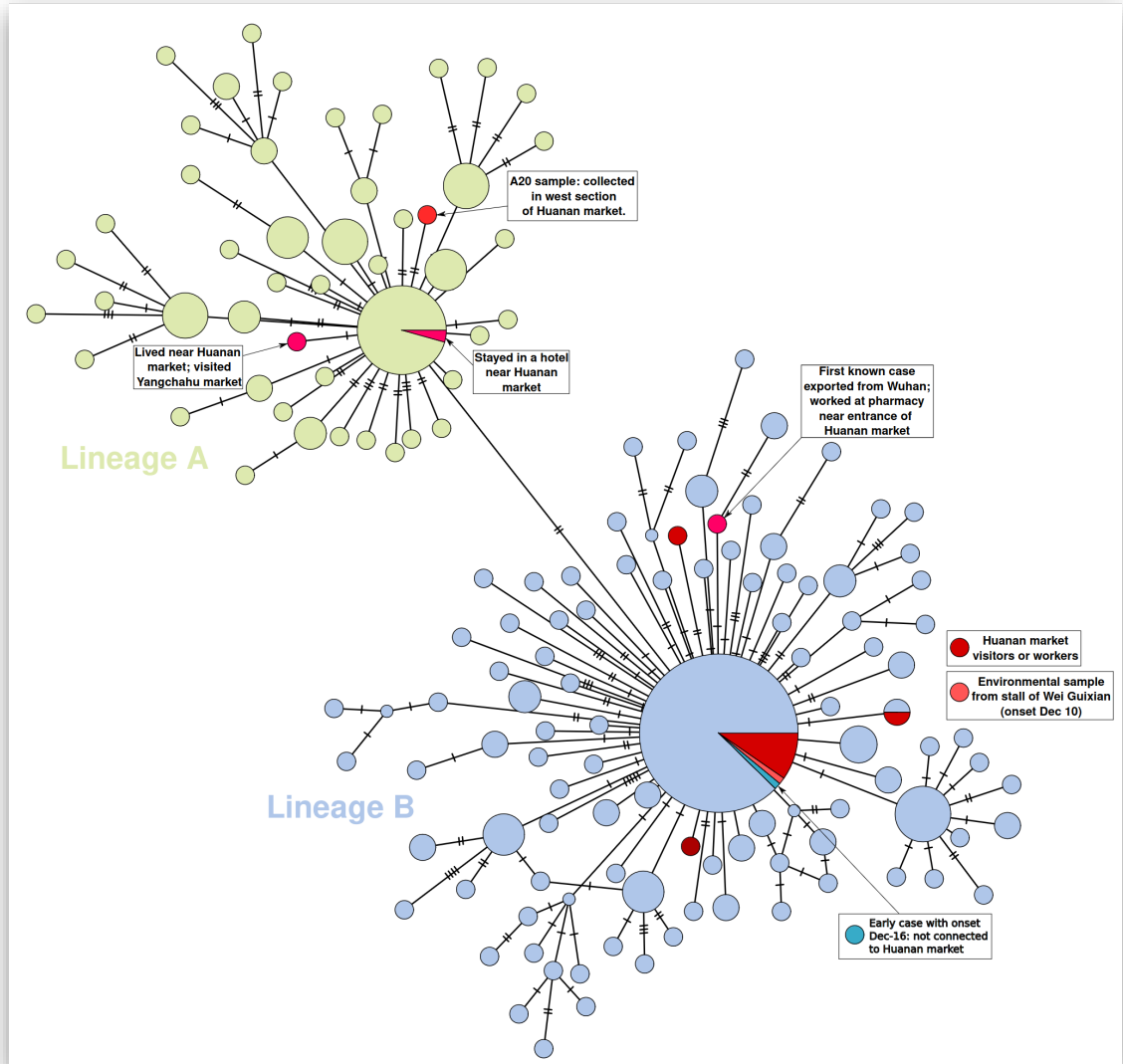
The origin of SARS-CoV-2 links to a single market in the middle of Wuhan



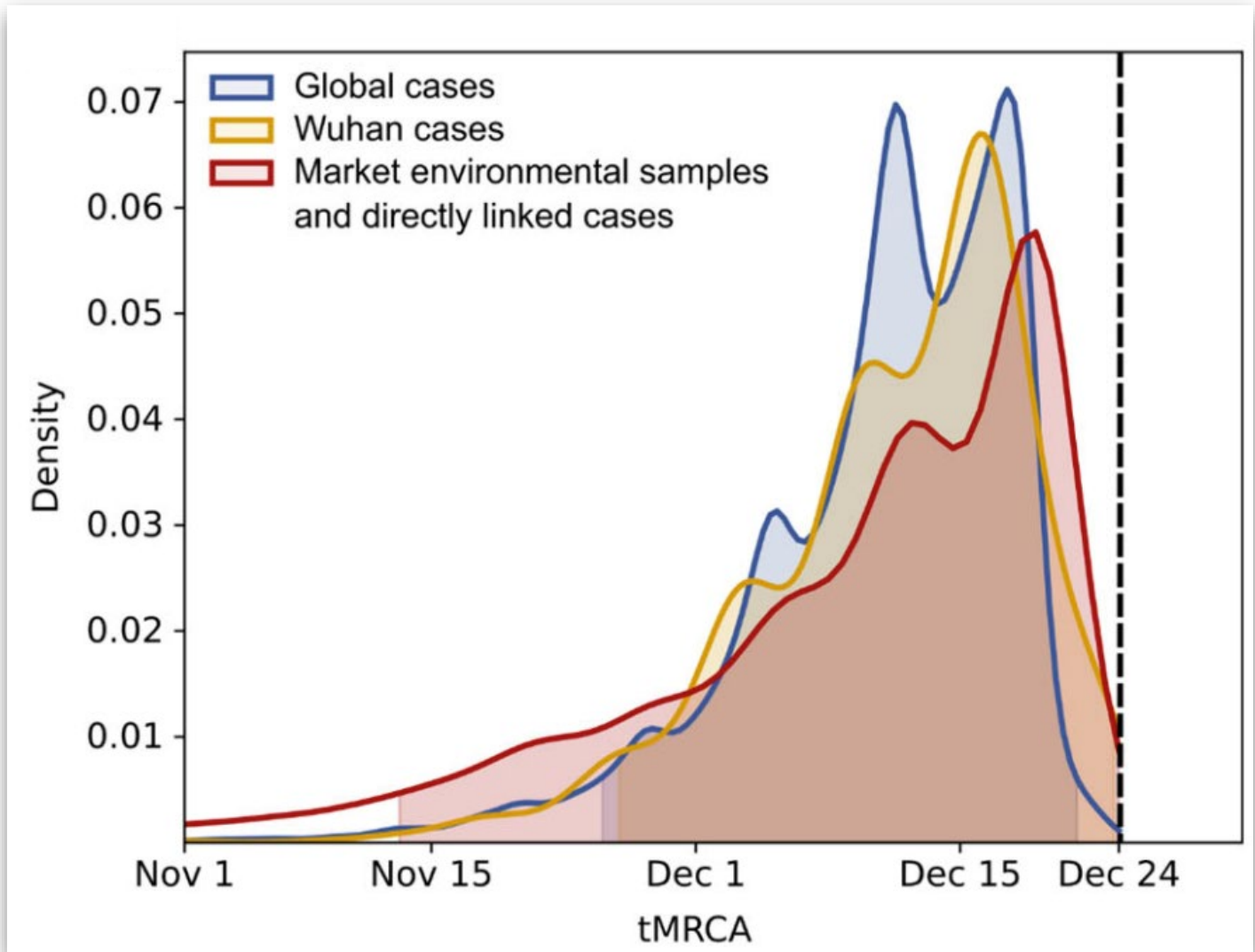
From: Lytras et al., Science 2021



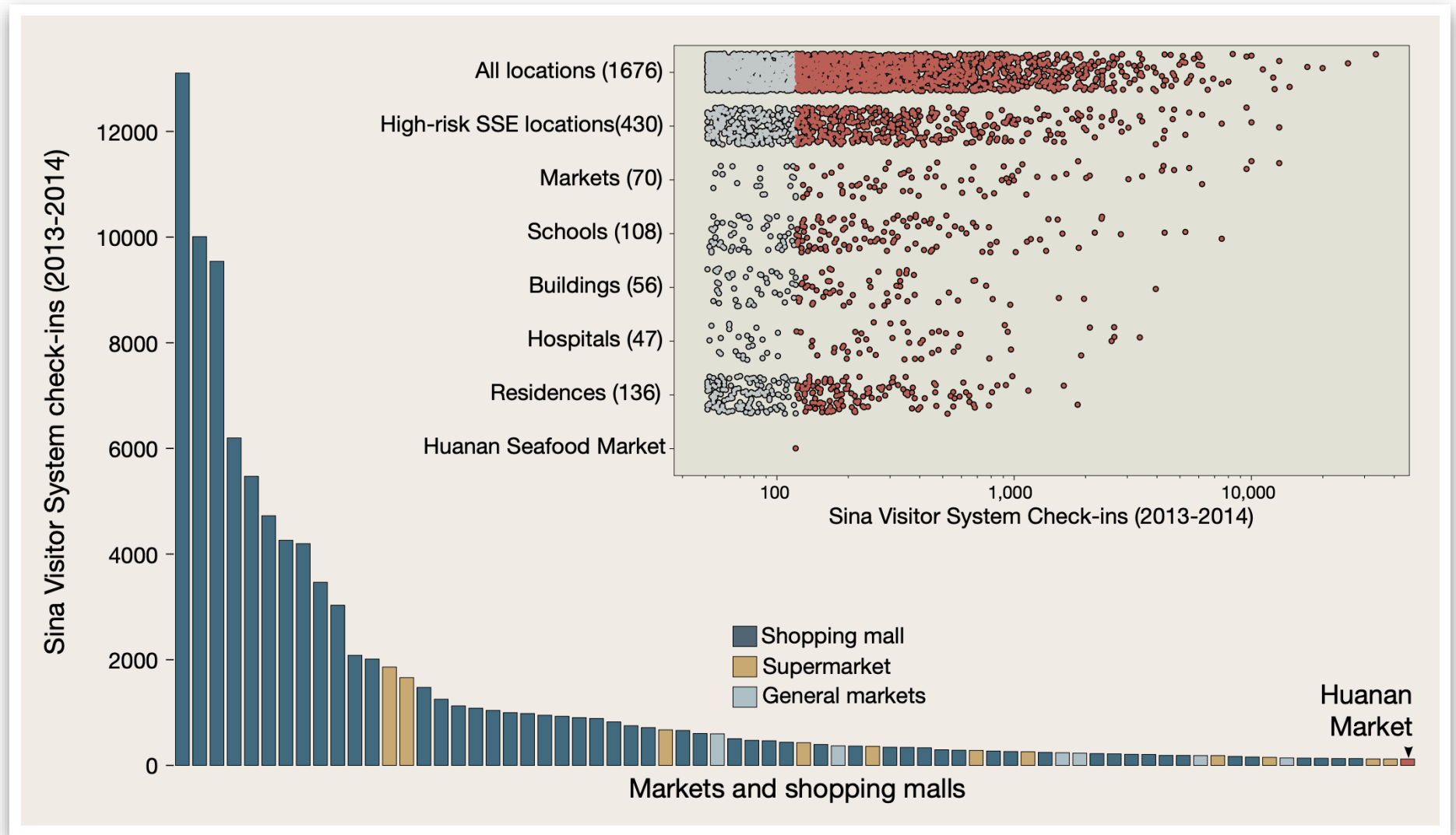
Andersen et al., Nature Medicine 2020



Pekar et al., Science 2022

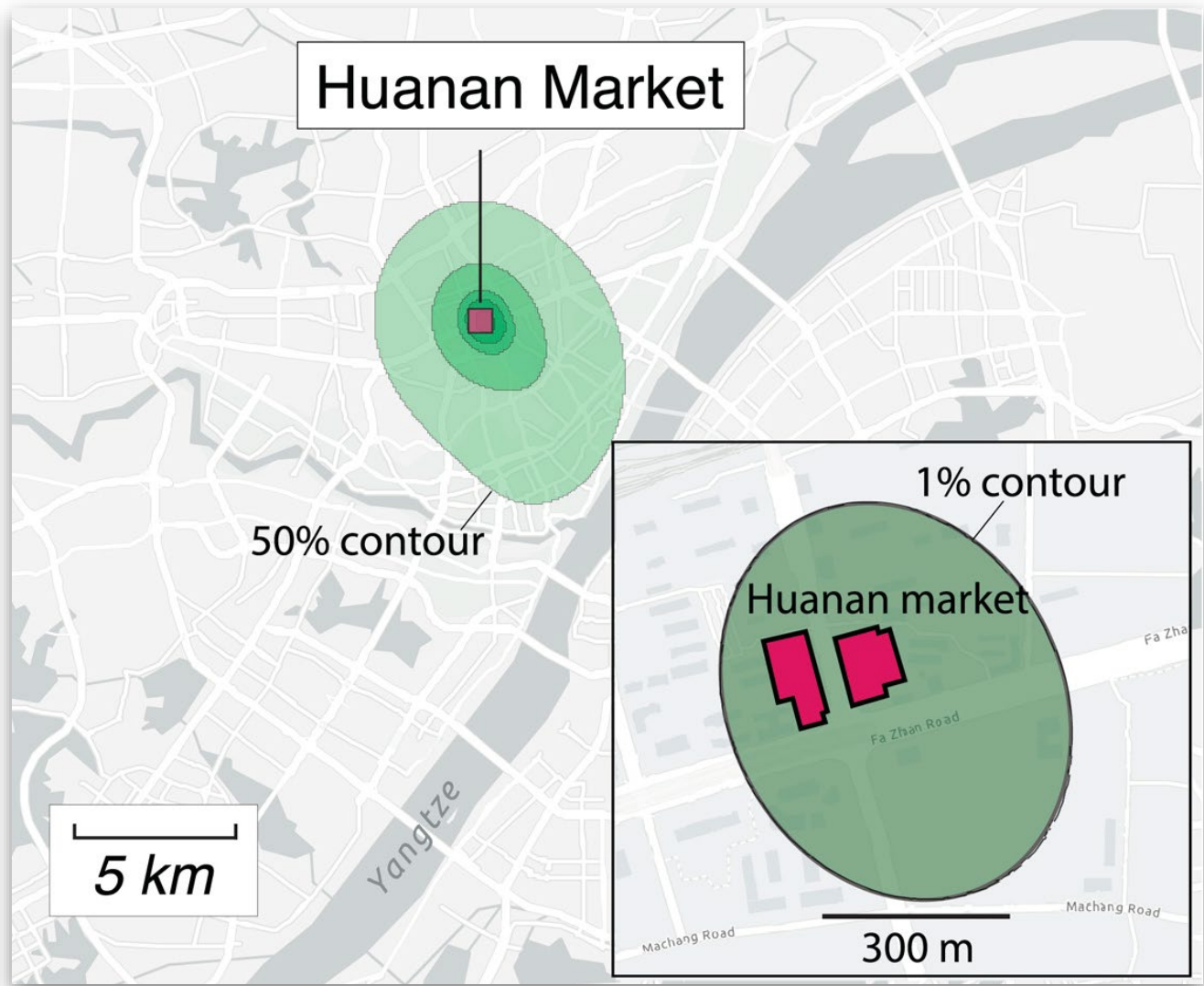


Crits-Christoph et al., Cell (accepted)

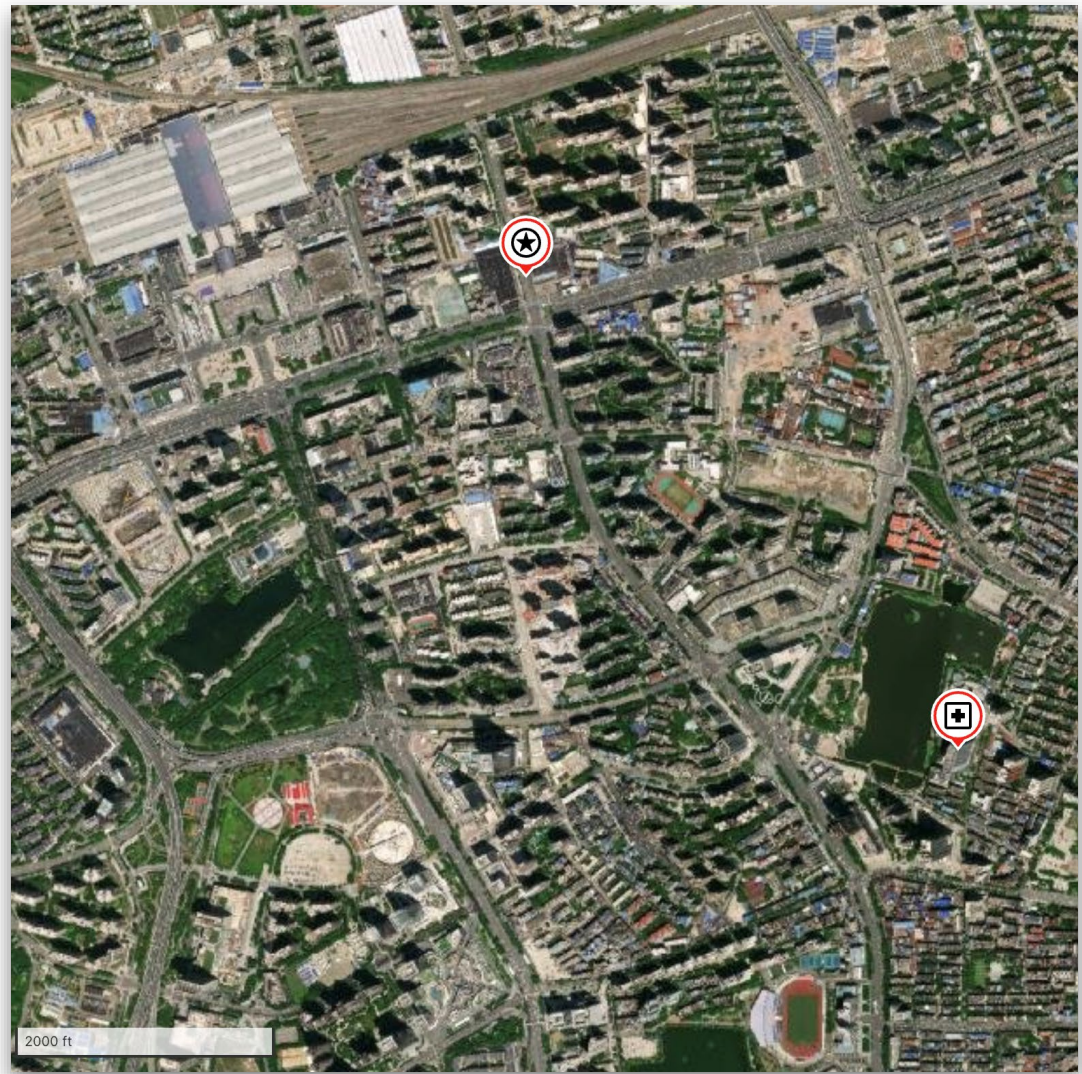


Worobey et al., Science 2022

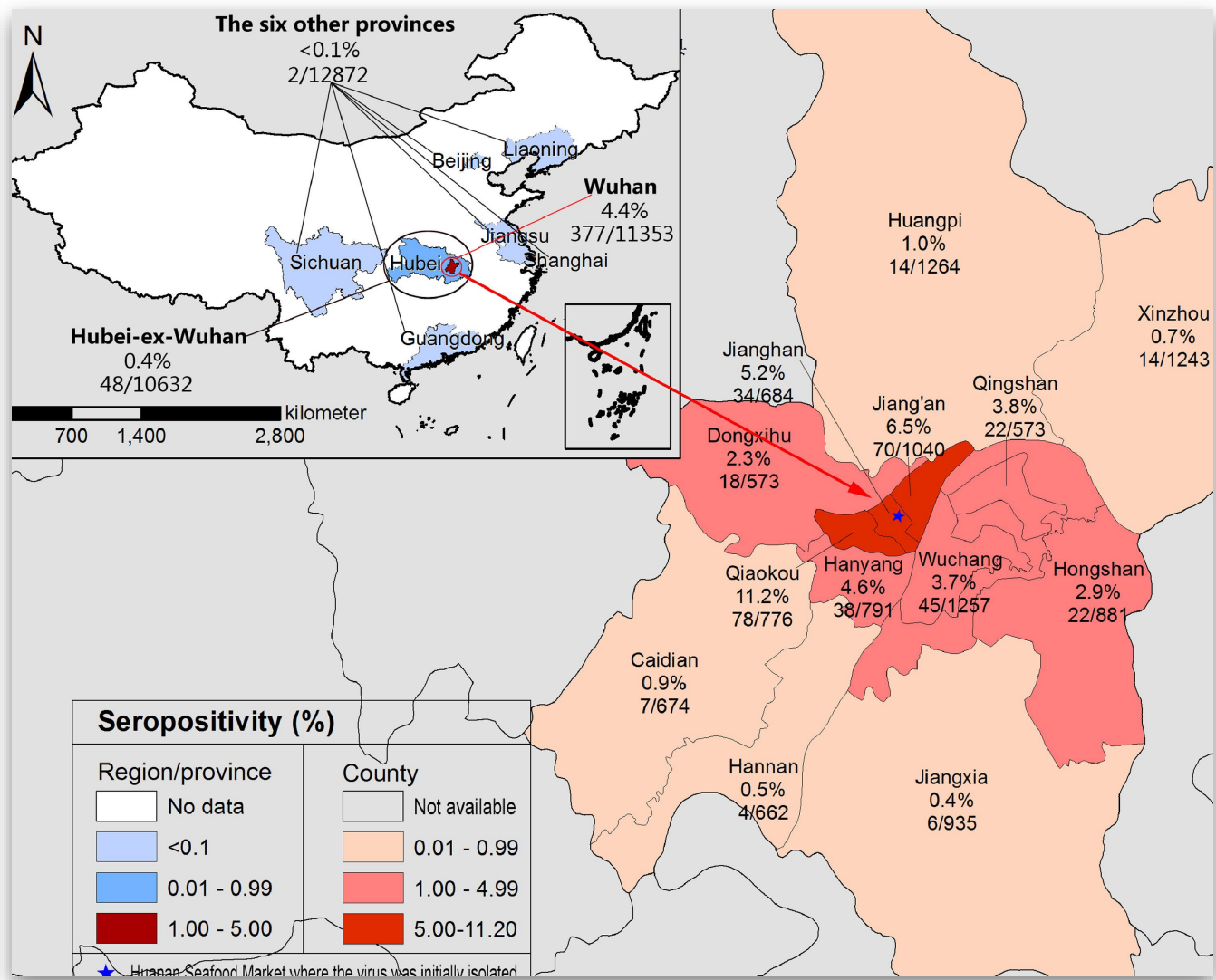
The origin of SARS-CoV-2 links to a single market in the middle of Wuhan



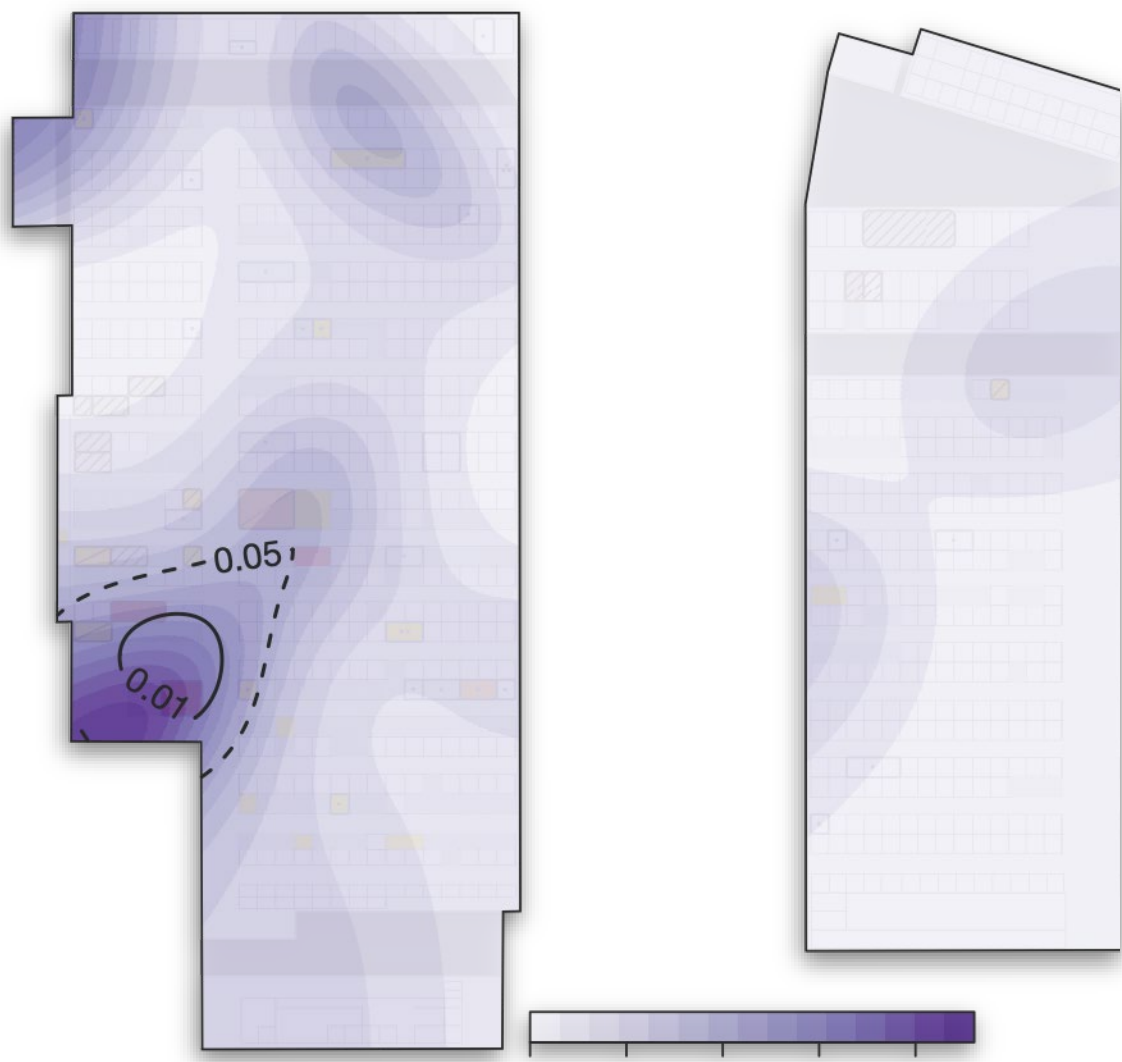
Worobey et al., Science 2022



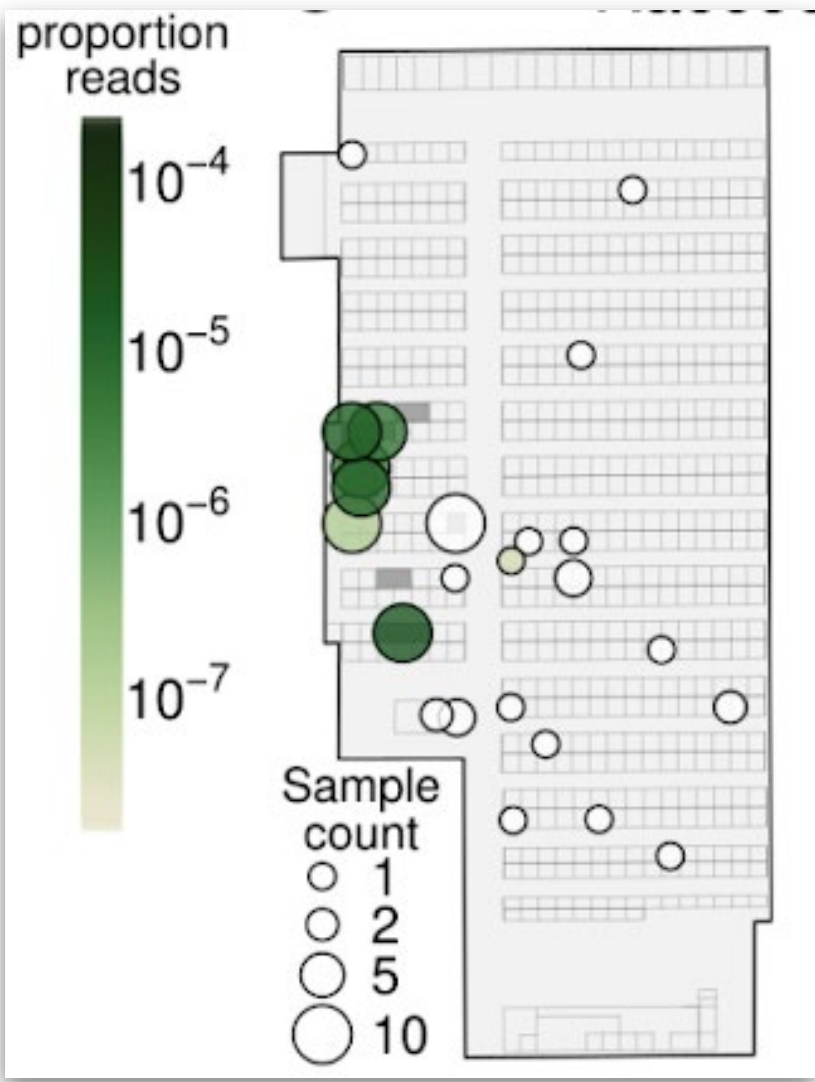
Holmes et al., Cell 2021



From: Li et al., Lancet Reg Health West Pac 2021



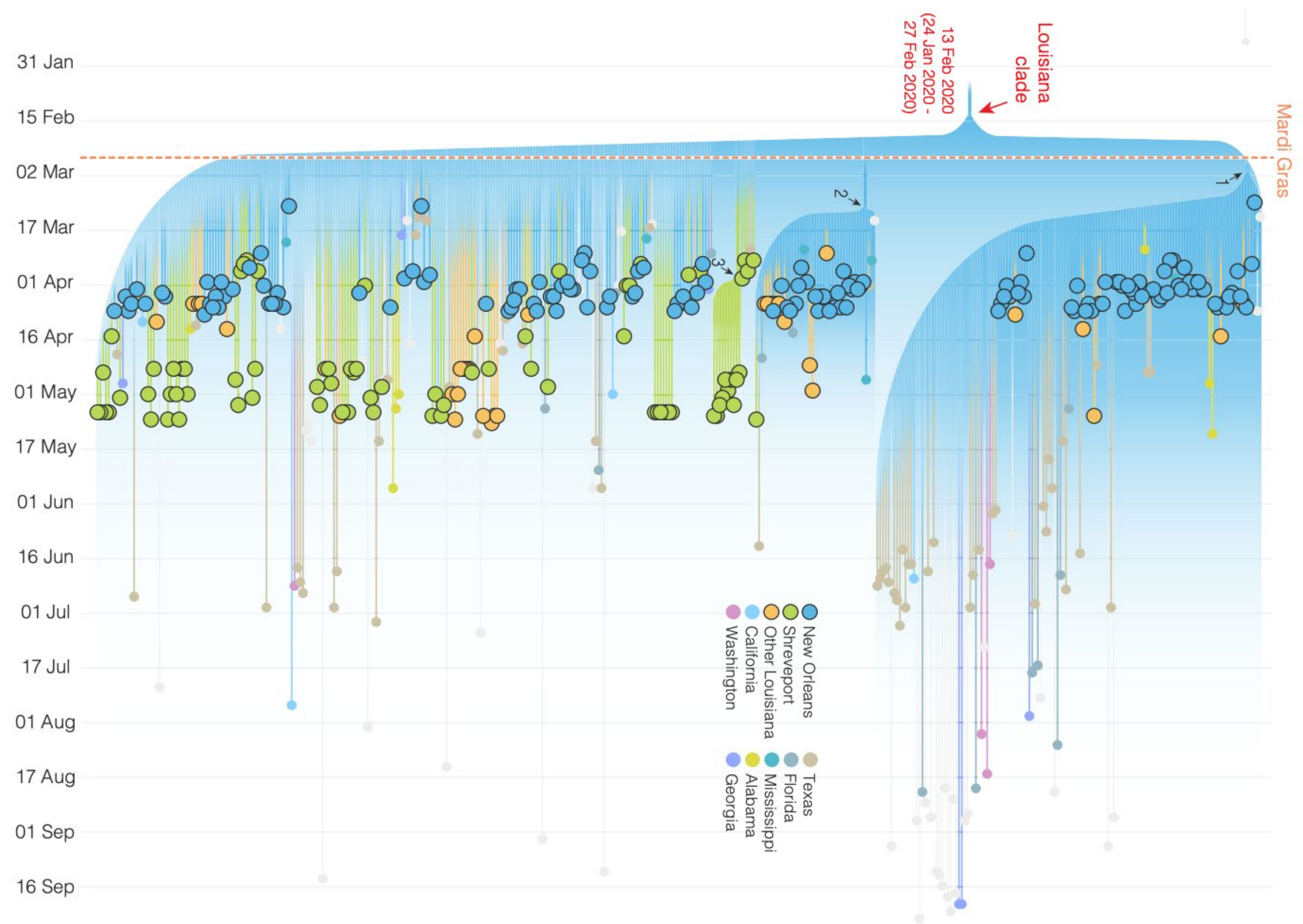
Worobey et al., Science 2022



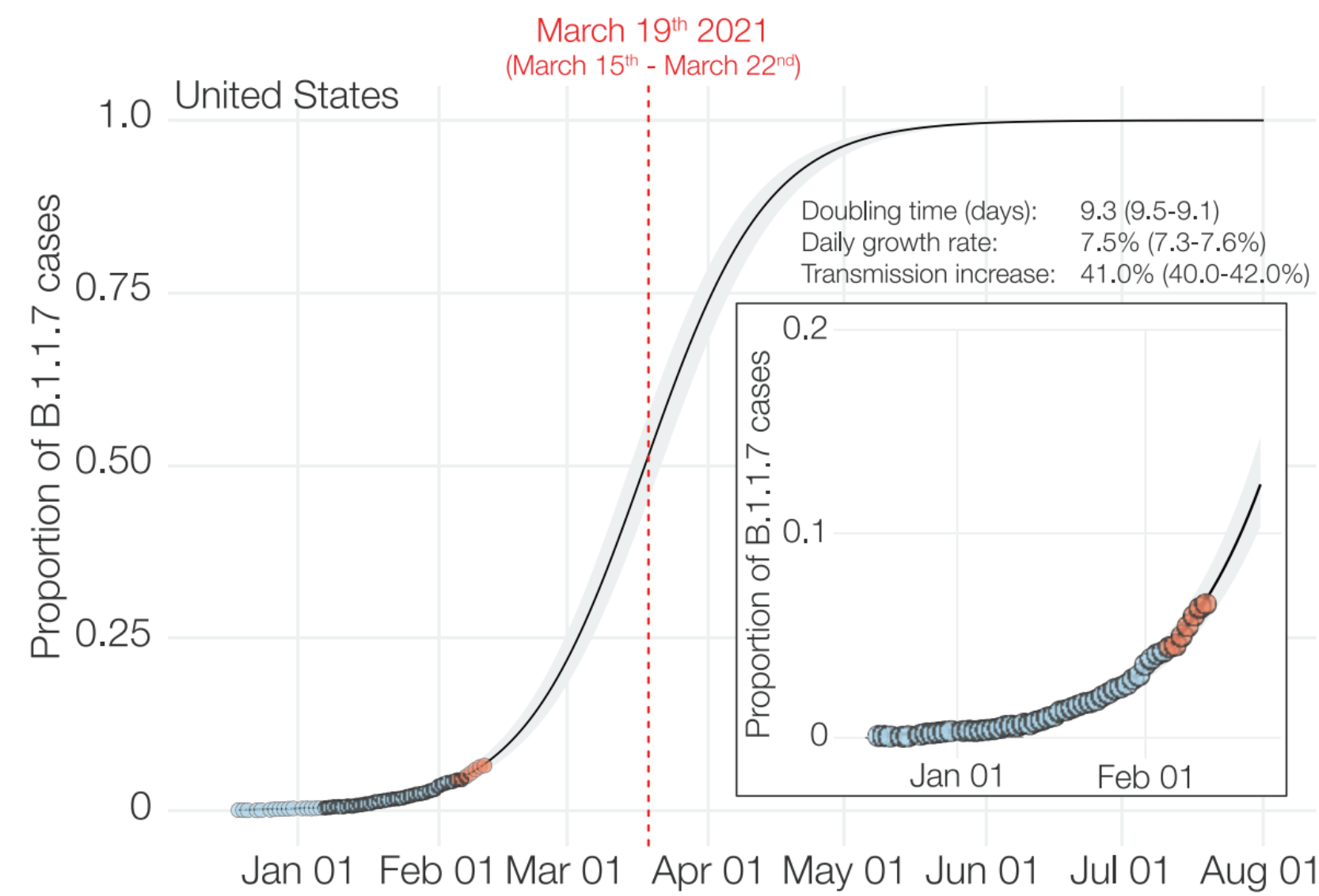
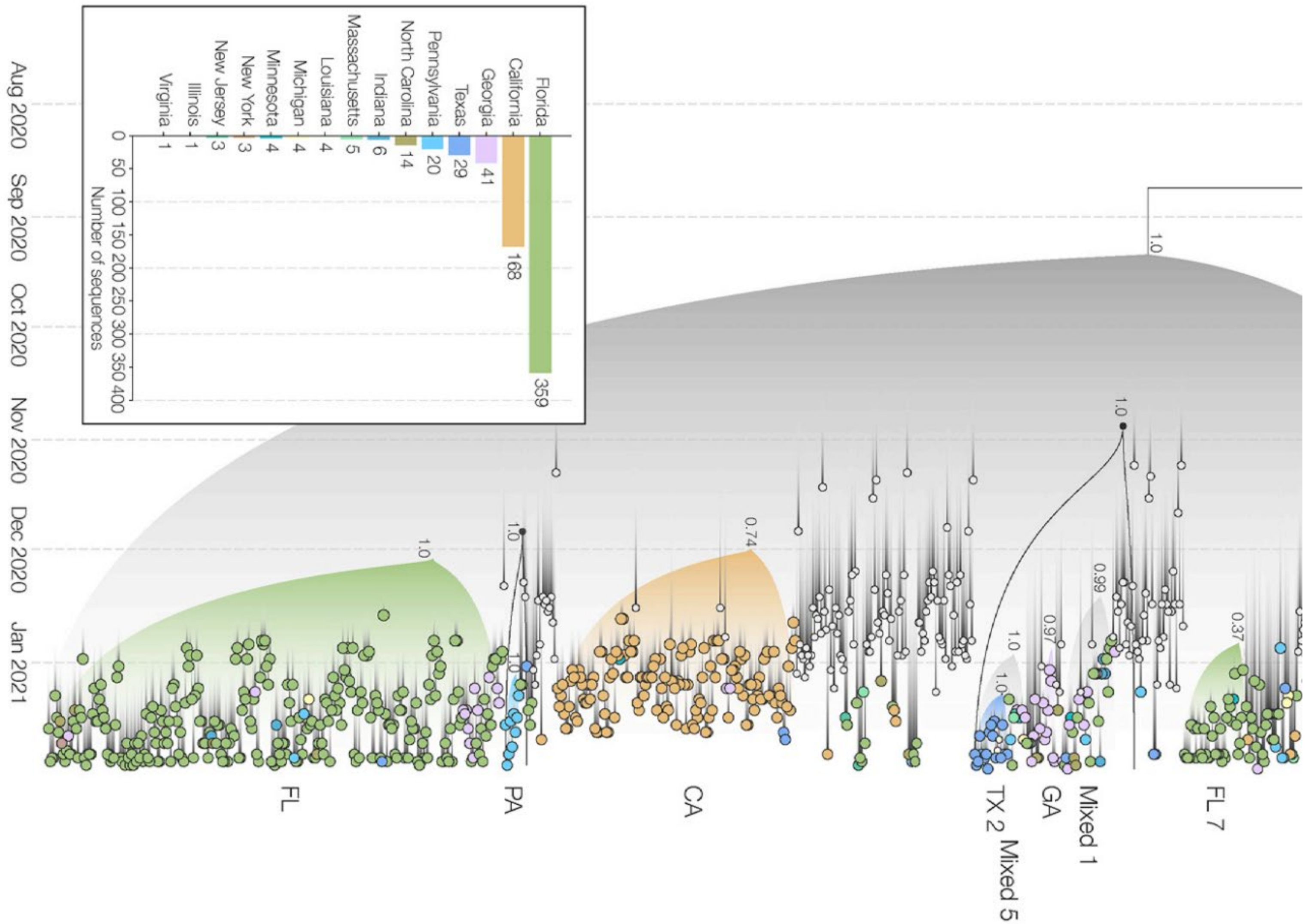
Crits-Christoph et al., Cell (accepted)

Epidemic > Endemic

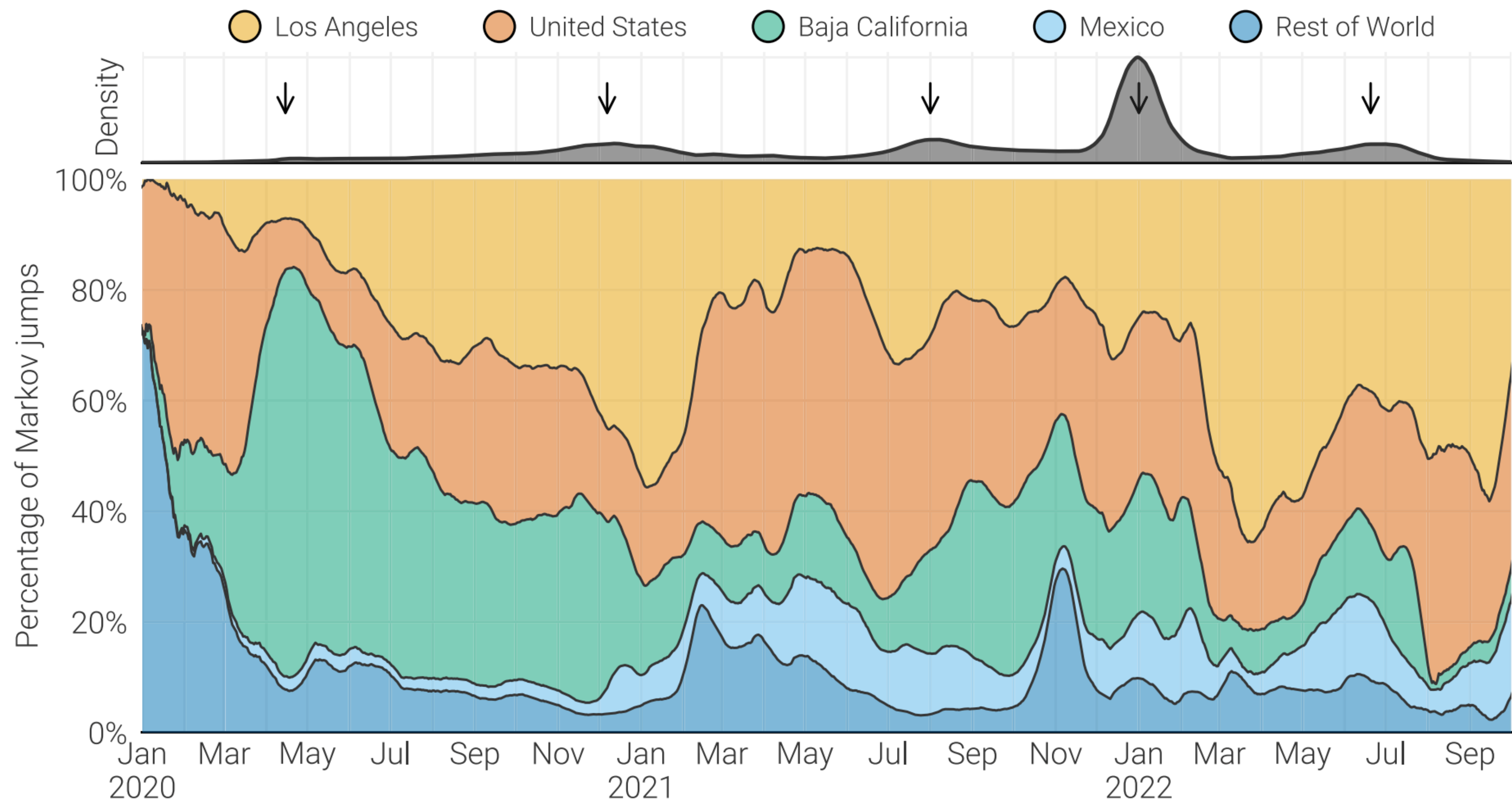
Early explosive spread in the United States | Single introduction into New Orleans



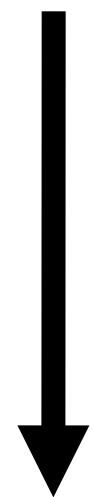
Then came the variants



Connectedness was dynamic and changed as we moved from pandemic to endemic



Endemic | Functional surveillance



De facto standard
FDA
CDC
Biobot
Internationally

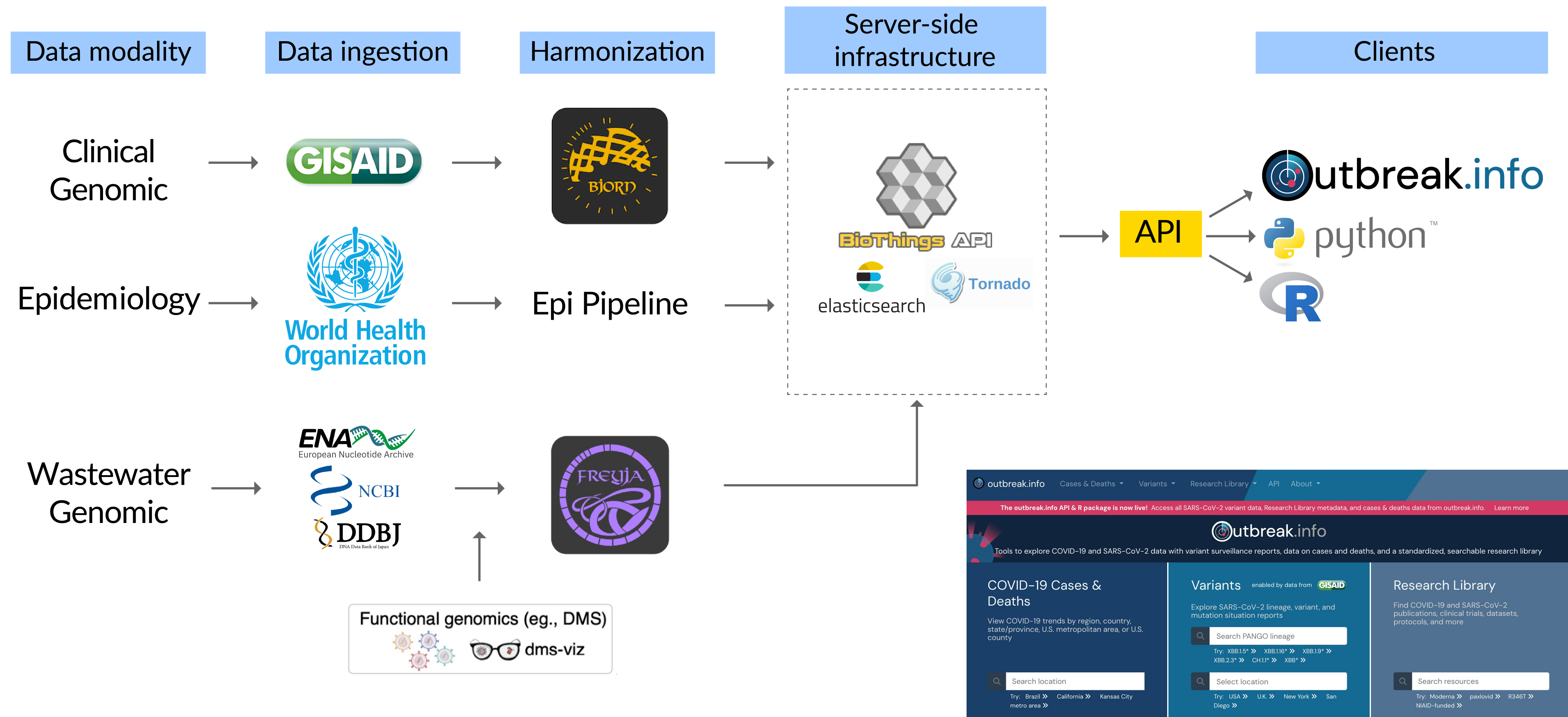
De facto standard
Millions of download

Gangavarapu et al., Nature Methods 2023
Tsueng et al., Nature Methods 2023

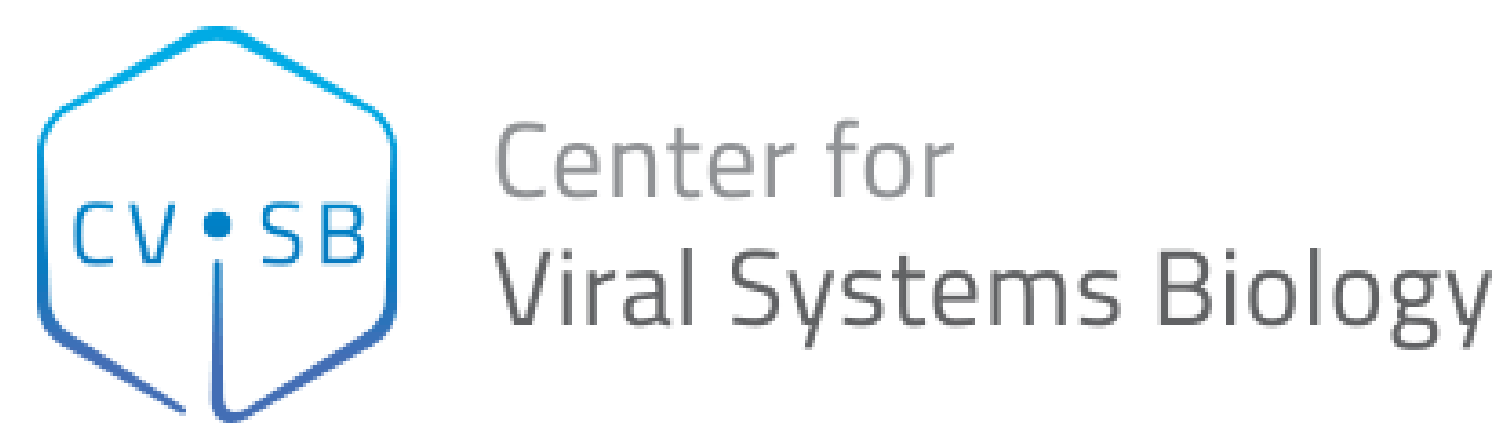
Karthikeyan et al., Nature 2022

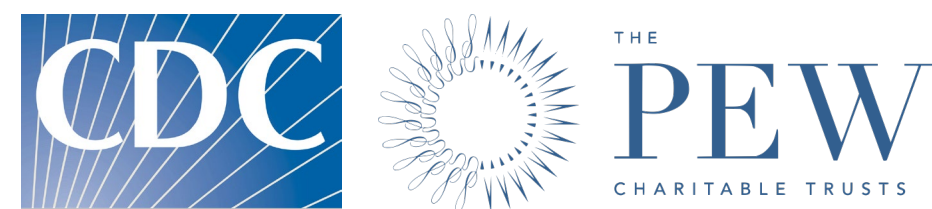
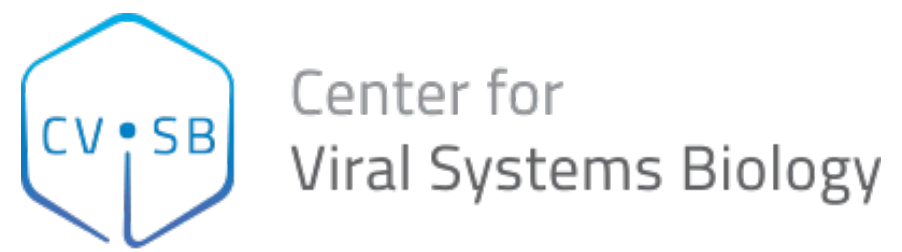
Grubaugh et al., Genome Biology 2019

Integrated programs | H5N1, SARS-CoV-2, others



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GATES foundation



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DK

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