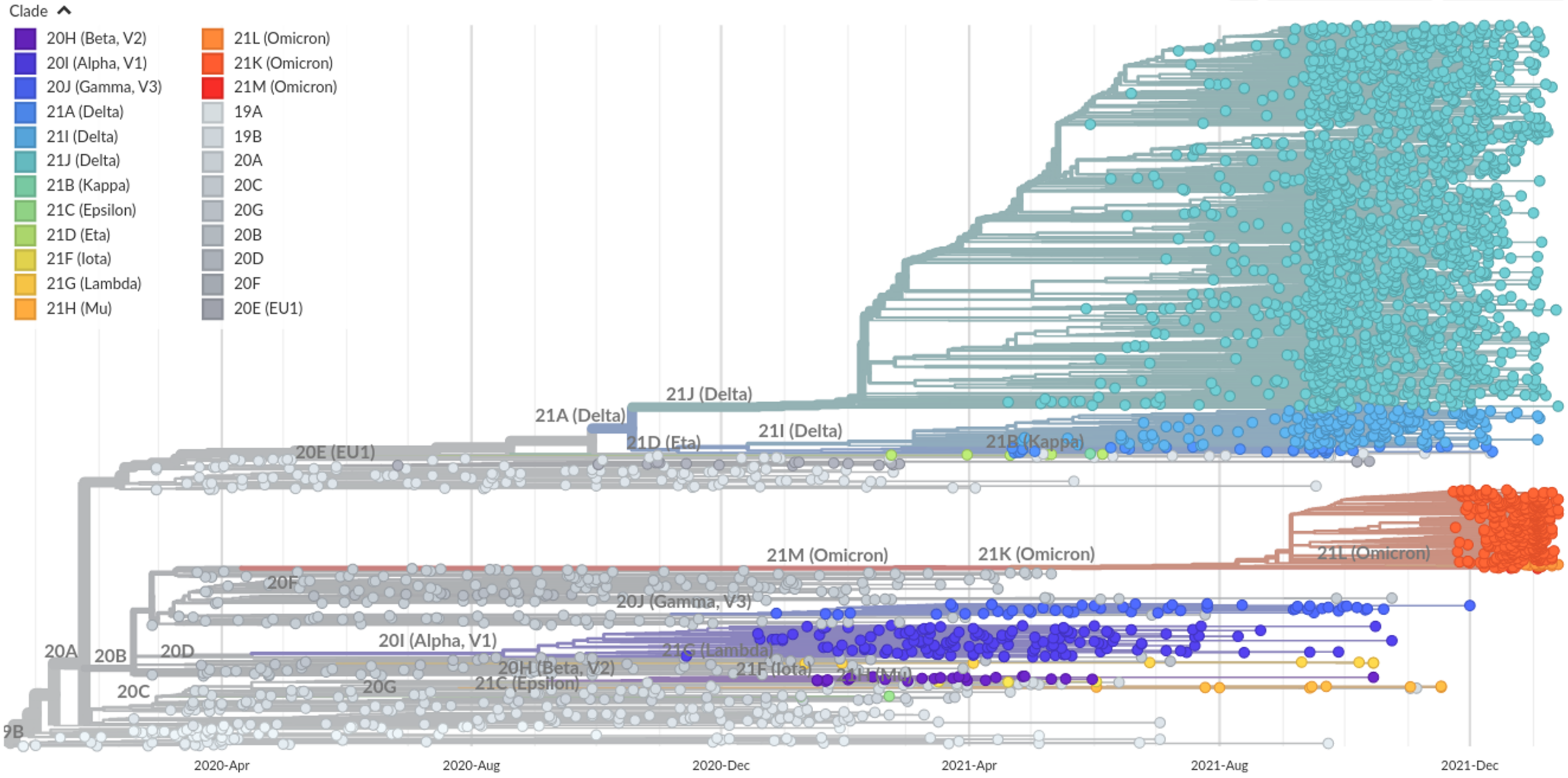
Wastewater sequencing (+Freyja) uncovers early, cryptic SARS-CoV-2 variant spread

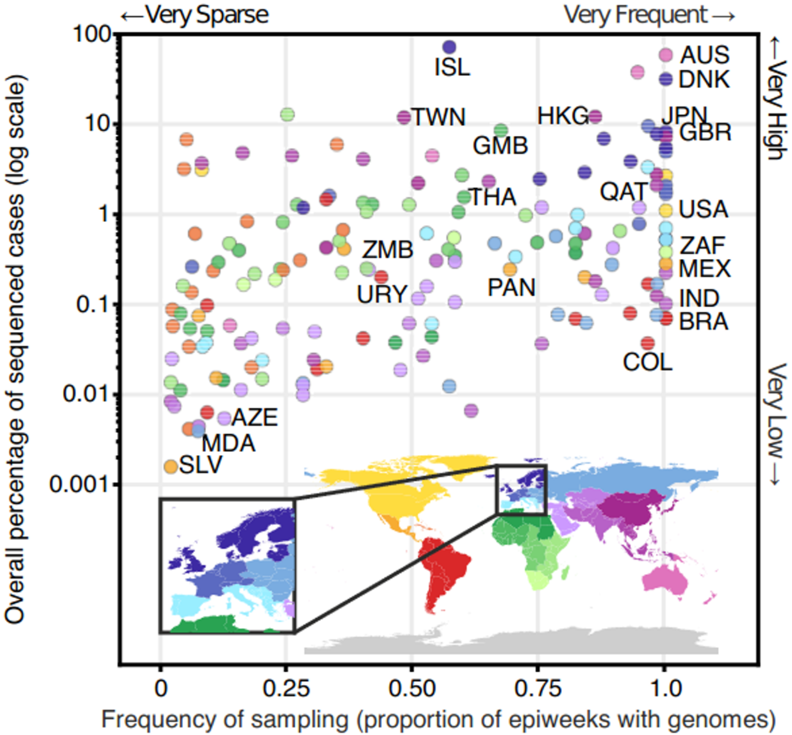
February 28, 2022

SARS-CoV-2 continues to evolve



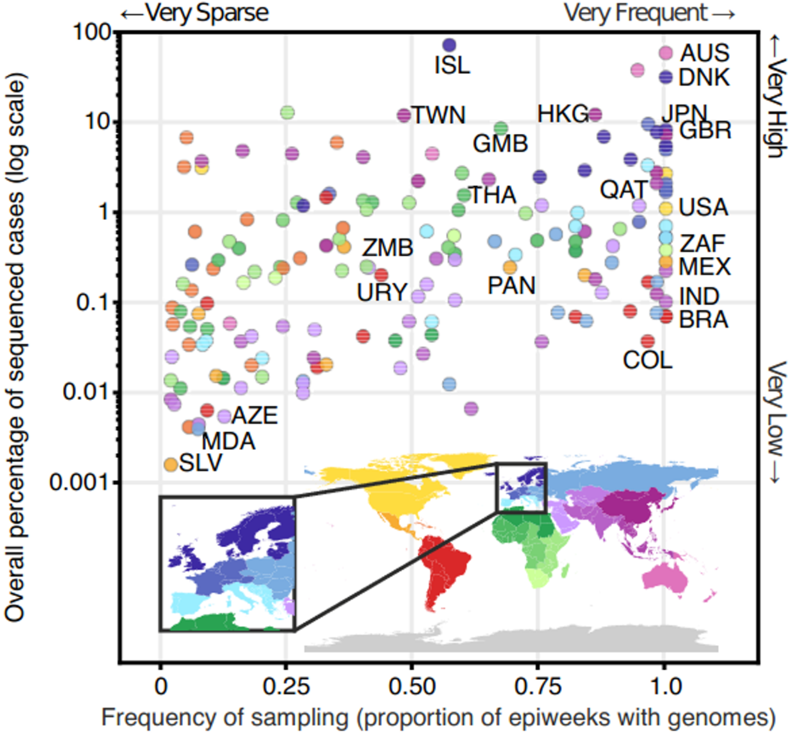
Nextstrain

Clinical sampling blind spots

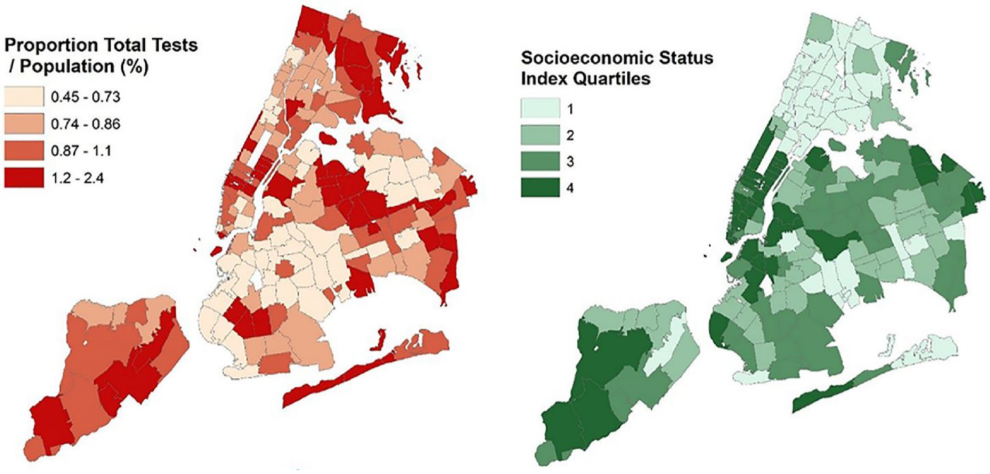


Brito, Semenova, Dudas et al., 2021

Clinical sampling blind spots

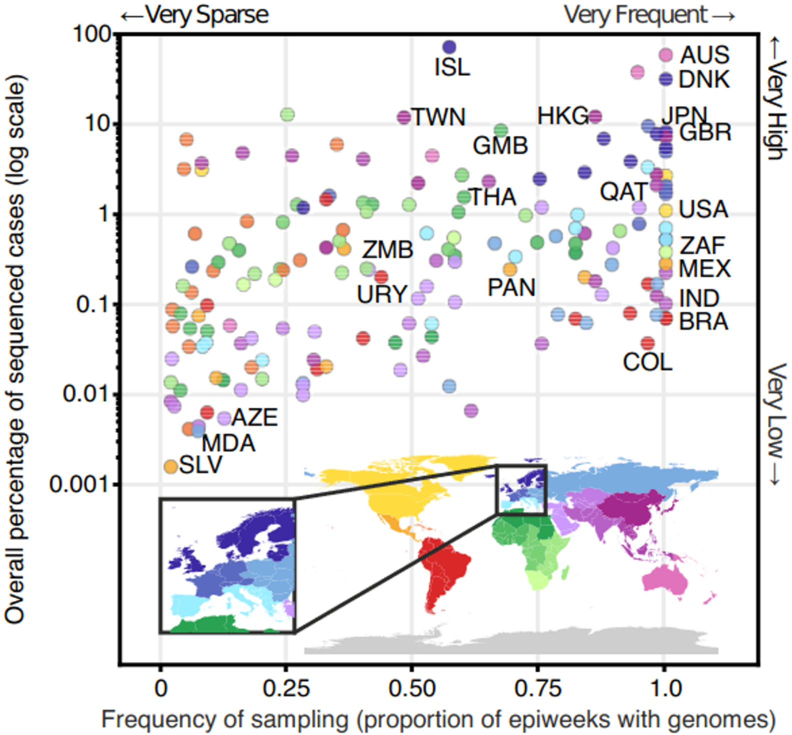


Brito, Semenova, Dudas et al., 2021

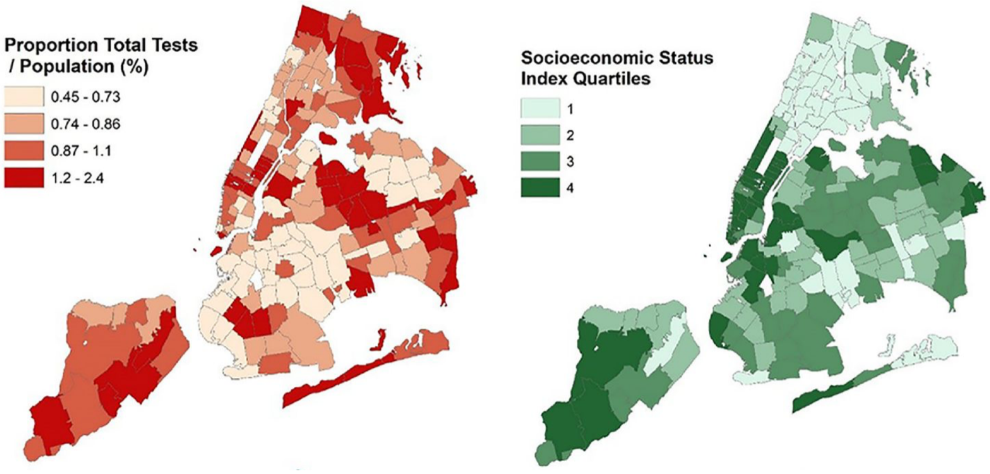


Lieberman-Cribbin et al., 2020

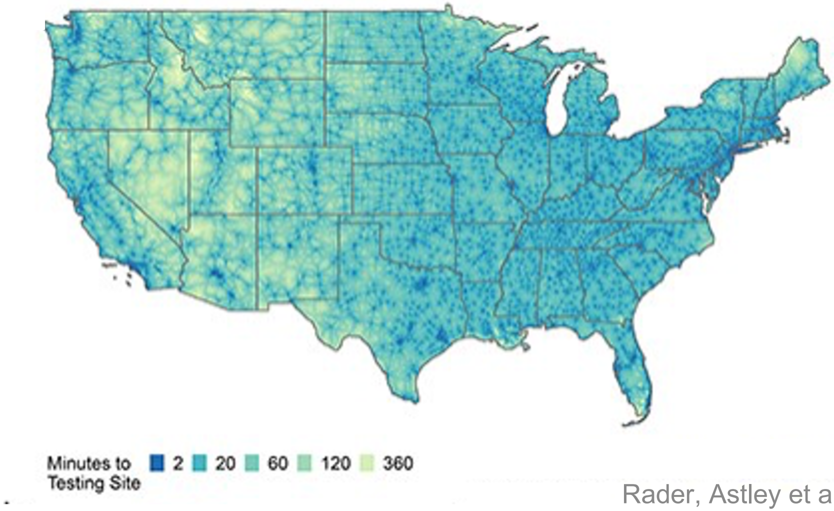
Clinical sampling blind spots



Brito, Semenova, Dudas et al., 2021

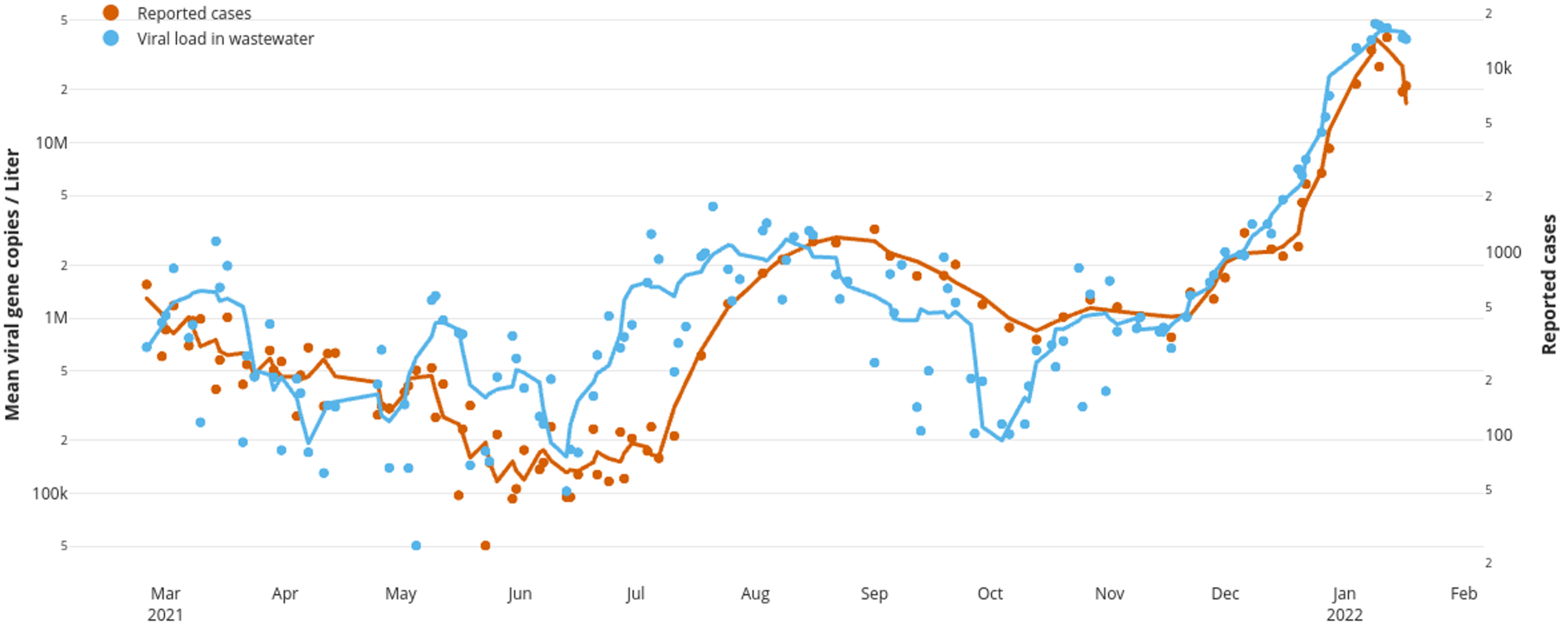


Lieberman-Cribbin et al., 2020

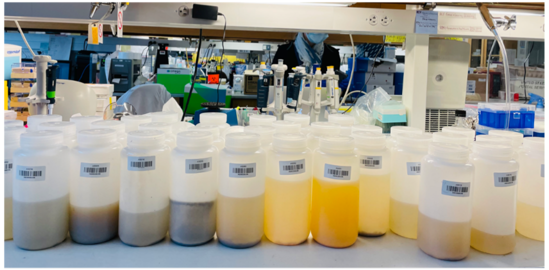


Rader, Astley et al., 2020

Wastewater surveillance is a promising alternative



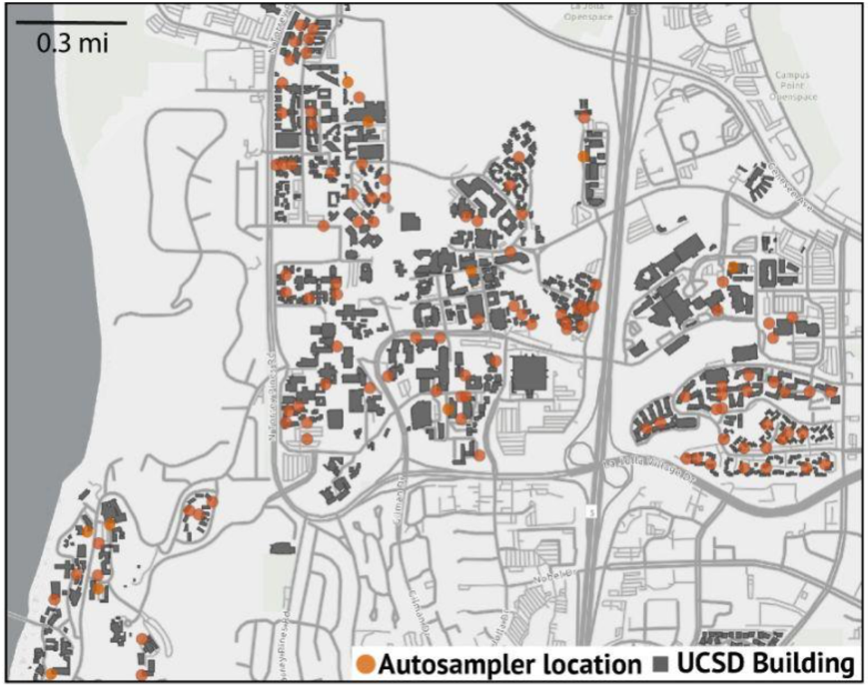
SEARCH Dashboard



KNIGHTLAB

Image credit: Erik Jepsen, Caroline Sheikhzadeh, UCSD

UCSD Campus



Sampler Types

Residential: 72

Isolation dorms: 4

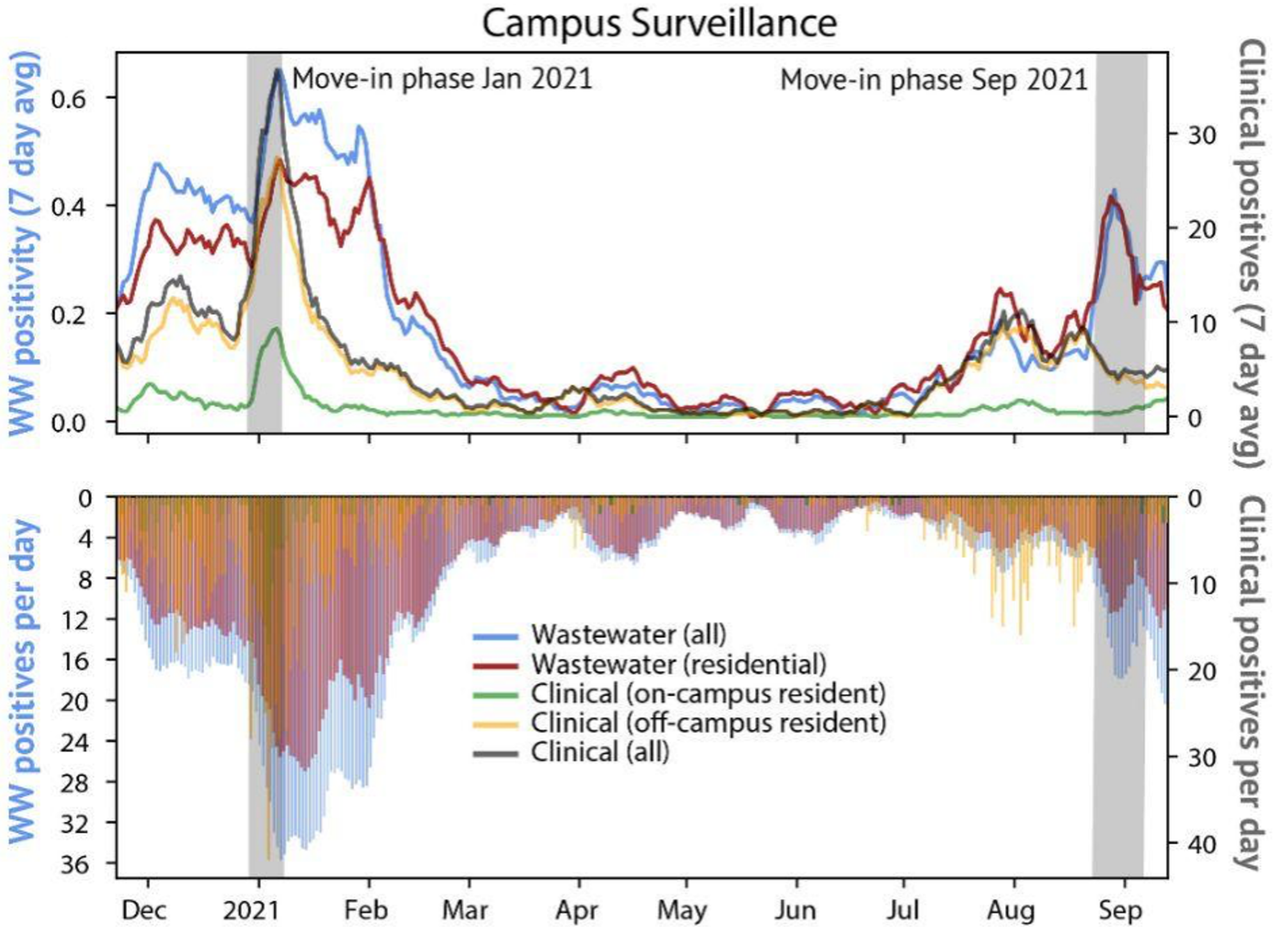
Non-residential: 58

Fall 2021: 18,000 residents in campus housing

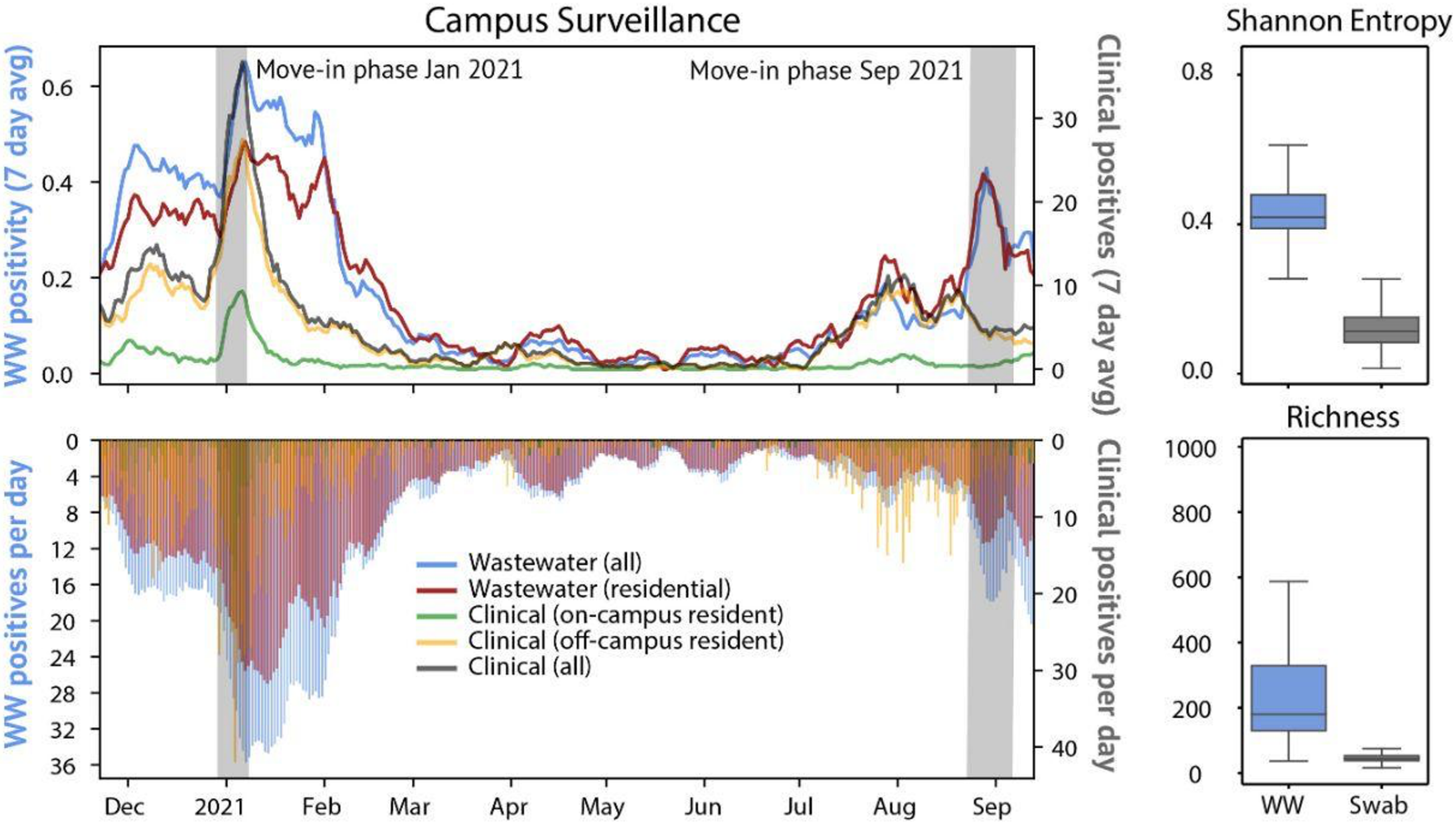
Point Loma

Primary wastewater treatment plant serving the greater SD area

Serves ~2.3 million residents



Karthikeyan and Levy, in review

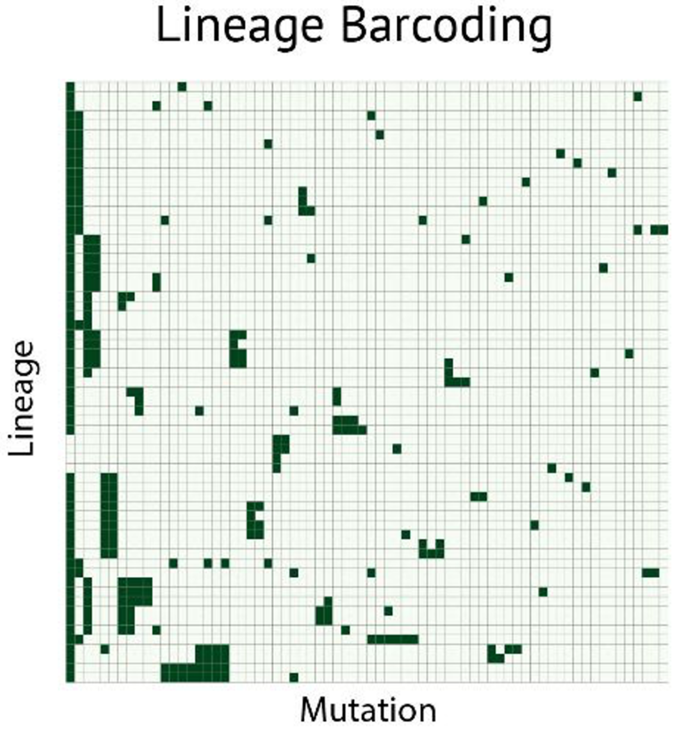


Campus Surveillance

Shannon Entropy

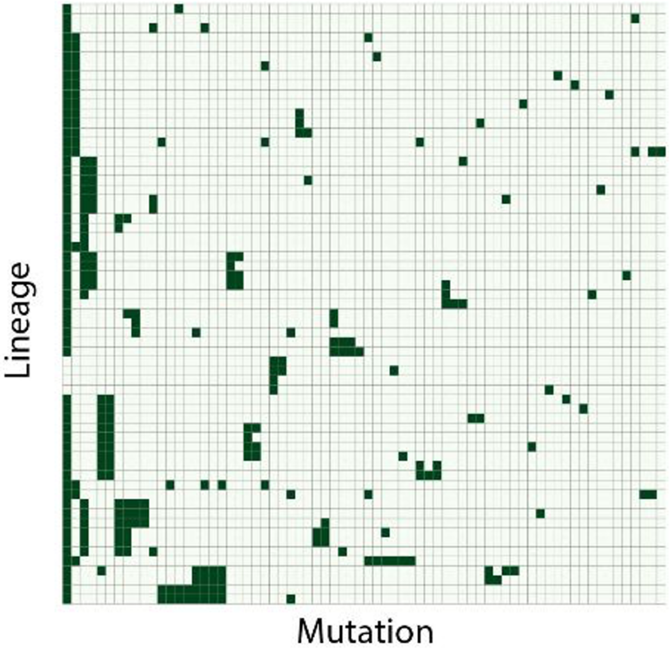
Richness

Karthikeyan and Levy, in review

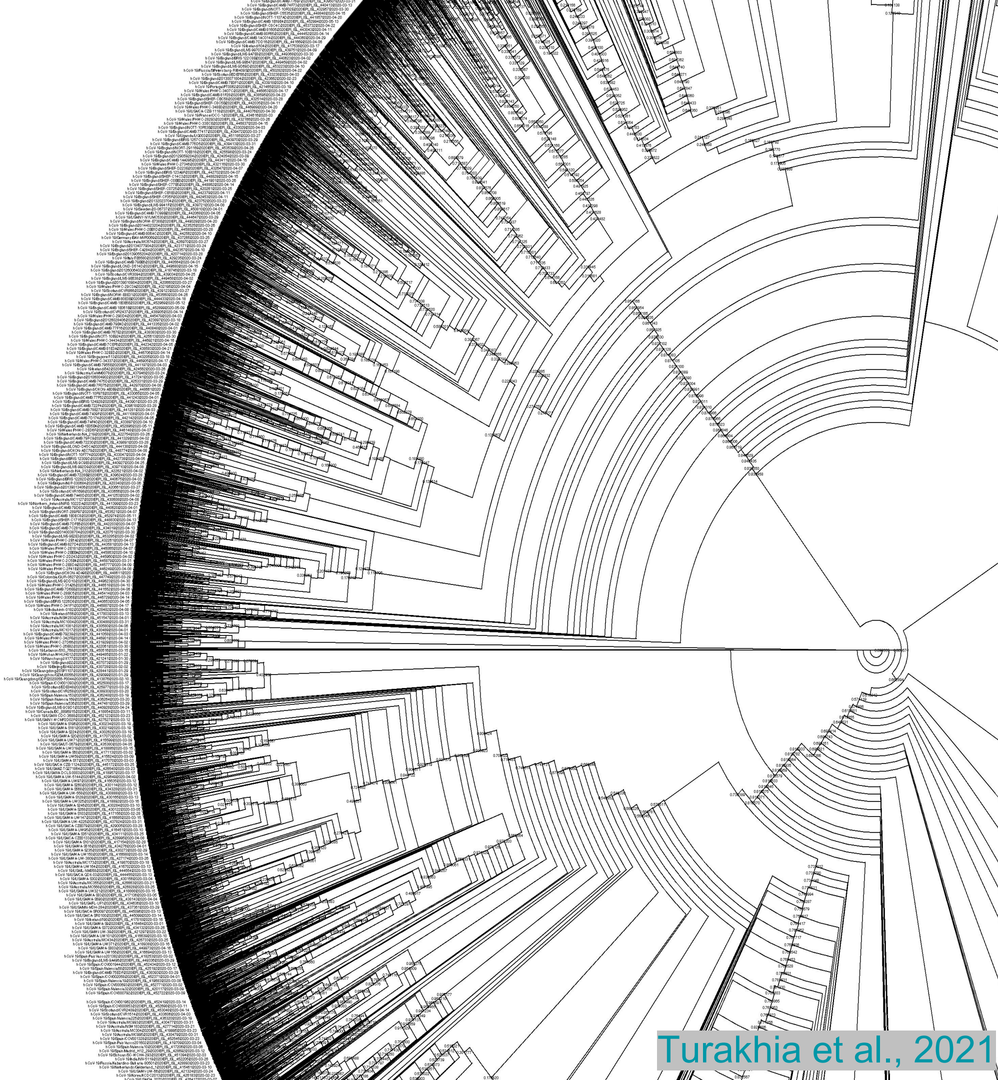


>1200 SARS-CoV-2 lineages

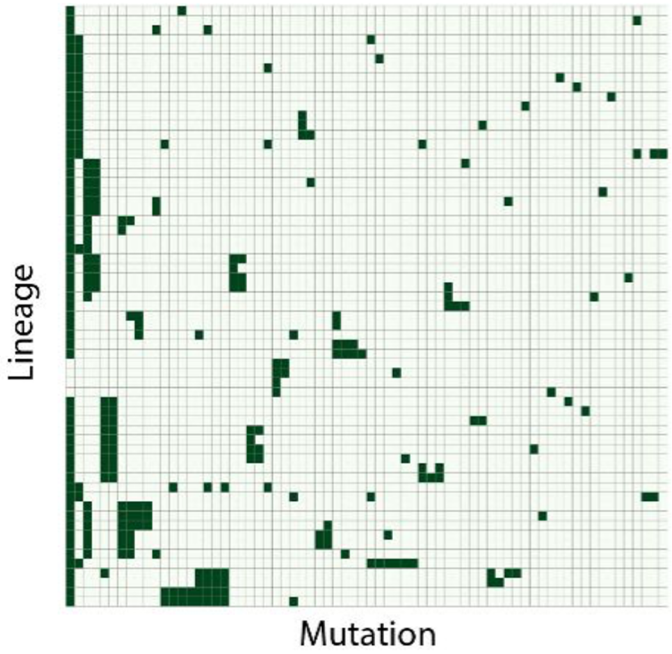
Lineage Barcoding



>1200 SARS-CoV-2 lineages

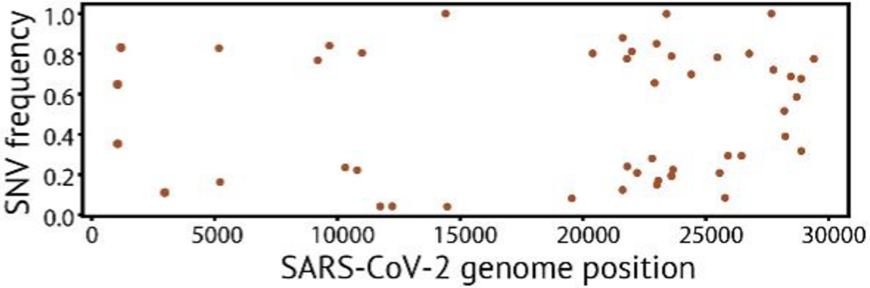


Turakhia et al., 2021



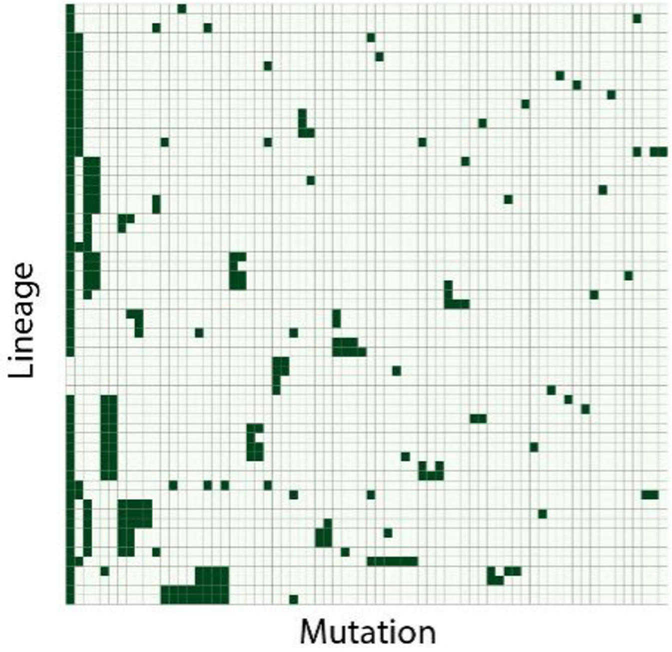
Lineage Barcoding

>1200 SARS-CoV-2 lineages



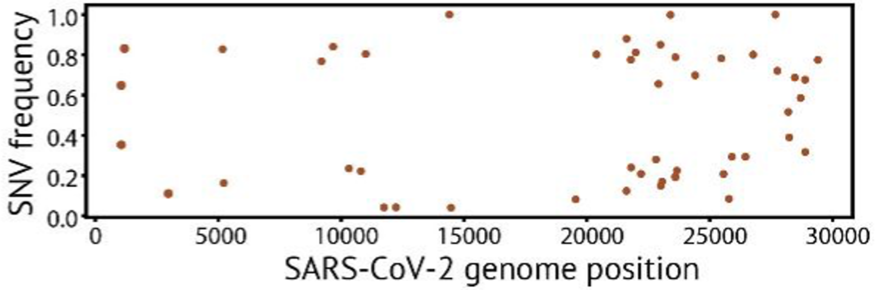
Detection of Single Nucleotide Variants

Lineage Barcoding



>1200 SARS-CoV-2 lineages

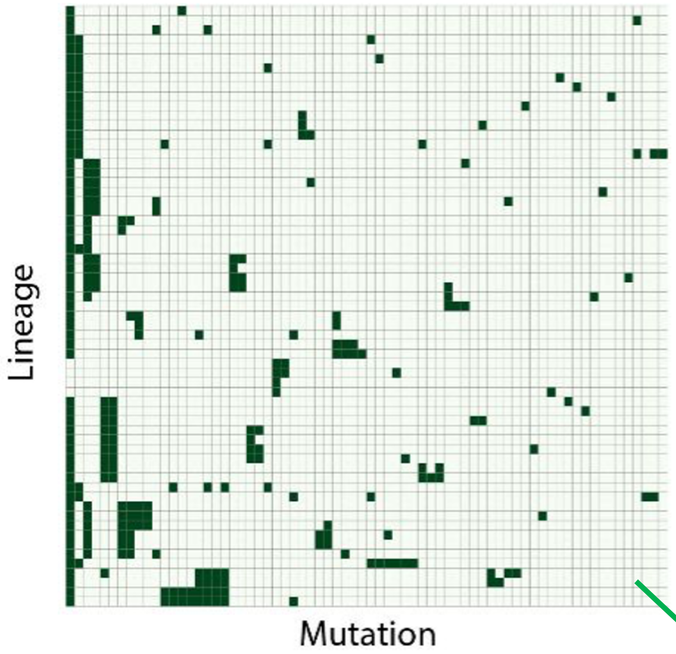
Detection of Single Nucleotide Variants



Depth-weighted de-mixing

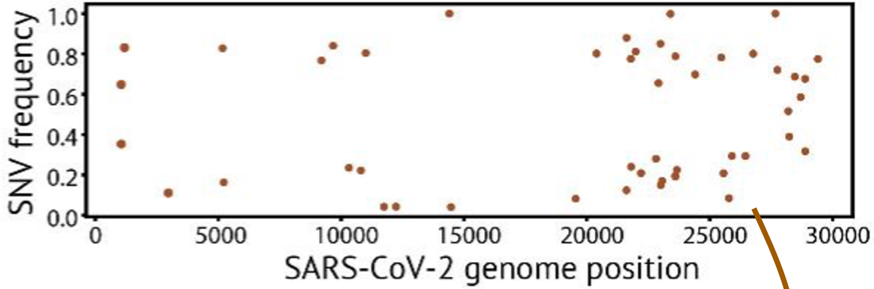
$$\hat{x} = \underset{\substack{x\geq 0 \\ \sum x=1}}{\operatorname{argmin}} \; ||A^T x - b||_{1W}$$

Lineage Barcoding



>1200 SARS-CoV-2 lineages

Detection of Single Nucleotide Variants



Depth-weighted de-mixing

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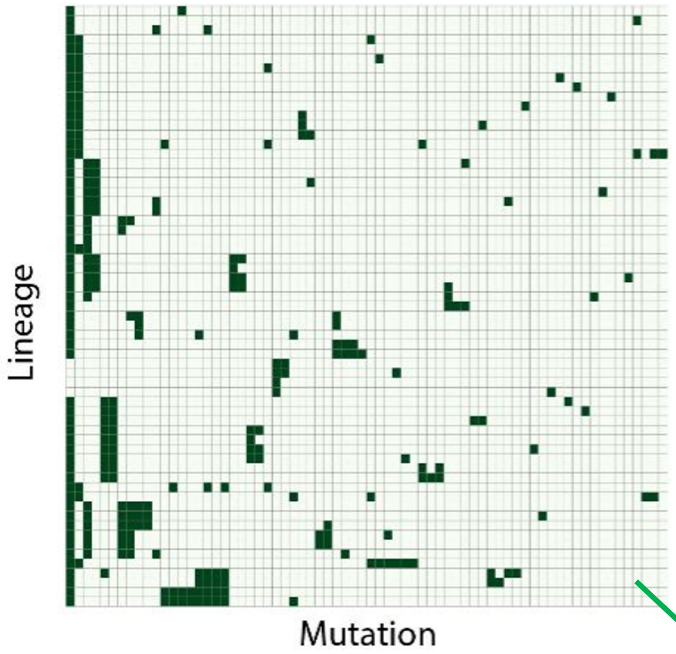
Lineage Barcoding



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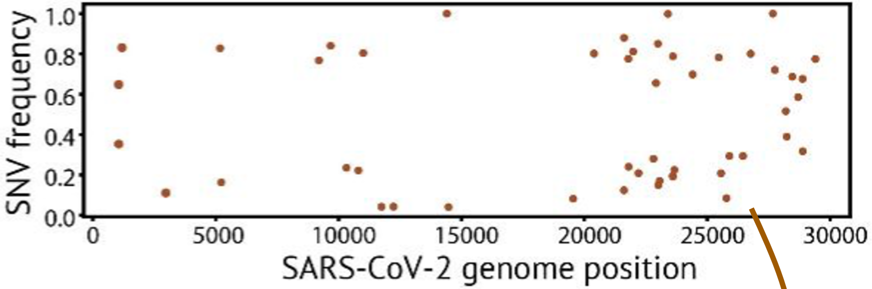
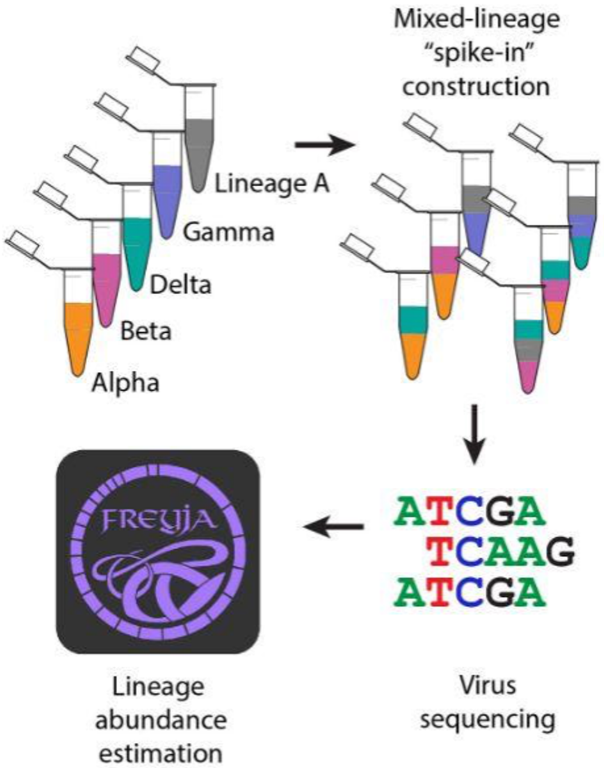
Detection of Single Nucleotide Variants



Depth-weighted de-mixing

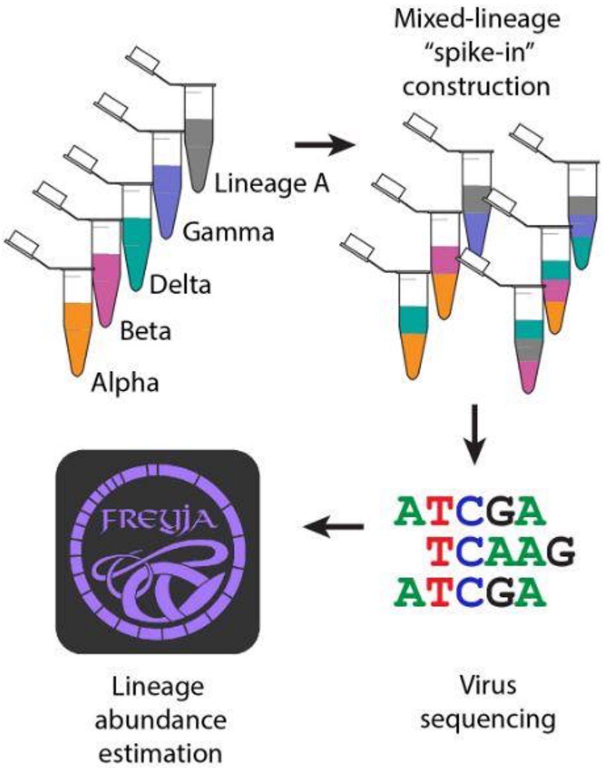
$$\hat{x} = \underset{\substack{x \geq 0 \\ \sum x = 1}}{\operatorname{argmin}} \; ||A^T x - b||_{1W}$$



Mixed-lineage "spike-in" construction

Virus sequencing

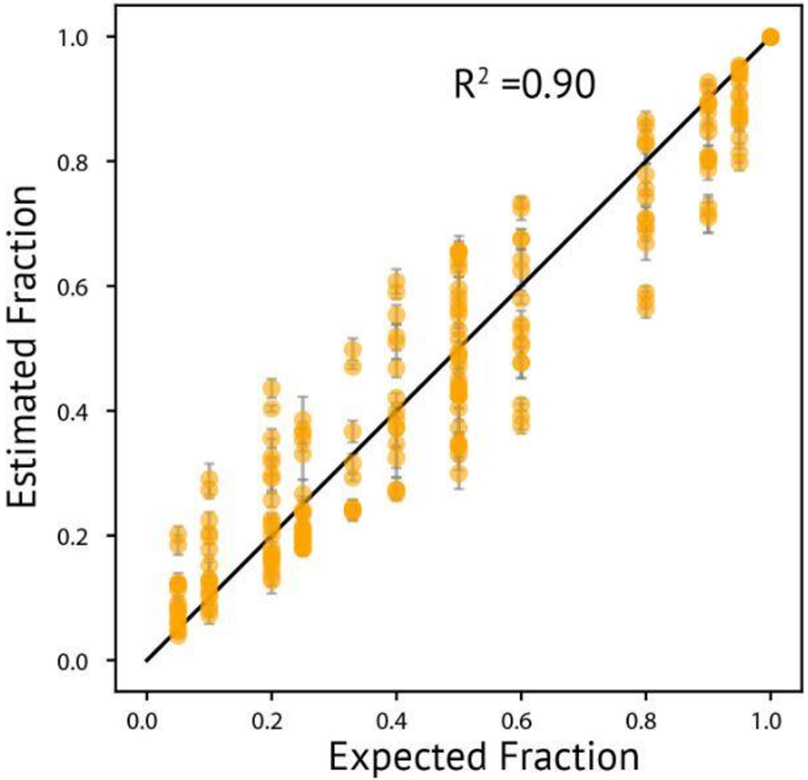
Lineage abundance estimation

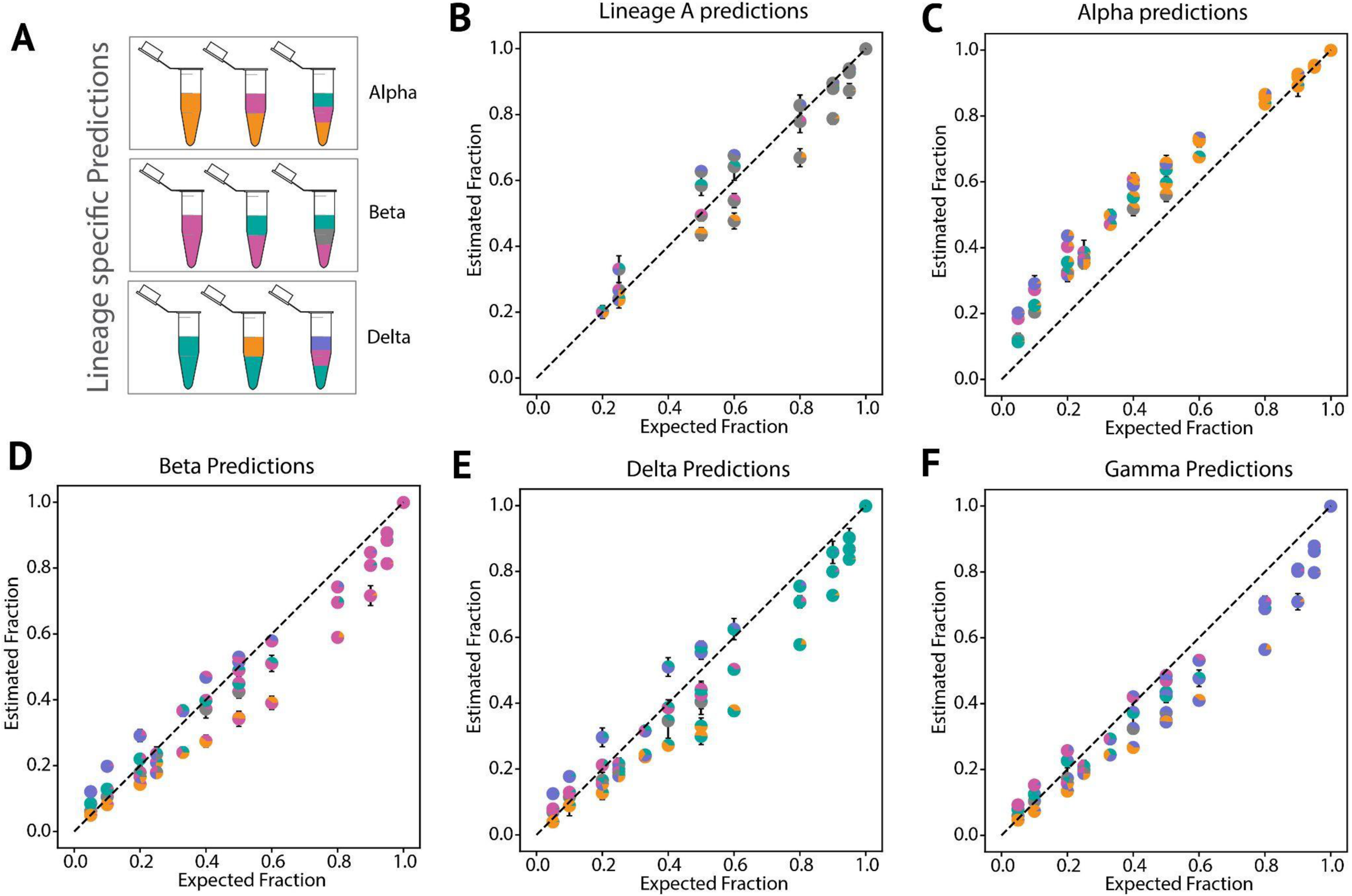


Mixed-lineage "spike-in" construction

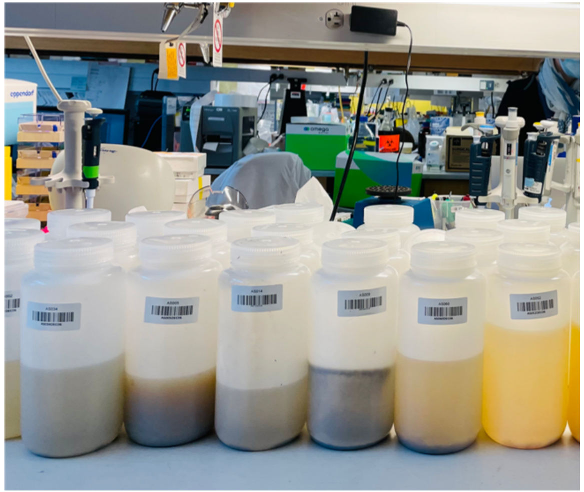
Virus sequencing

Lineage abundance estimation

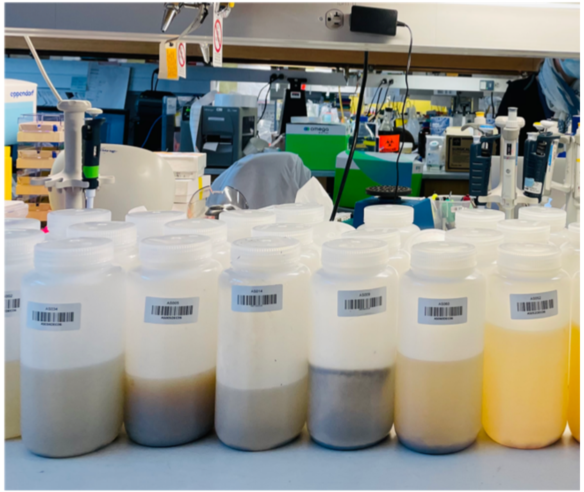


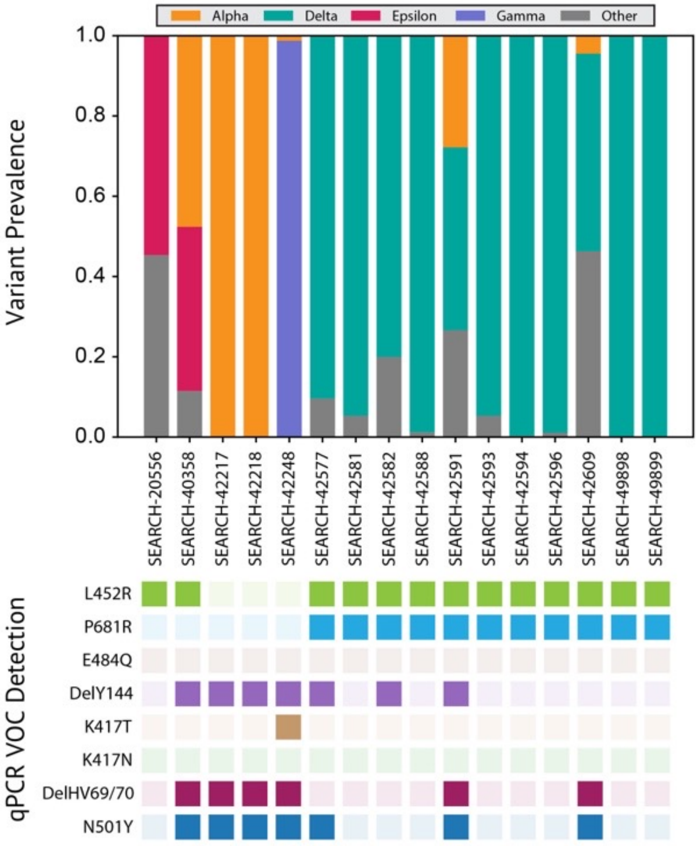

A
Lineage specific Predictions
Alpha
Beta
Delta
B
Lineage A predictions
C
Alpha predictions
D
Beta Predictions
E
Delta Predictions
F
Gamma Predictions
Estimated Fraction
Expected Fraction
0.0
0.2
0.4
0.6
0.8
1.0

Does this work on wastewater?

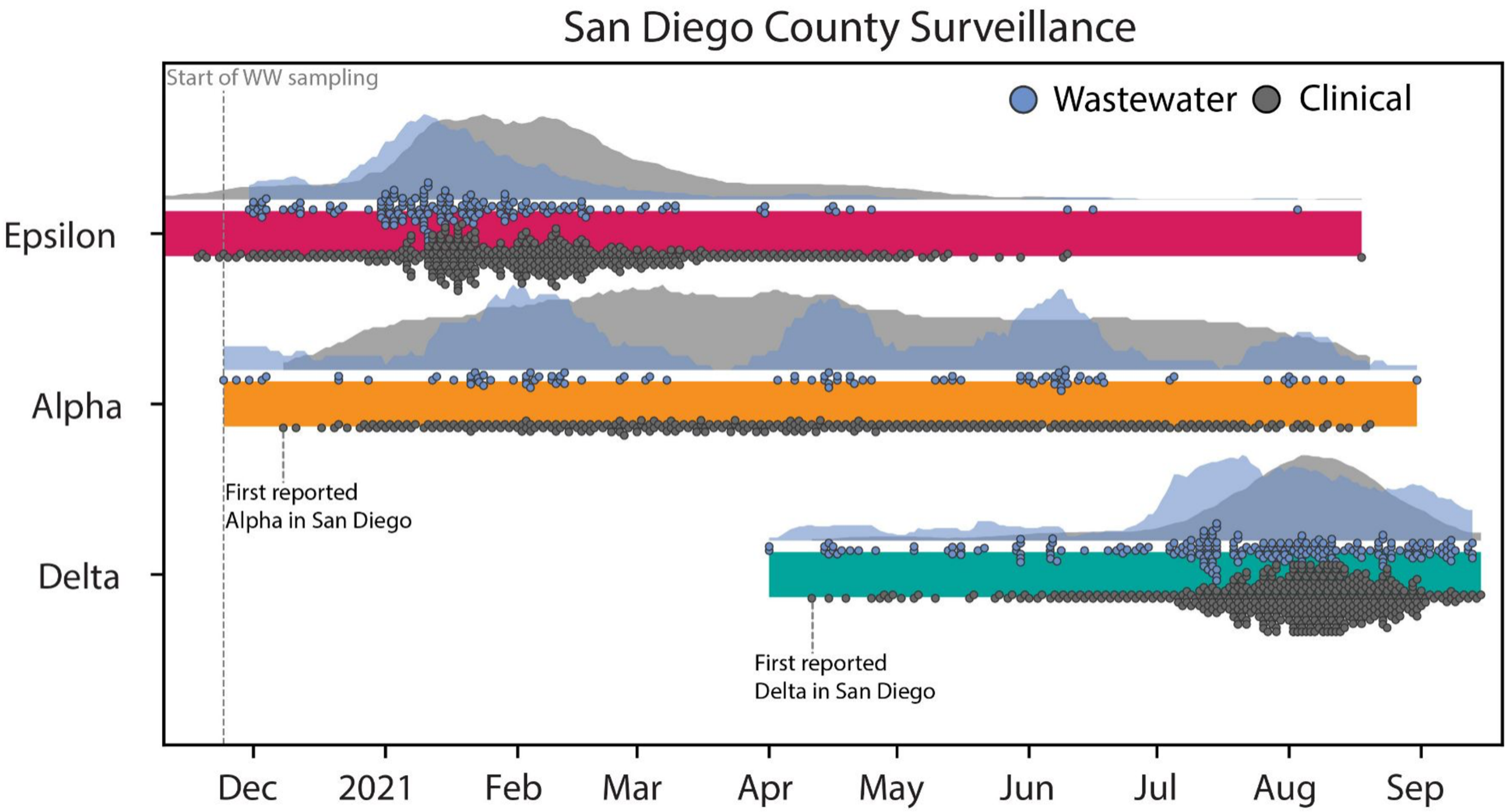


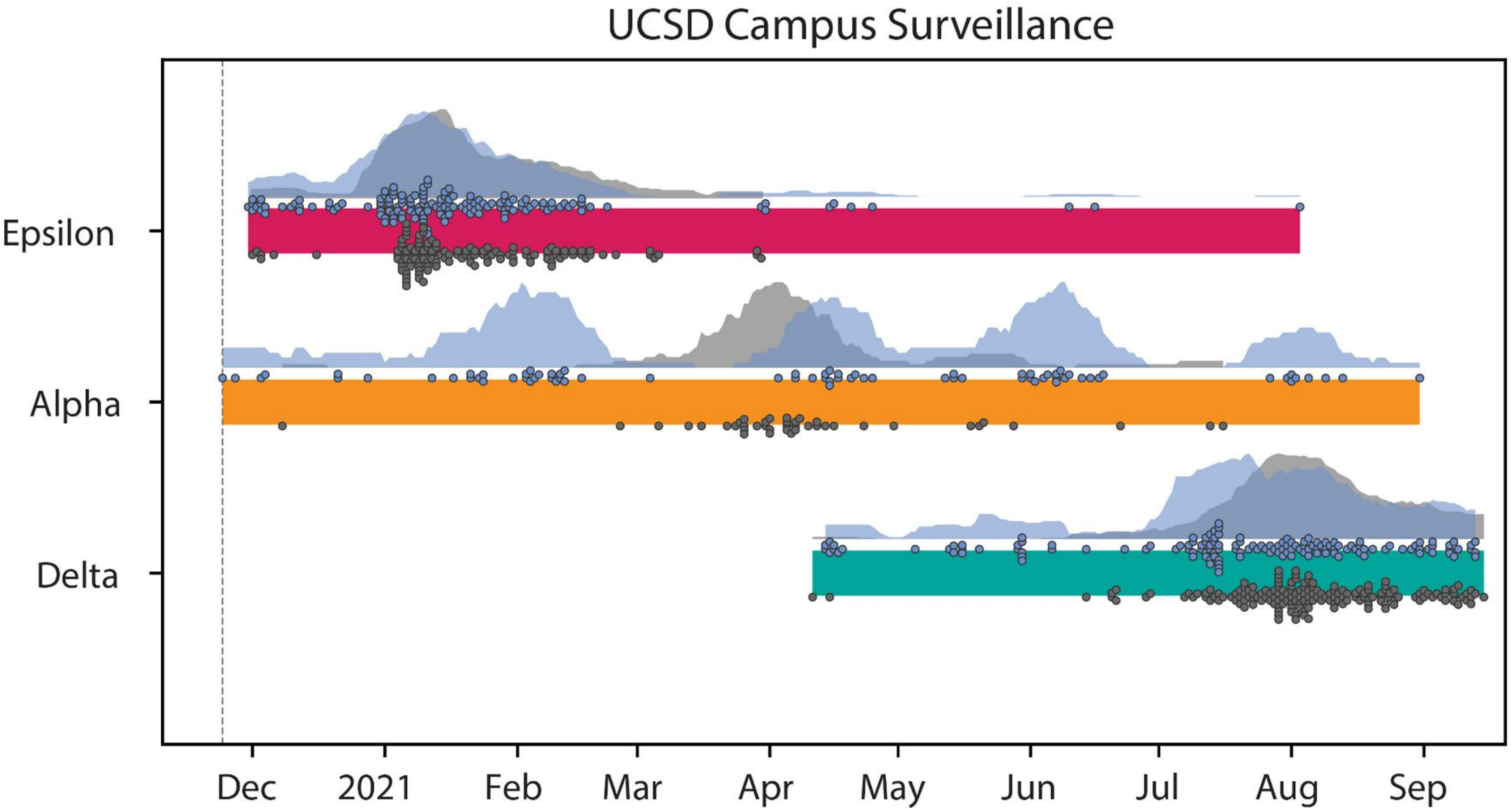
Does this work on wastewater?



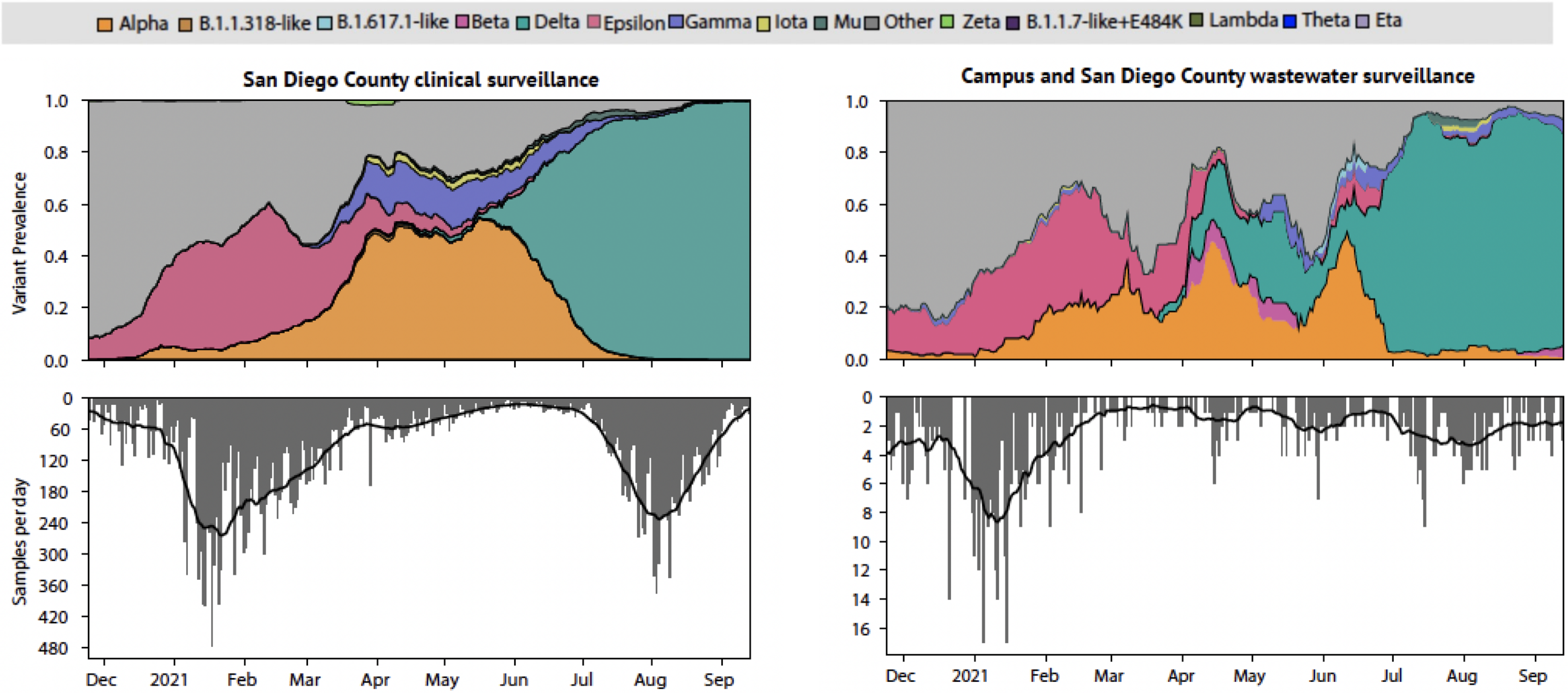


Mutation	Variants	Mutation	Variants
L452R	Delta, Epsilon, Kappa	K417T	Gamma
P681R	Delta, Kappa	K417N	Beta
E484Q	Kappa	DelHV69/70	Alpha
DelY144	Alpha	N501Y	Alpha, Beta, Gamma

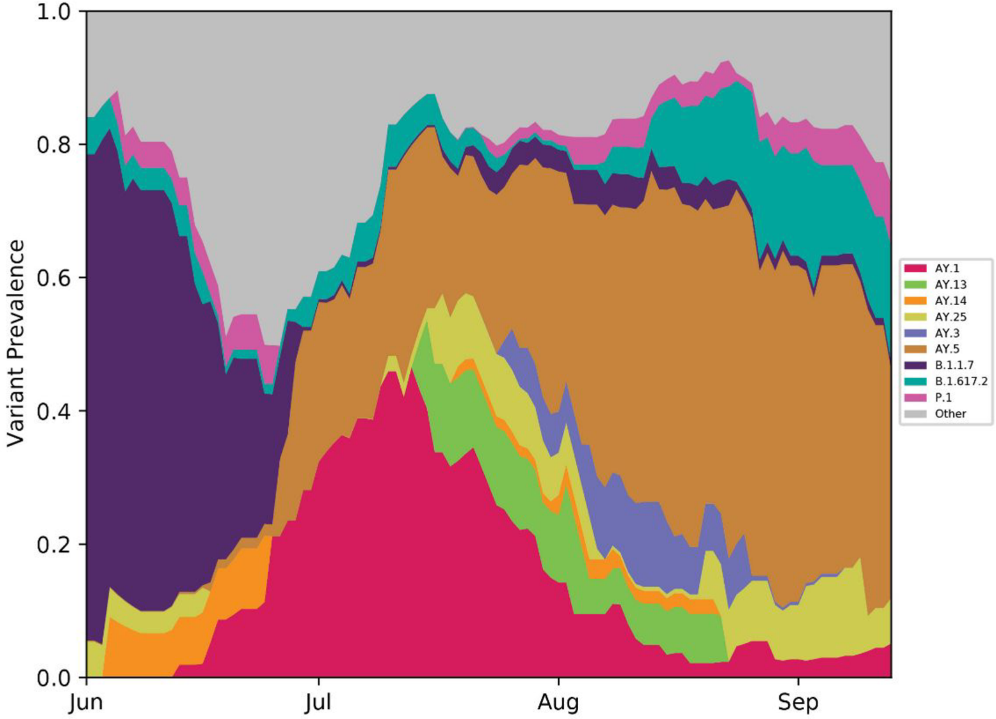

San Diego County Surveillance
Start of WW sampling
Wastewater
Clinical
Epsilon
Alpha
Delta
First reported Alpha in San Diego
First reported Delta in San Diego
Dec
2021
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep



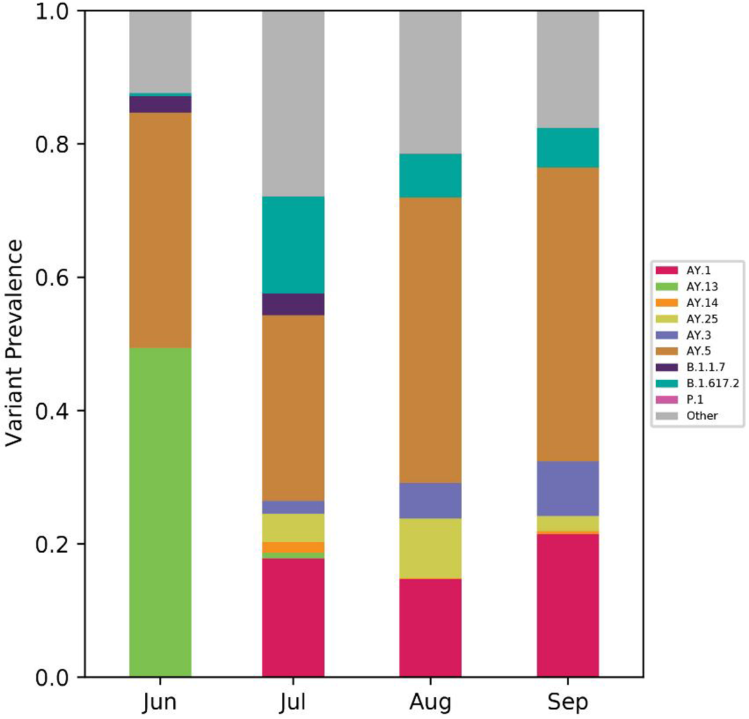
UCSD Campus Surveillance
Epsilon
Alpha
Delta
Dec
2021
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep


Alpha
B.1.1.318-like
B.1.617.1-like
Beta
Delta
Epsilon
Gamma
Iota
Mu
Other
Zeta
B.1.1.7-like+E484K
Lambda
Theta
Eta
San Diego County clinical surveillance
Campus and San Diego County wastewater surveillance
Variant Prevalence
1.0
0.8
0.6
0.4
0.2
0.0
Samples per day
0
60
120
180
240
300
360
420
480
0
2
4
6
8
10
12
14
16
Dec
2021
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

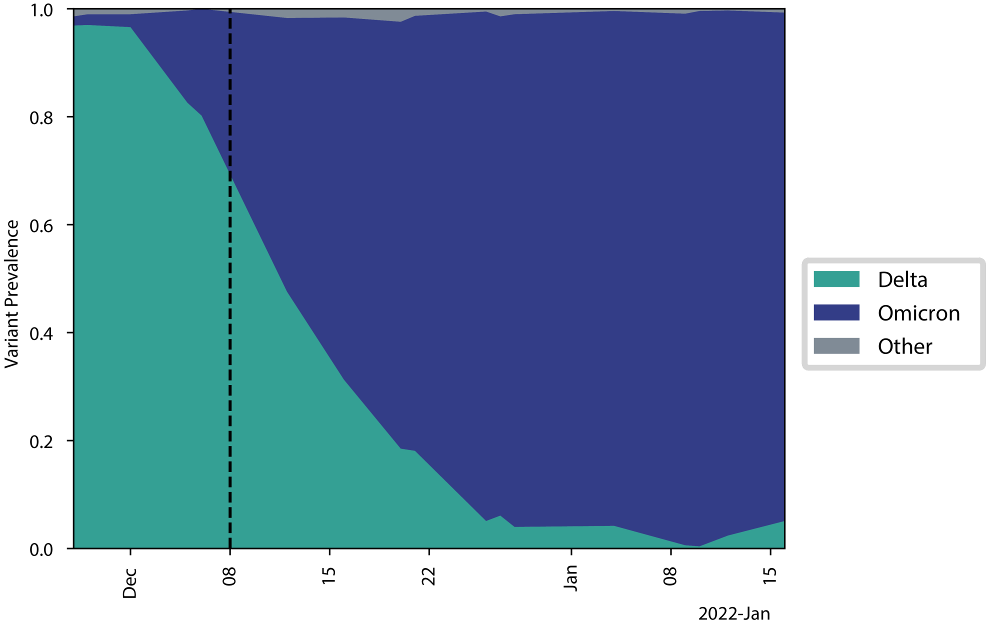
RTL (Campus)



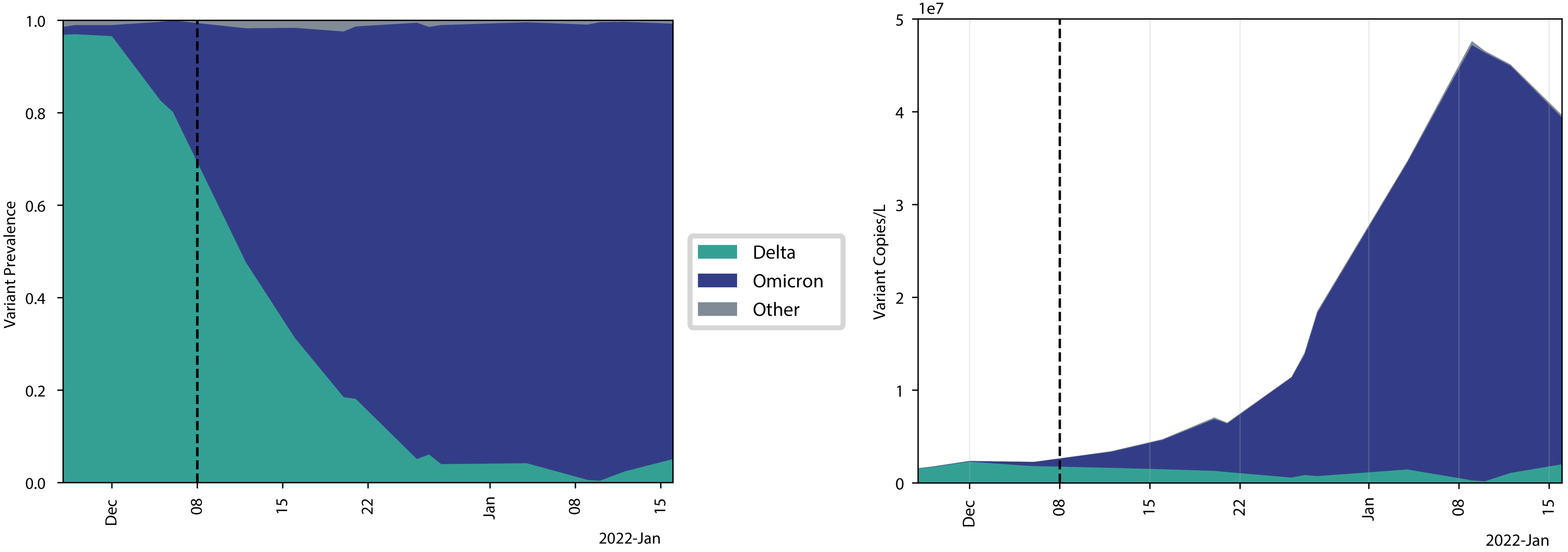
Point Loma



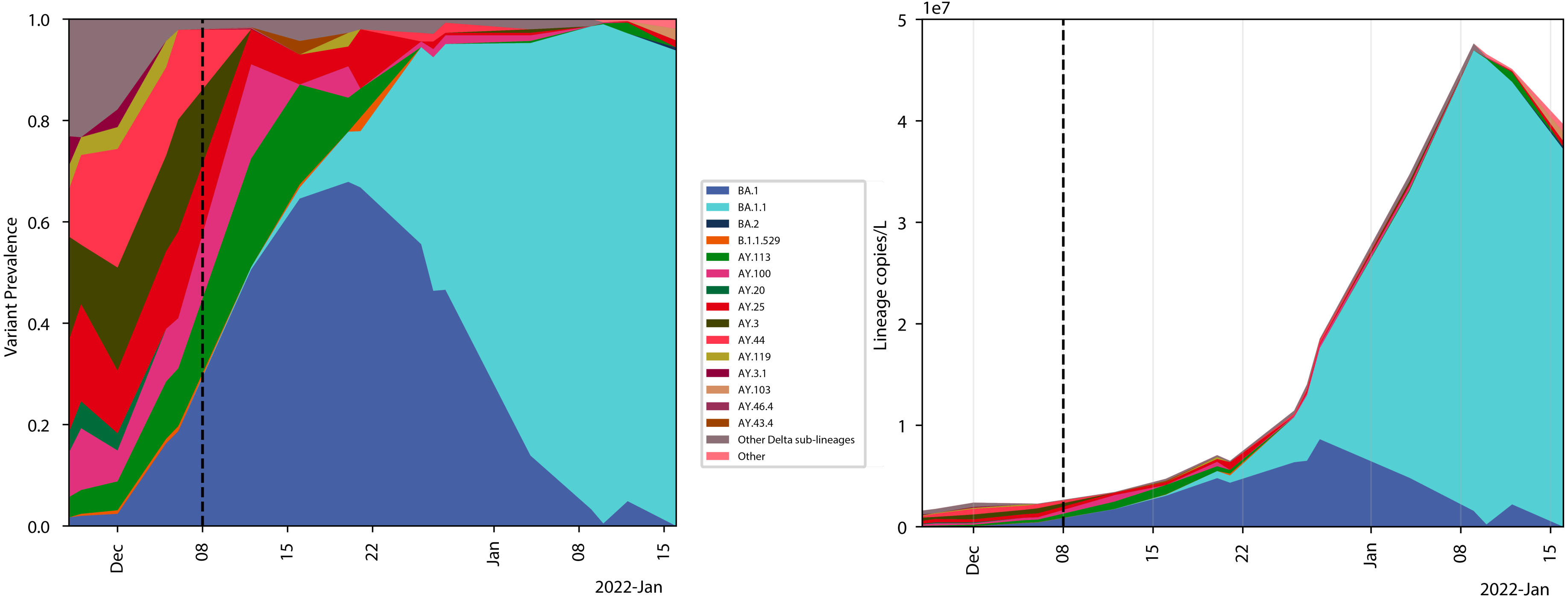
The Omicron wave in San Diego

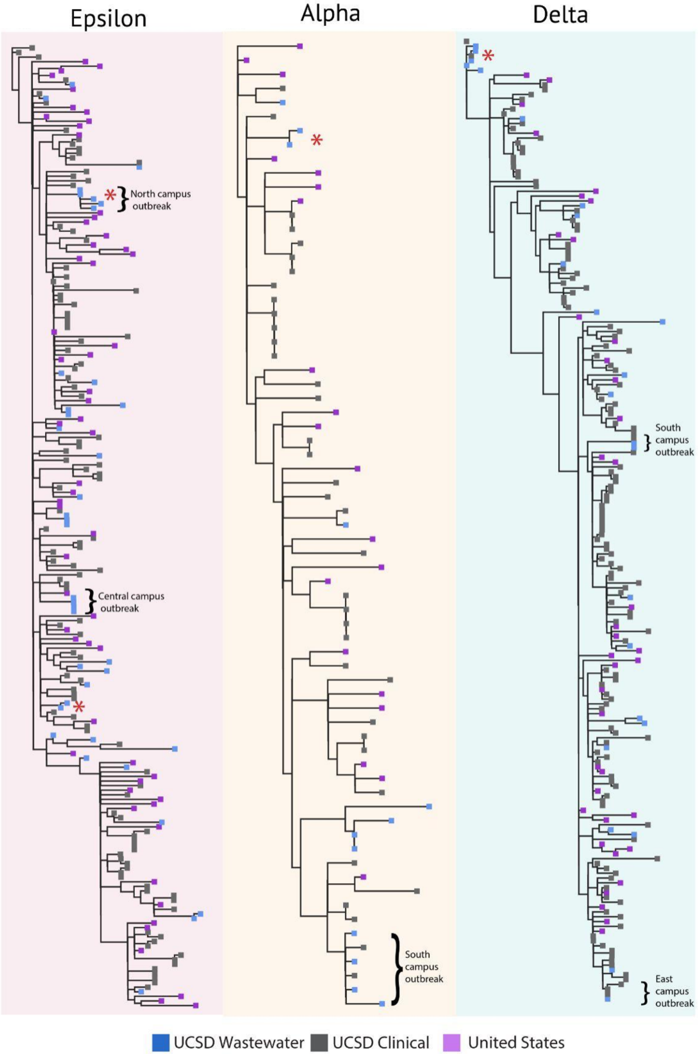


The Omicron wave in San Diego



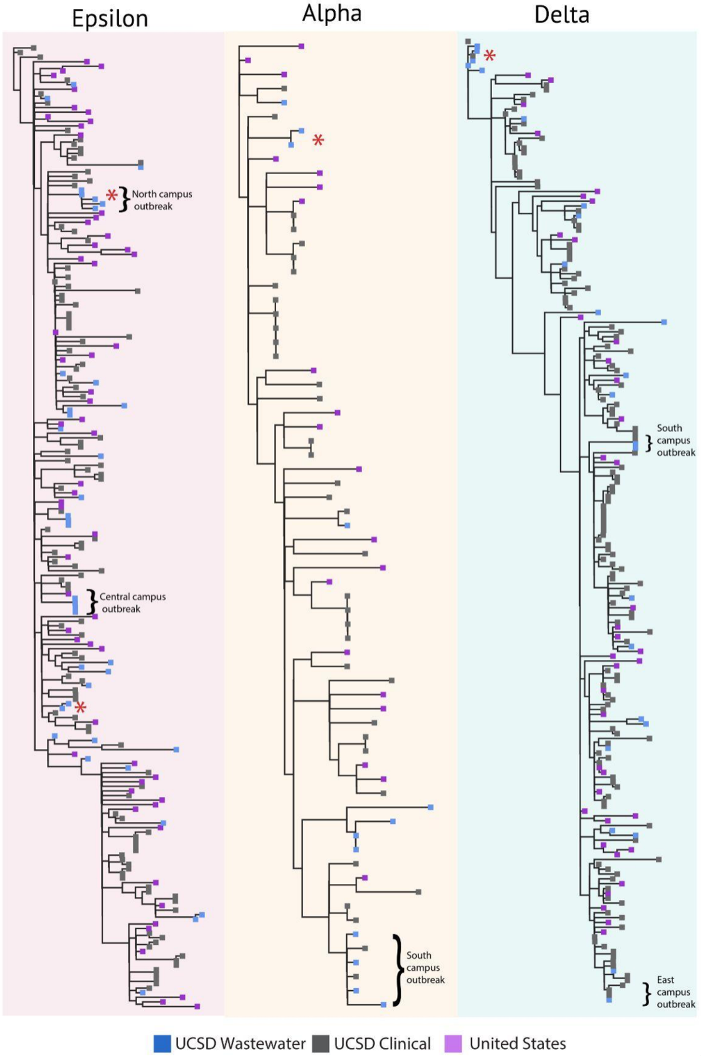
The Omicron wave in San Diego

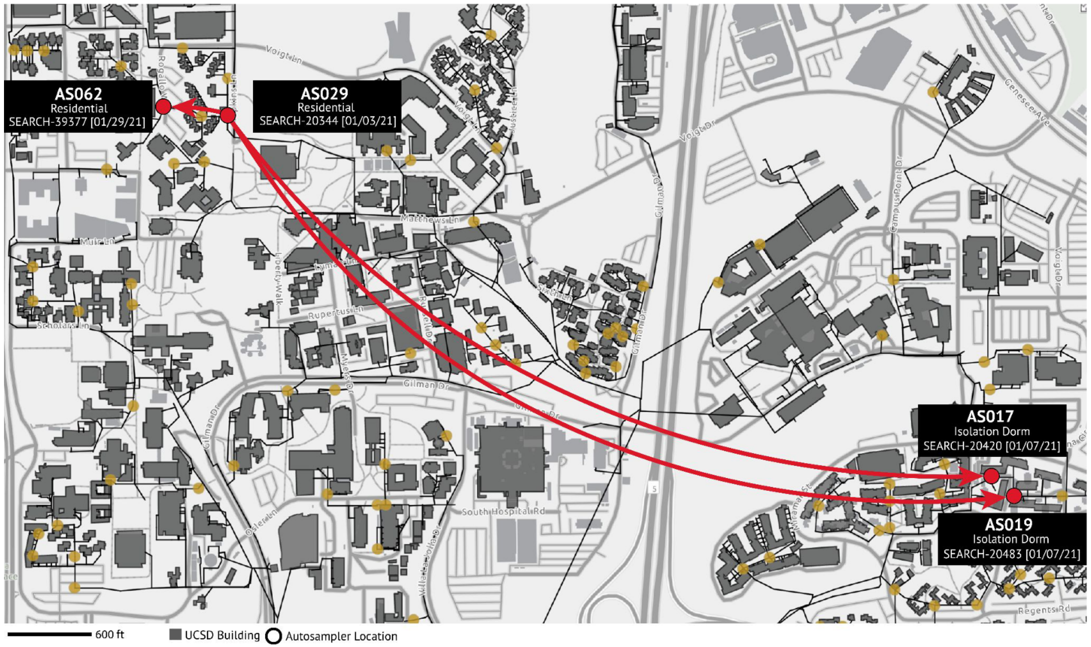



Epsilon

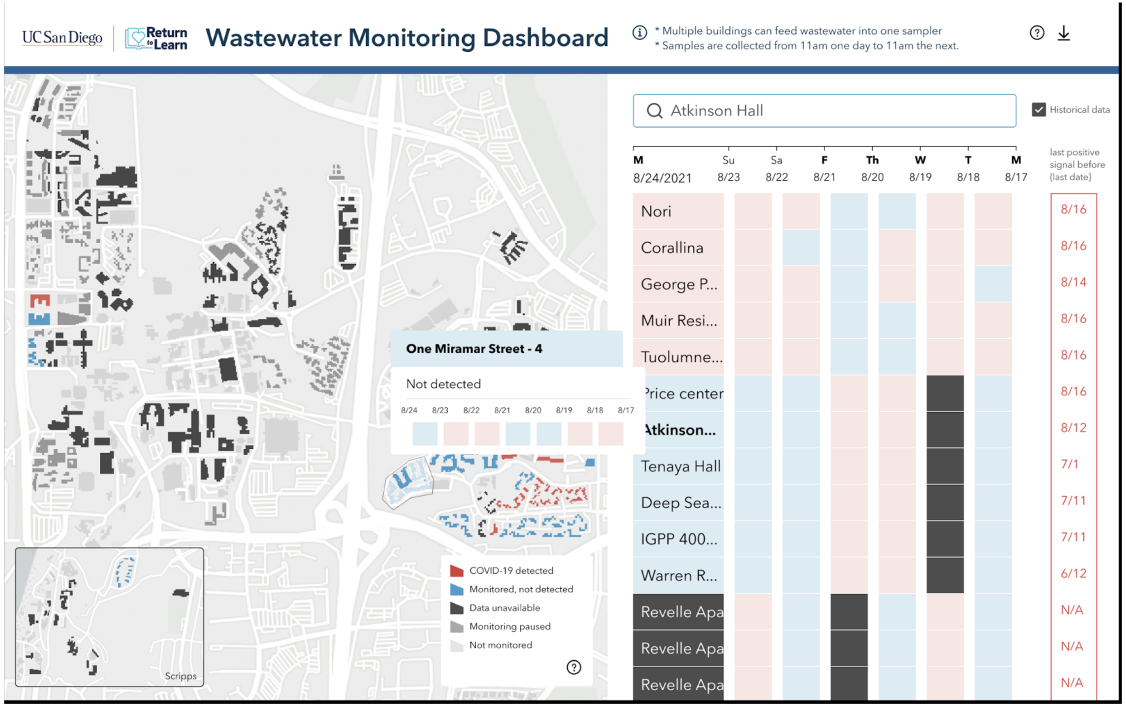
Alpha

Delta


Epsilon
Alpha
Delta
*
North campus outbreak
Central campus outbreak
South campus outbreak
South campus outbreak
East campus outbreak
UCSD Wastewater
UCSD Clinical
United States


AS062
Residential
SEARCH-39377 [01/29/21]
AS029
Residential
SEARCH-20344 [01/03/21]
AS017
Isolation Dorm
SEARCH-20420 [01/07/21]
AS019
Isolation Dorm
SEARCH-20483 [01/07/21]
Voigt Ln
Voigt Dr
Matthews Ln
Muir Ln
Scholars Ln
Library Walk
Lyman Ln
Rupertus Ln
Sixth Ln
Gilman Dr
Myers Dr
Osler Ln
Villa La Jolla Dr
South Hospital Rd
Genesee Ave
Campus Point Dr
Miramar St
Regents Rd
600 ft
UCSD Building
Autosampler Location

Public health use of wastewater surveillance



UC San Diego | Return to Learn **Wastewater Monitoring Dashboard**

* Multiple buildings can feed wastewater into one sampler
* Samples are collected from 11am one day to 11am the next.

Atkinson Hall

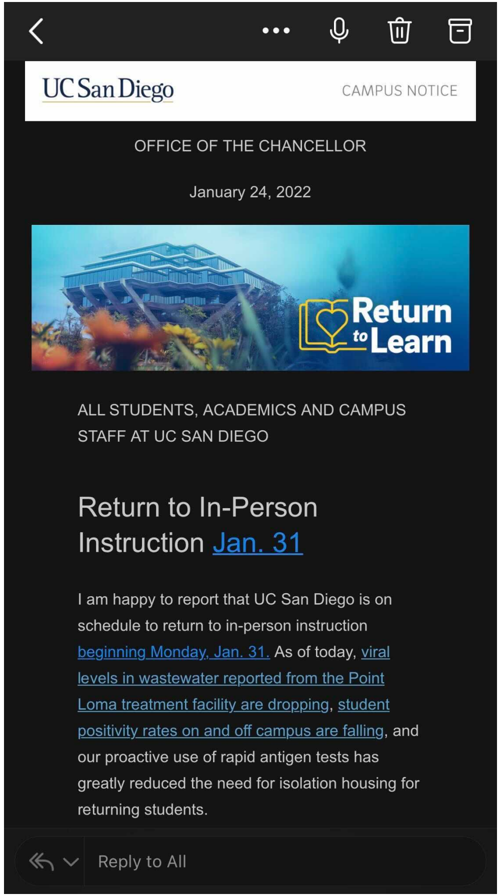
☑ Historical data

M 8/24/2021	Su 8/23	Sa 8/22	F 8/21	Th 8/20	W 8/19	T 8/18	M 8/17	last positive signal before {last date}
🟥 Nori	🟥	🟥	🟦	🟦	🟥	🟥		8/16
🟥 Corallina	🟥	🟦	🟦	🟥	🟥	🟥		8/16
🟥 George P...	🟥	🟥	🟦	🟥	🟥	🟦		8/14
🟥 Muir Resi...	🟥	🟥	🟦	🟦	🟥	🟥		8/16
🟥 Tuolumne...	🟥	🟥	🟦	🟦	🟥	🟥		8/16
🟦 Price center	🟦	🟦	🟥	🟥	⬛	🟦		8/16
🟦 **Atkinson...**	🟦	🟦	🟥	🟥	⬛	🟦		8/12
🟦 Tenaya Hall	🟦	🟦	🟥	🟥	⬛	🟦		7/1
🟦 Deep Sea...	🟦	🟦	🟥	🟥	⬛	🟦		7/11
🟦 IGPP 400...	🟦	🟦	🟥	🟥	⬛	🟦		7/11
🟦 Warren R...	🟦	🟦	🟥	🟥	⬛	🟦		6/12
⬛ Revelle Apa	🟥	🟦	⬛	🟦	🟥	🟦		N/A
⬛ Revelle Apa	🟥	🟦	⬛	🟦	🟥	🟦		N/A
⬛ Revelle Apa	🟥	🟦	⬛	🟦	🟥	🟦		N/A

One Miramar Street - 4

Not detected

🟥 COVID-19 detected
🟦 Monitored, not detected
⬛ Data unavailable
▨ Monitoring paused
☐ Not monitored



UC San Diego CAMPUS NOTICE

OFFICE OF THE CHANCELLOR

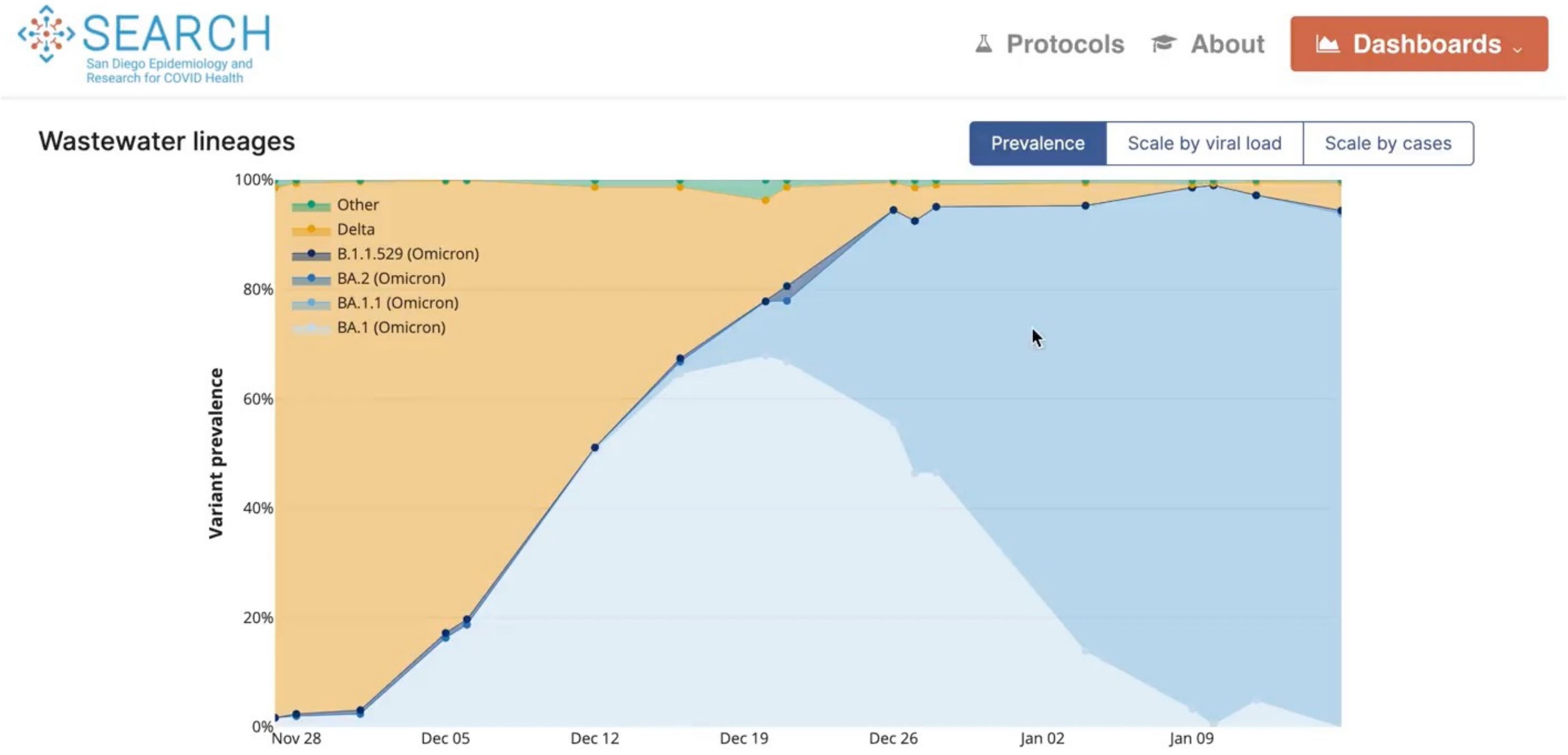
January 24, 2022

ALL STUDENTS, ACADEMICS AND CAMPUS STAFF AT UC SAN DIEGO

Return to In-Person Instruction Jan. 31

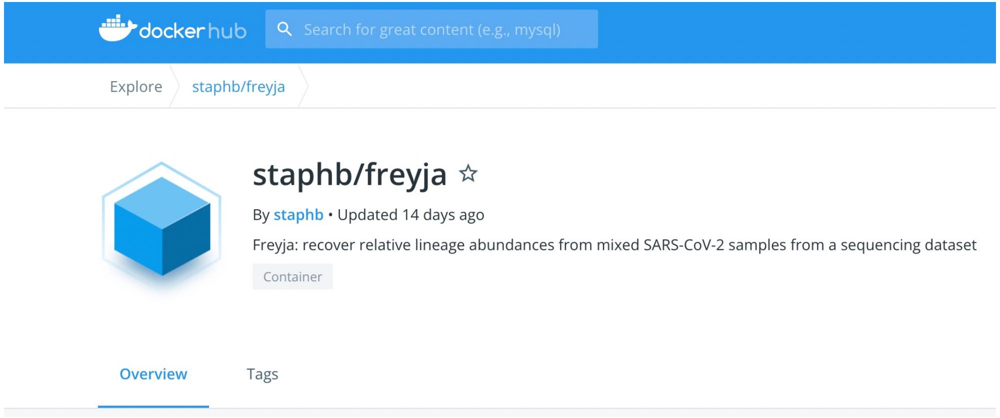
I am happy to report that UC San Diego is on schedule to return to in-person instruction beginning Monday, Jan. 31. As of today, viral levels in wastewater reported from the Point Loma treatment facility are dropping, student positivity rates on and off campus are falling, and our proactive use of rapid antigen tests has greatly reduced the need for isolation housing for returning students.

Public health use of wastewater surveillance



Code deployment and usage

BIOCONDA®



staphb/freyja ☆

By staphb • Updated 14 days ago

Freyja: recover relative lineage abundances from mixed SARS-CoV-2 samples from a sequencing dataset

FDA

CDC

← Back to list

Freyja_FASTQ

Version: v2.0.0

Source: github.com/theiagen/public_health_viral_genomics/Freyja_FASTQ:v2.0.0

Synopsis:

No documentation provided

○ Run workflow with inputs defined by file paths

● Run workflow(s) with inputs defined by data table

Step 1

Select root entity type: Wastewater_Freyja

Step 2

SELECT DATA

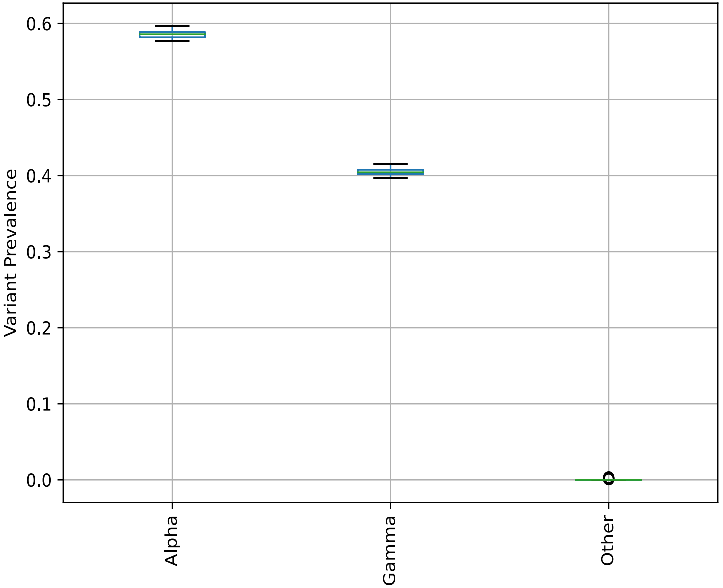
No data selected

☑ Use call caching ☐ Delete intermediate outputs ☐ Use reference disks ☐ Retry with more memory

H/T Kevin Libuit

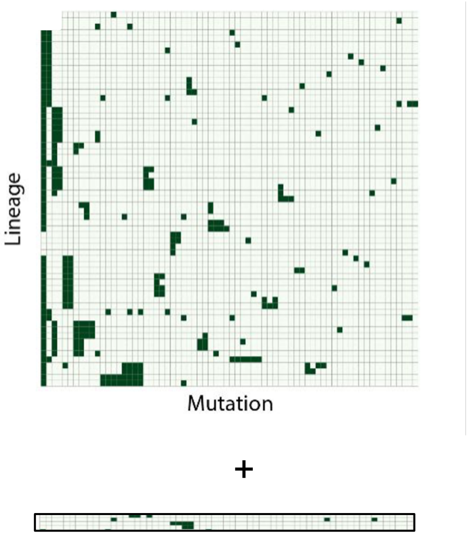
Ongoing development of Freyja

Fast bootstrapping



Now available

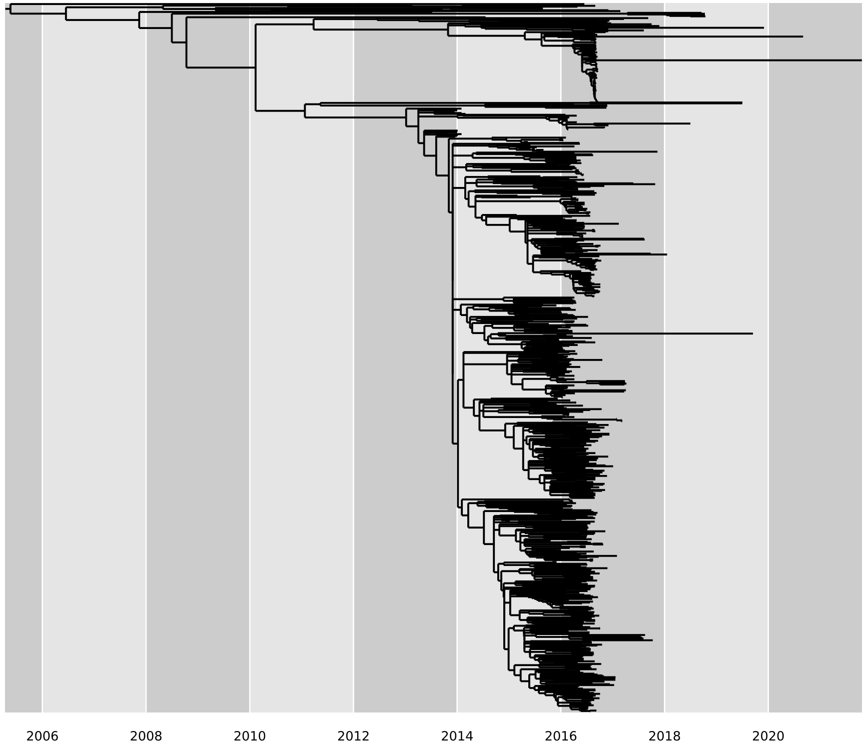
Novel lineage detection



Coming soon

Ongoing: Extending to other viruses

Zika (2013-2019)



Coming soon

Thanks!!

Smruthi Karthikeyan

Peter DeHoff

Andersen Lab

Knight Lab

Kevin Libuit (Theiagen)

SEARCH
San Diego Epidemiology and
Research for COVID Health

Scripps Research Rady Children's Institute Genomic Medicine UC San Diego Outbreak.info

NIH T32 Training grant 5T32AI007244-38