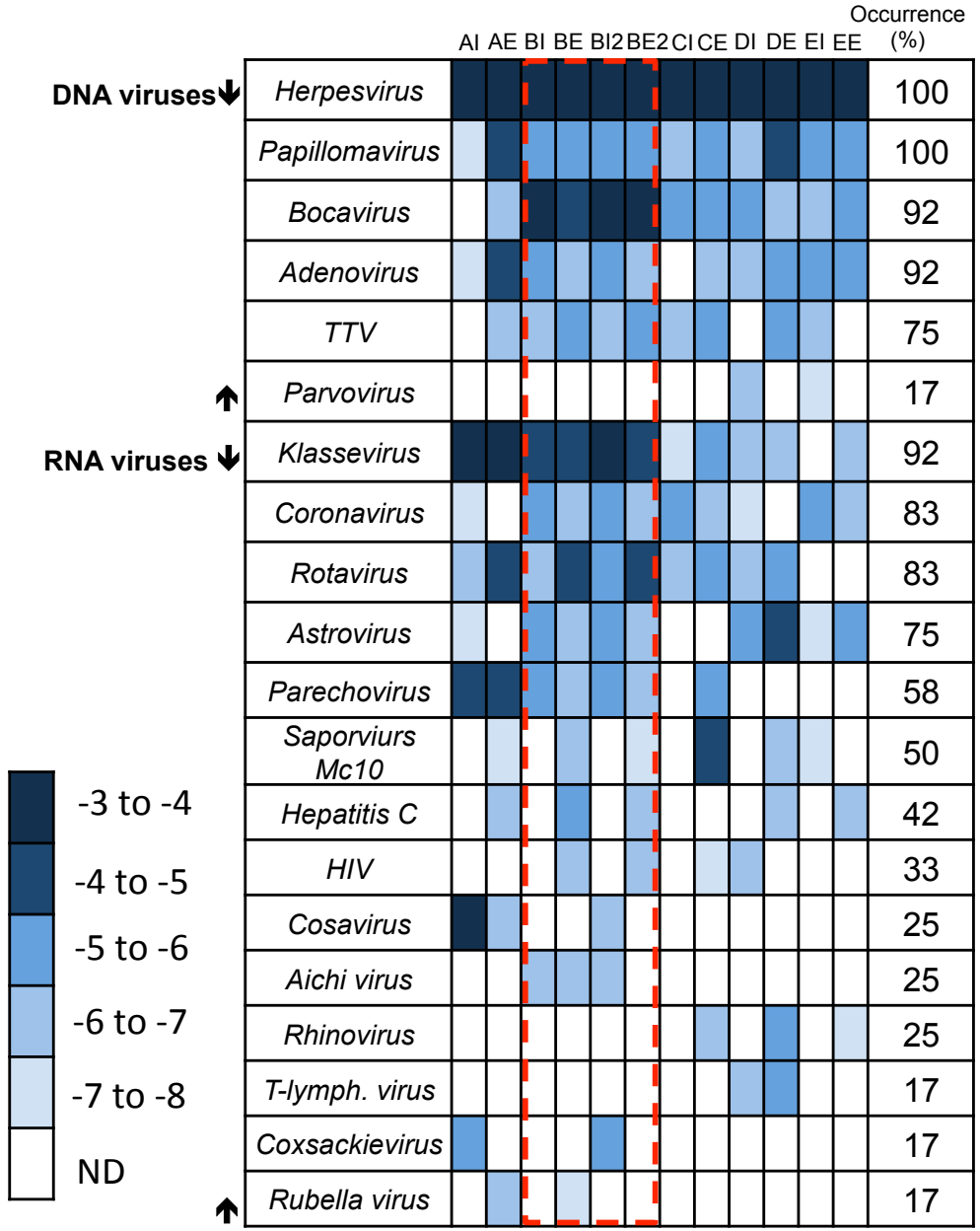
Tracking epidemics at the population level through wastewater-based epidemiology

Jordan Peccia
Yale University, School of Engineering and Applied Sciences

2.23.2021

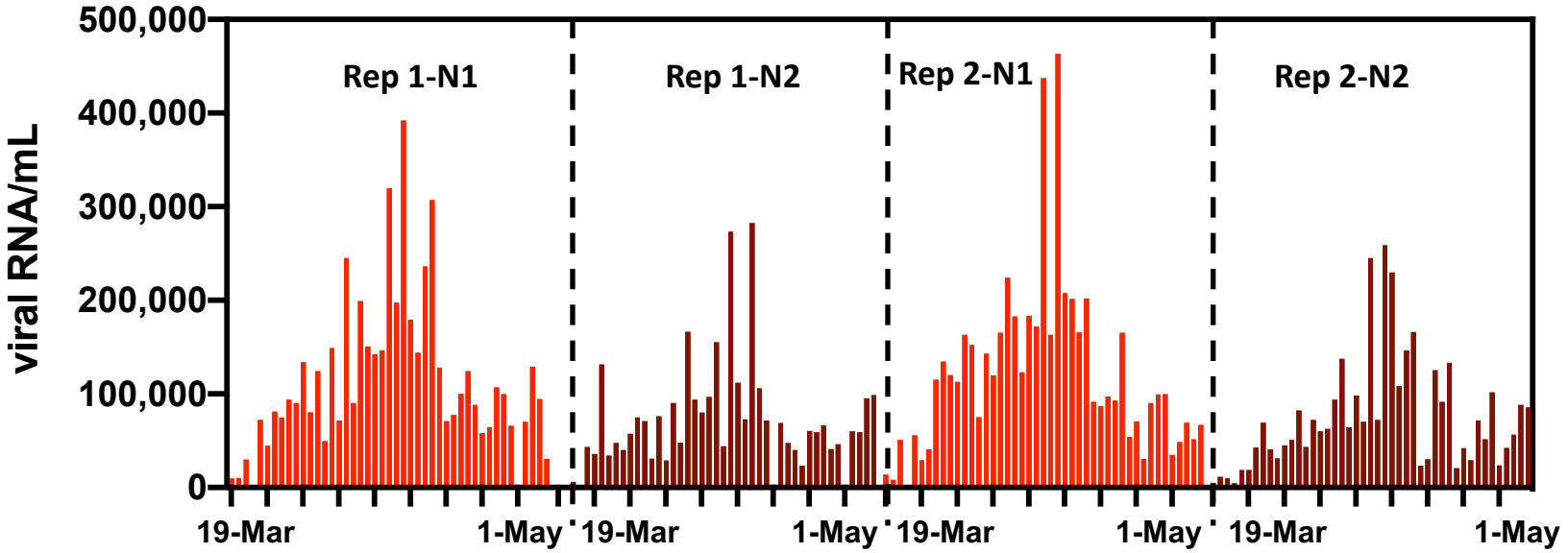
Viral Metagenome of Sewage Sludge



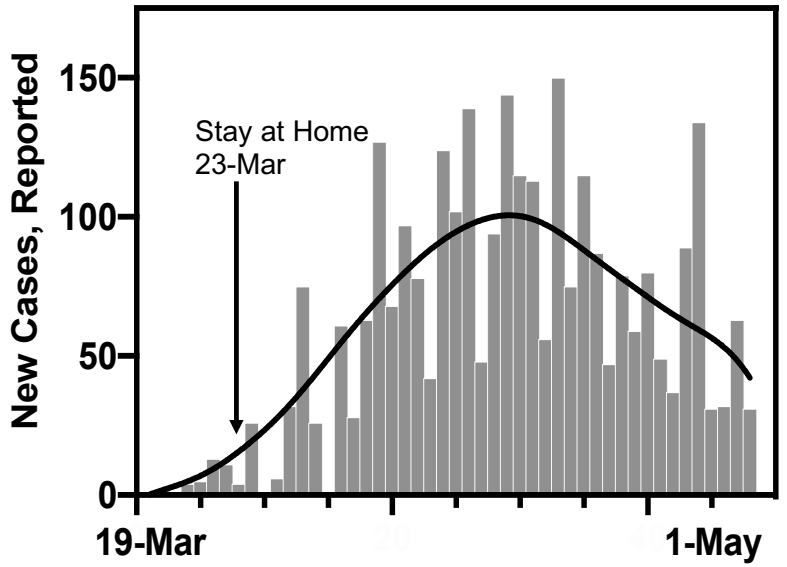
Bibby et al., *Environmental Science and Technology* (2013)

SARS-CoV-2 in WASTEWATER TRACKS CASES

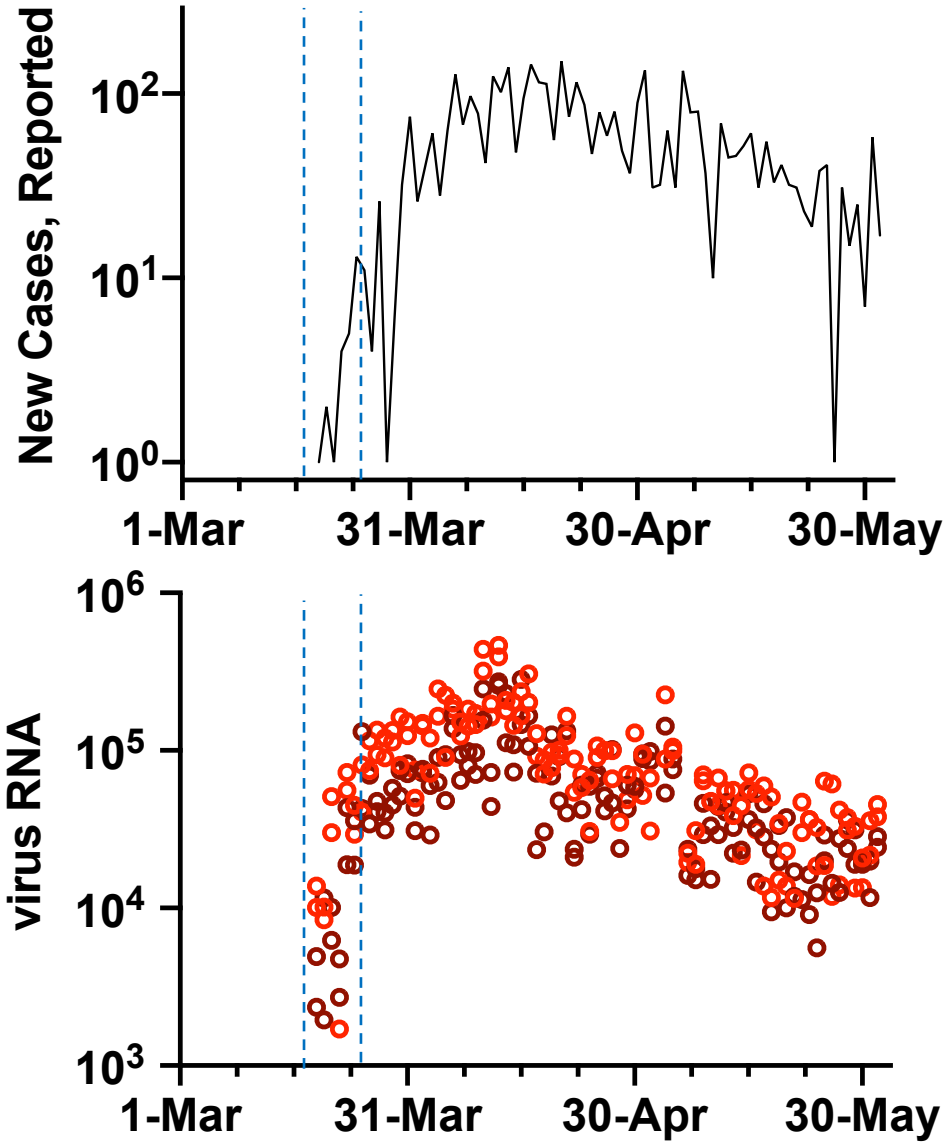
Primary sludge SARS-CoV-2 RNA



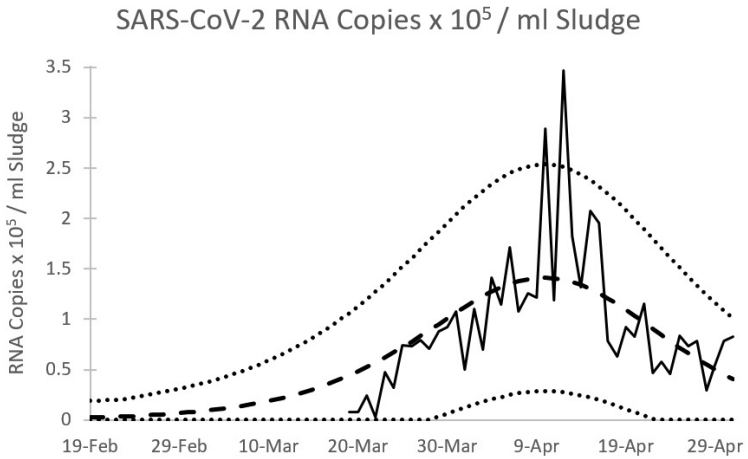
New Cases



Comparing Wastewater Data with Testing data (Report date) (7 day leading indicator)

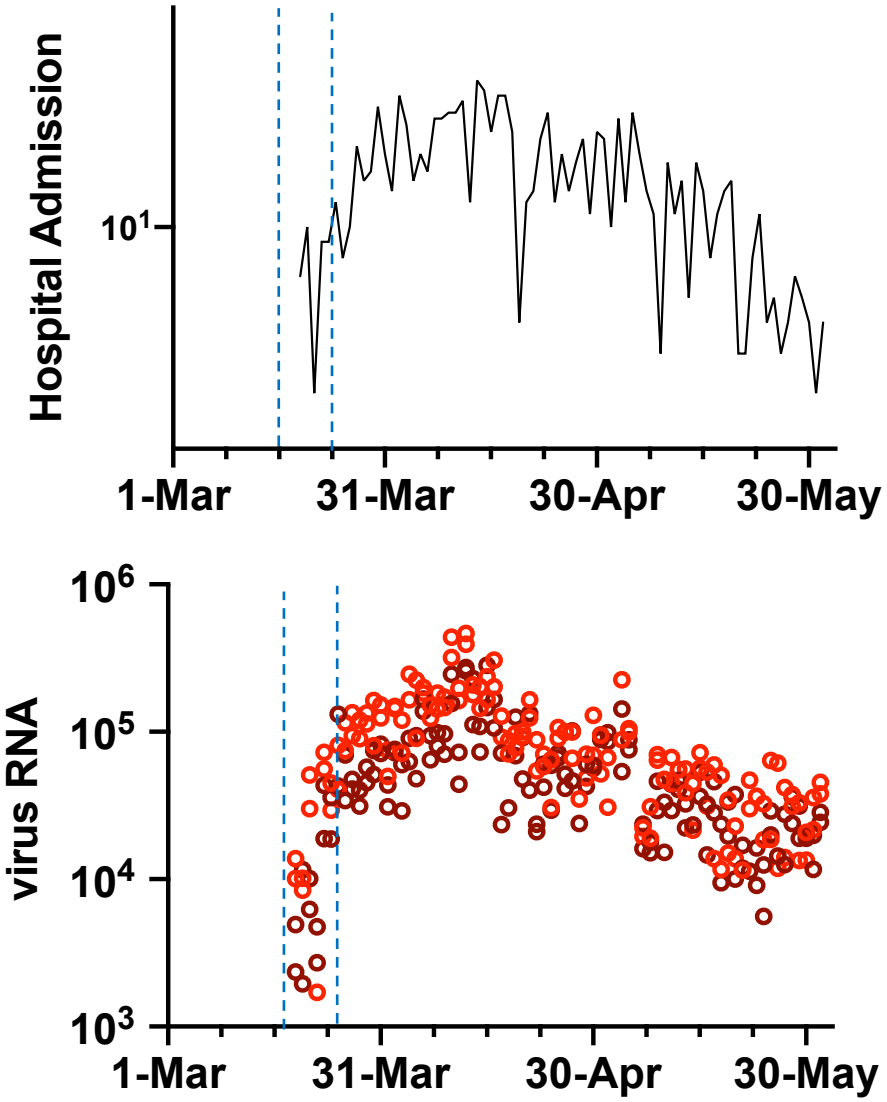


Peccia et al., *Nature Biotech (*2020)



Kaplan et al.
https://doi.org/10.1101/2020.06.27.20141739

Comparing Wastewater Data with Testing Data (HOSPITALIZATIONS)



Peccia et al., *Nature Biotech* (2020)

Yale COVID-19 Wastewater Project

Yale SCHOOL OF ENGINEERING & APPLIED SCIENCE

Yale SCHOOL OF PUBLIC HEALTH

CAES
The Connecticut Agricultural Experiment Station

DPH

CDC
Centers for Disease Control and Prevention

SARS-CoV-2 in Wastewater tracks cases, but is more:

efficient ($),
faster,
accurate (maybe) than testing.

Efficient ($):

1. Currently, 6 daily samples track ~1,000,000 residents in CT
2. Cost of wastewater analysis is roughly equal to that of individual COVID-19 testing 1 person

Fast:

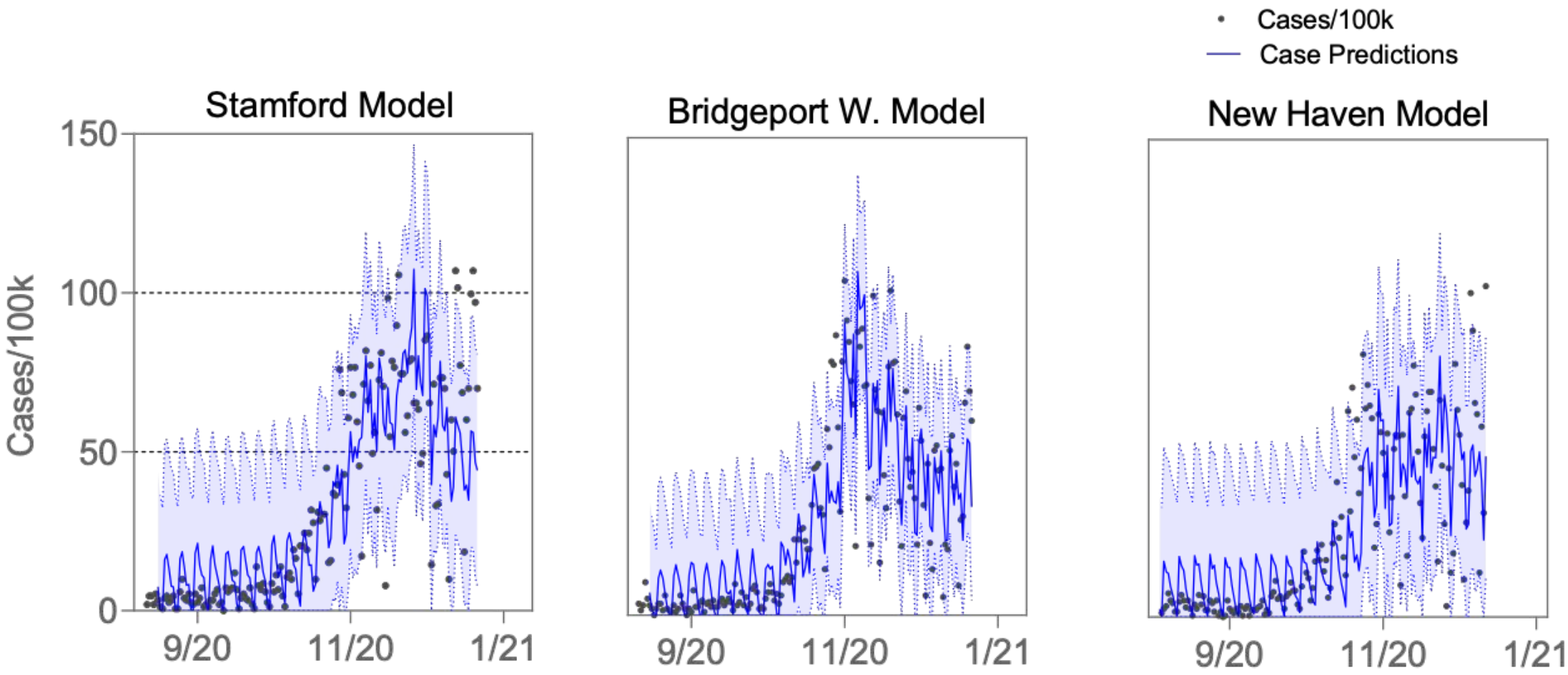
1. Testing is prompted by symptoms, an infected person may shed before getting tested.
2. It takes time to recognize symptoms, test and report

More accurate:

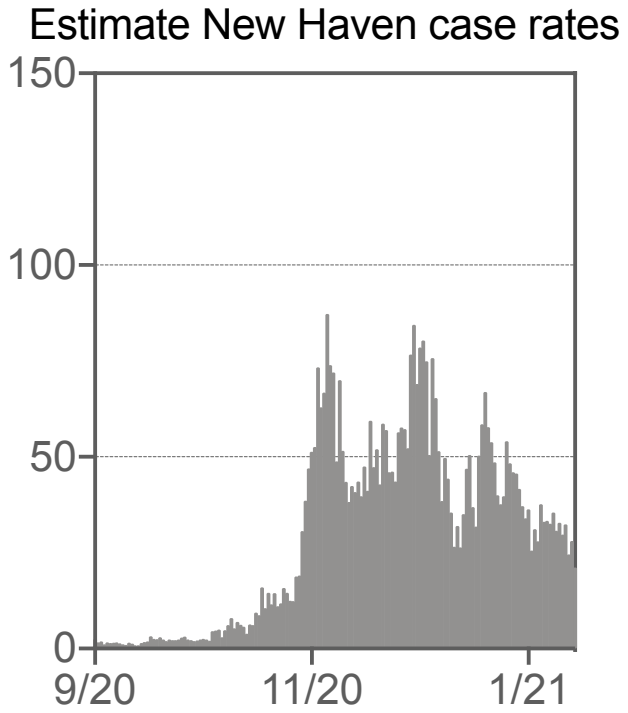
1. Wastewater surveillance doesn't care if a case is asymptomatic or about other factors that influence testing volume (holidays, governments, resources)

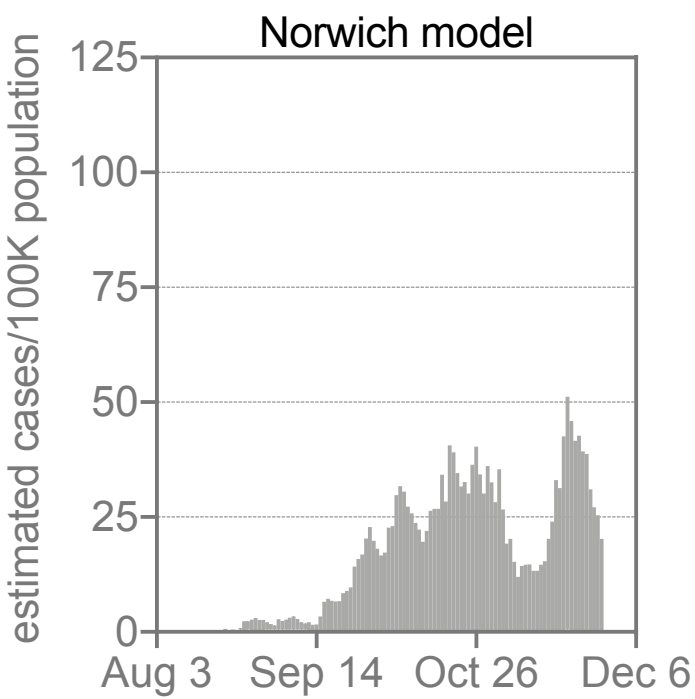
Estimating Case Rate from Wastewater Data

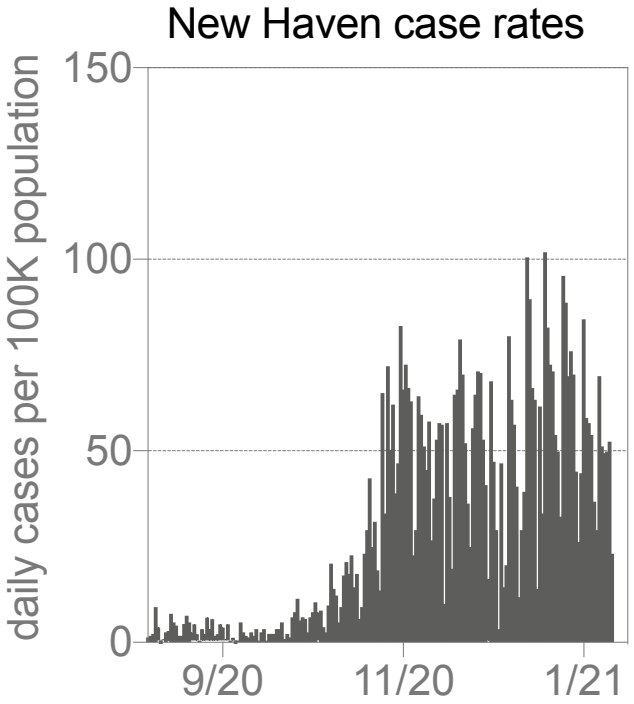
$$case\ rate_{i,t} = \alpha_i + \sum_{j=0}^{\tau} \beta_{i,j} RNA_{i,t-j} + \sum_{d=1}^{6} \gamma_{i,d} x_{d,t} + \epsilon_{i,t}$$

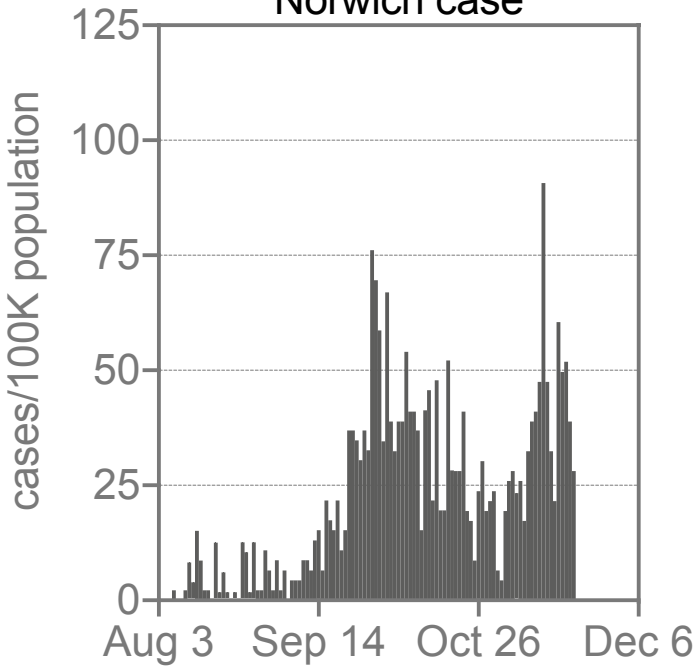


Using Wastewater Surveillance we can Estimate Cases without ever Testing



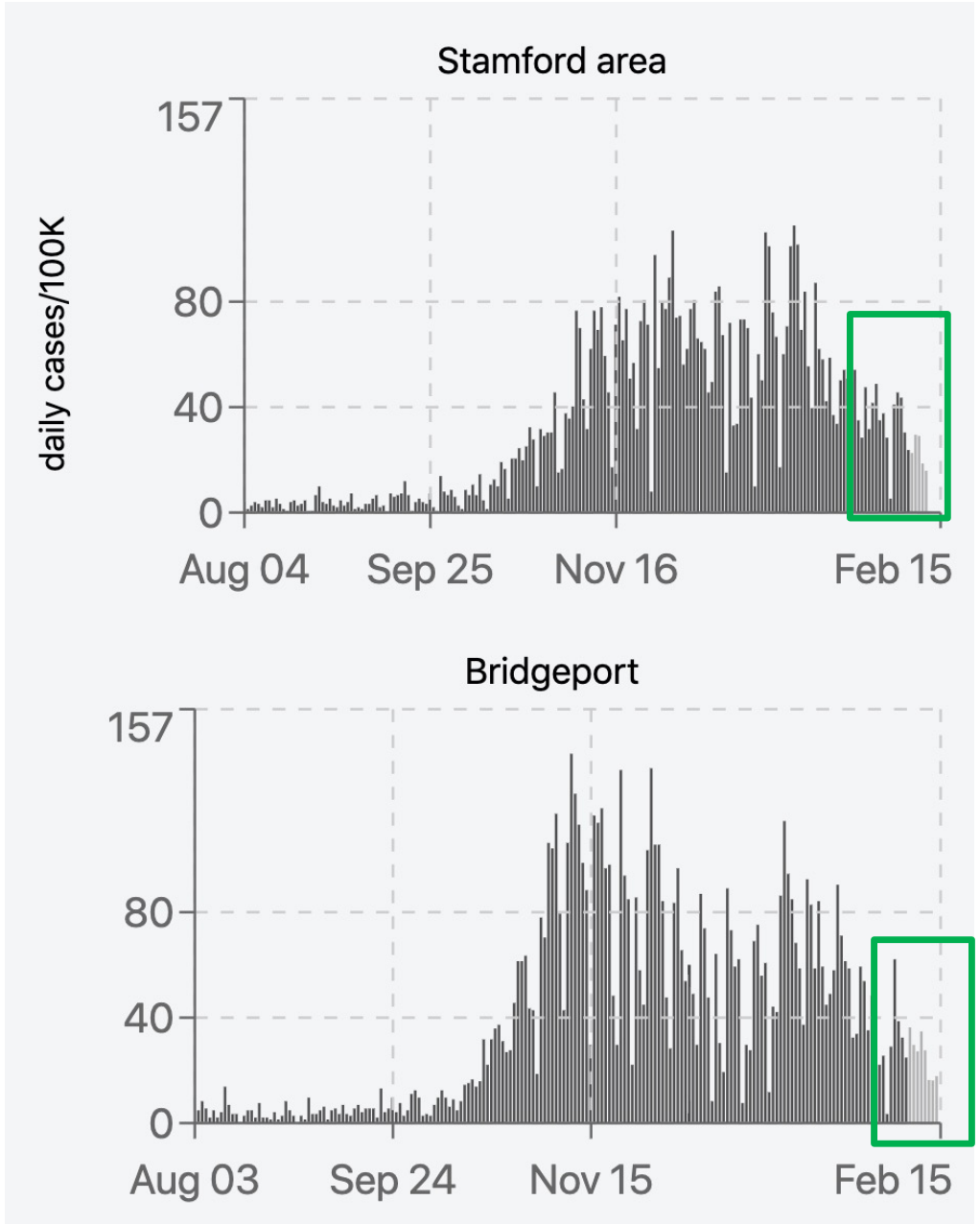


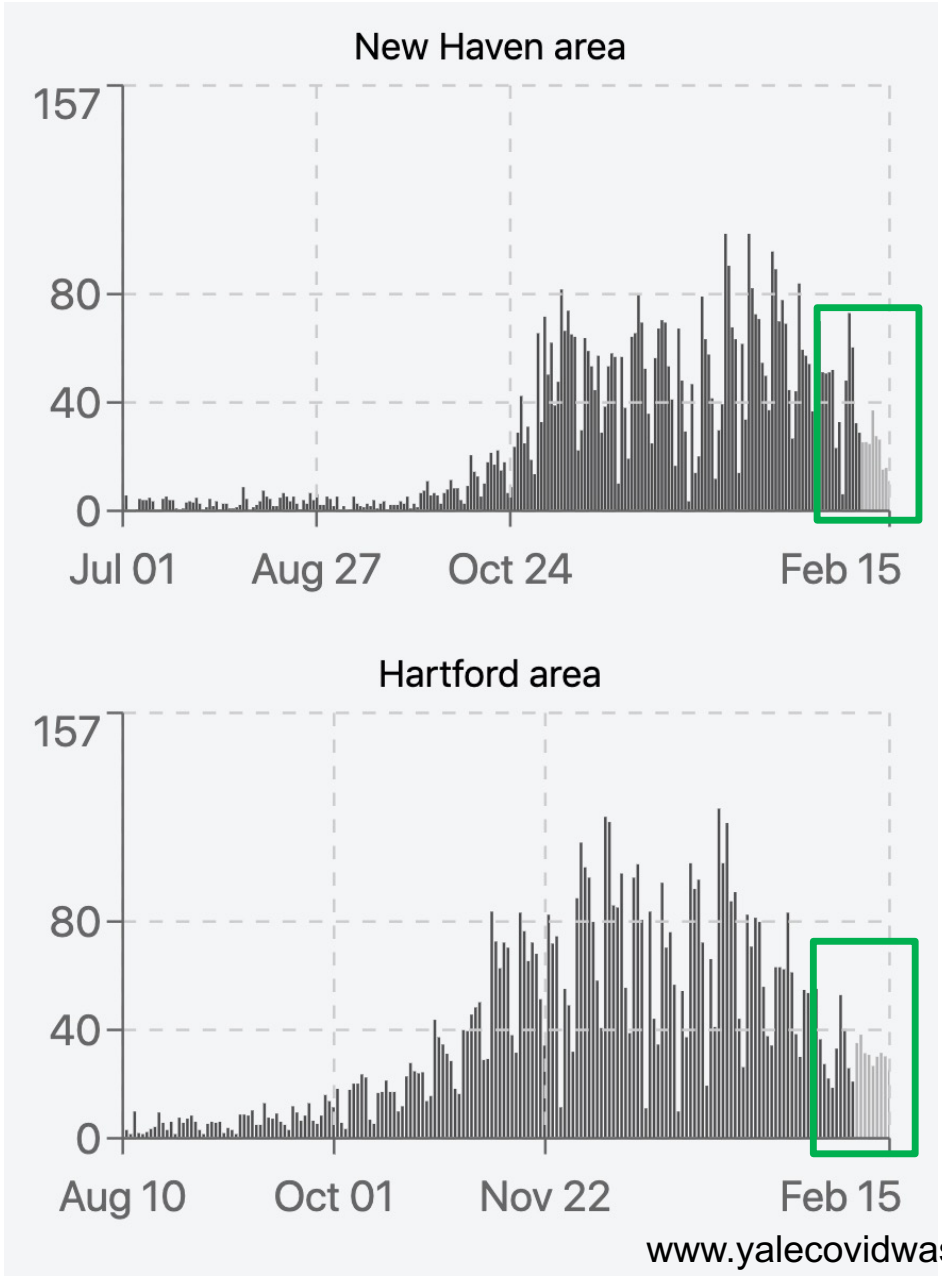




Zulli et al., *unpublished* (2021)

We Can also Keep the State Data Up-to-Date





www.yalecovidwastewater.com

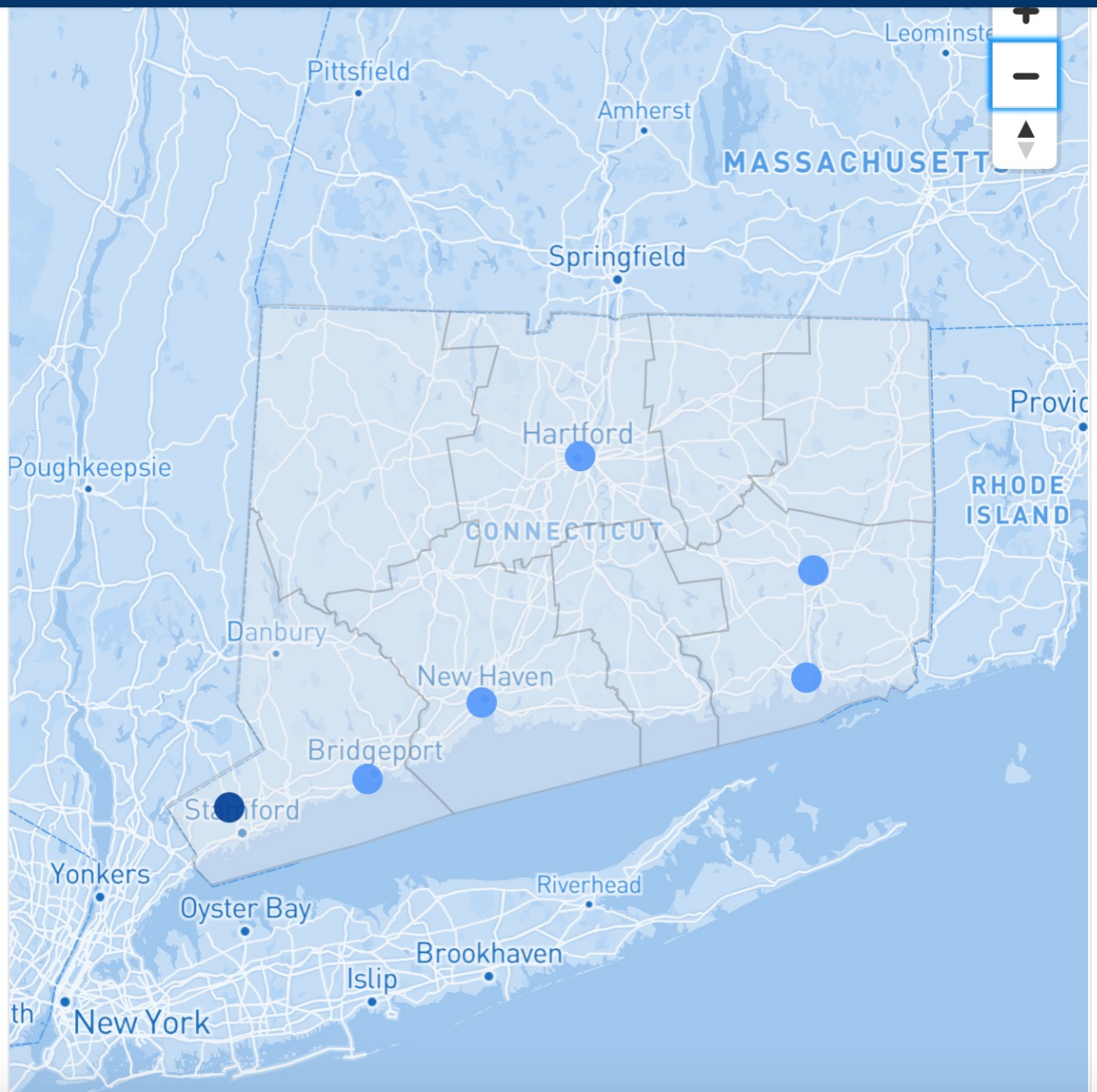
Data to Policy

- Report to CT Commissioner of Health and State Epidemiologist 2 times weekly
- Weekly interaction with a CDC officer deployed in CT
- Interaction with local health directors and governments and hospitals
- Website provides information to the general public

Google: “Yale COVID wastewater”

Yale COVID-19 Wastewater Tracker

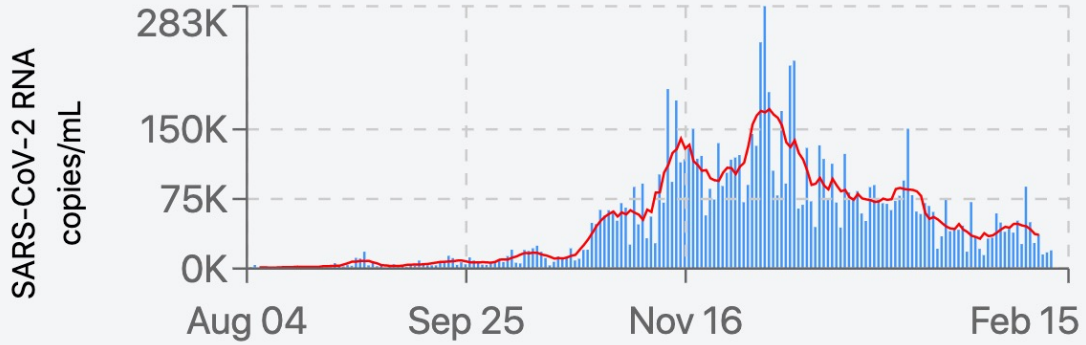
Home Reports Protocols and studies FAQ



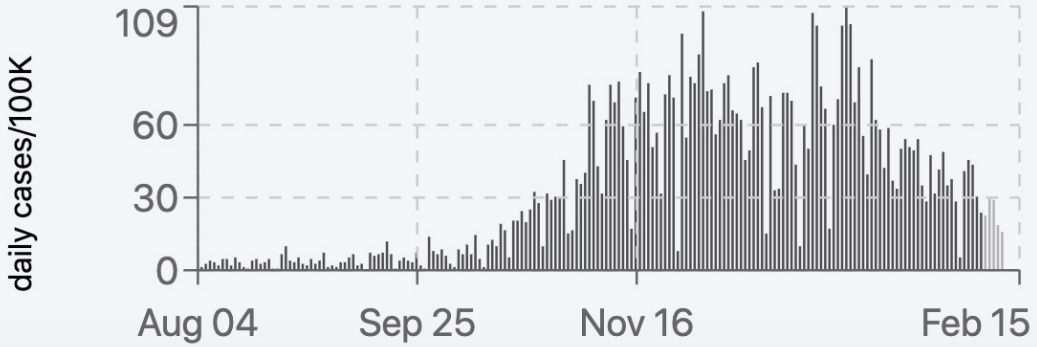
Stamford WWTP

The Stamford, CT Water Pollution Control Facility serves 135,000 people.

Areas served: Stamford, Darien

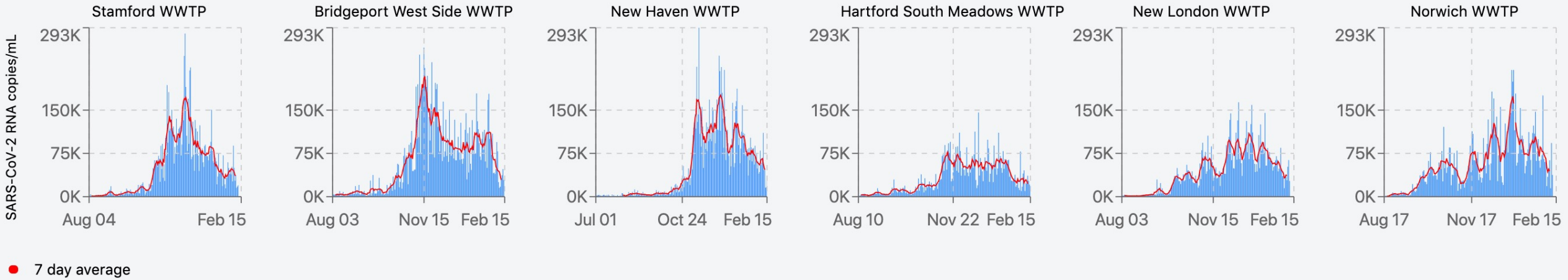


● 7 day average



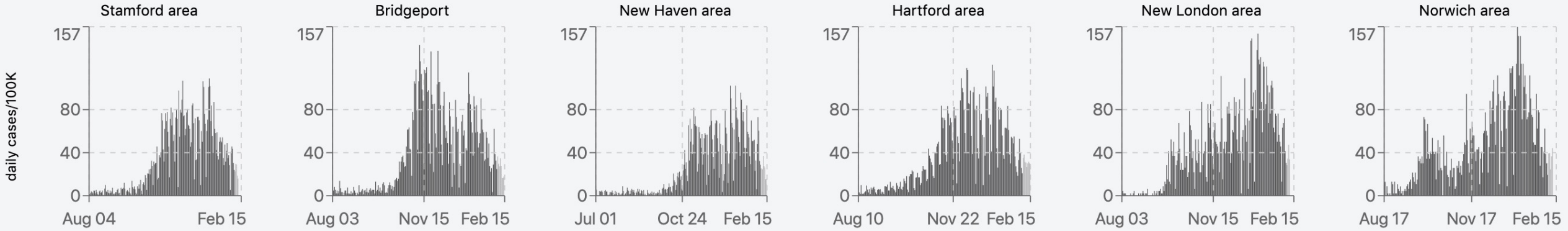
www.yalecovidwastewater.com

Wastewater SARS-CoV-2 data



Case data

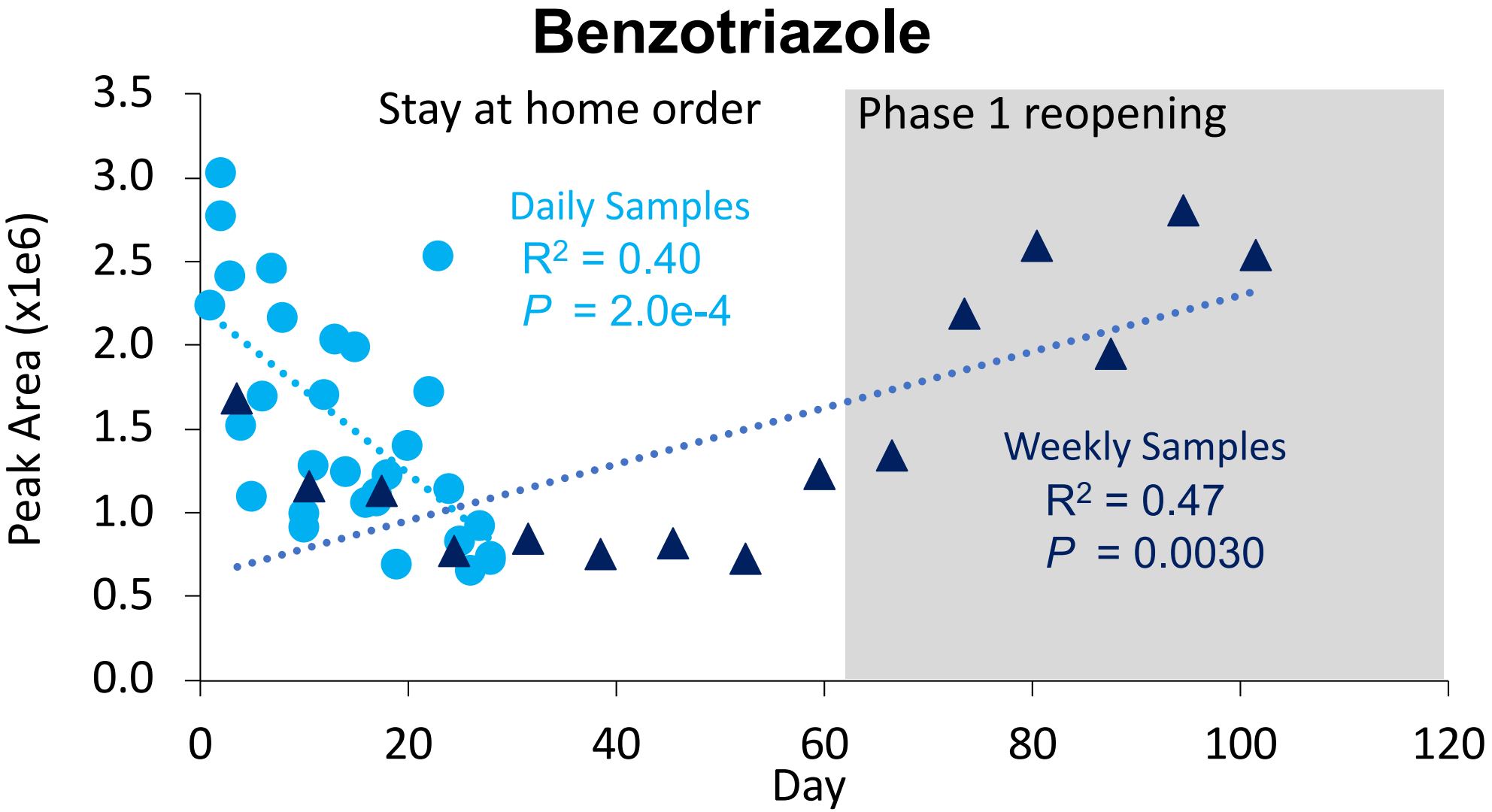
By date of specimen collection



www.yalecovidwastewater.com

Other things we are working on:

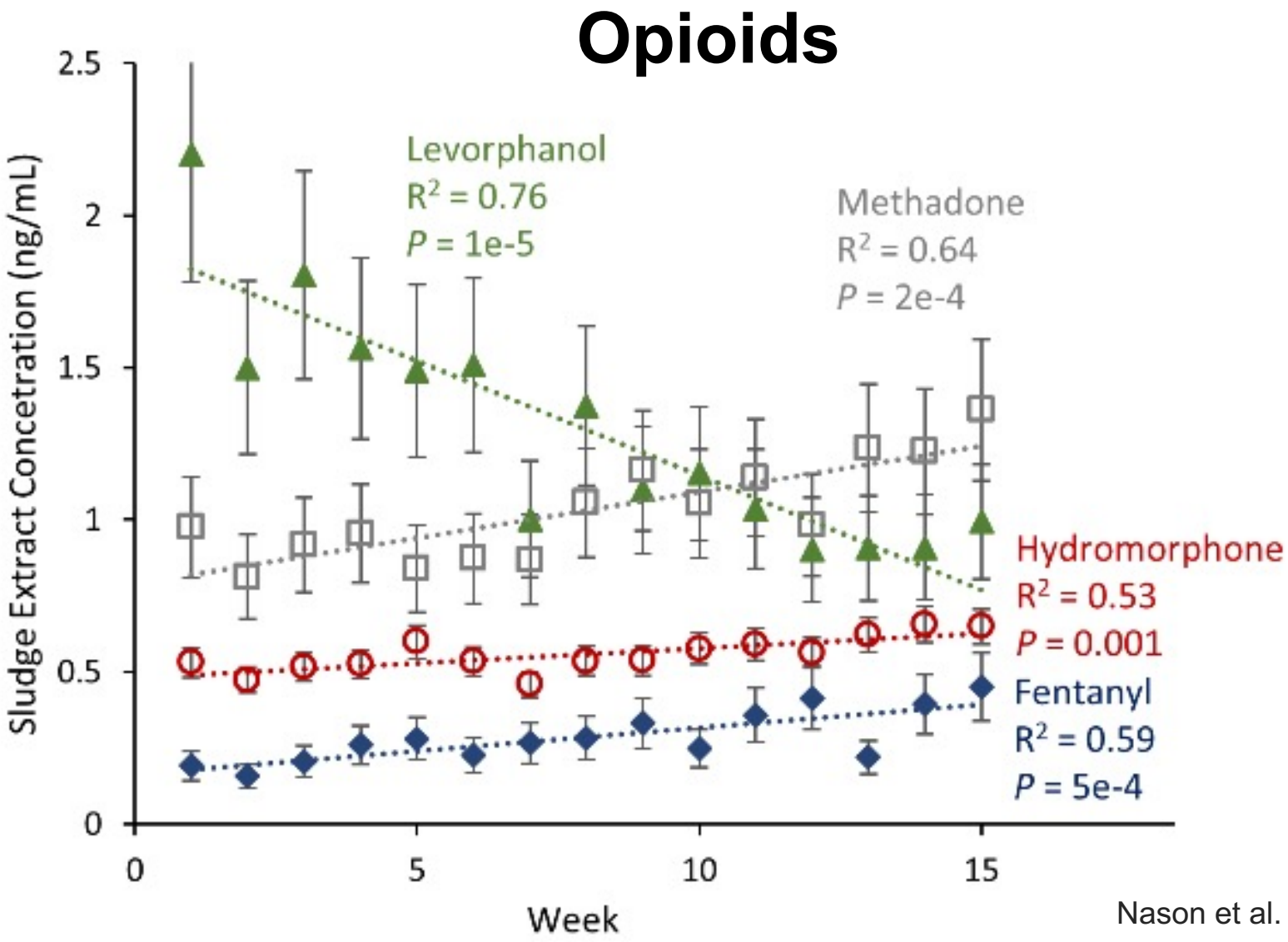
Chemical analysis of wastewater:



Sara Nason
CT Ag. Station

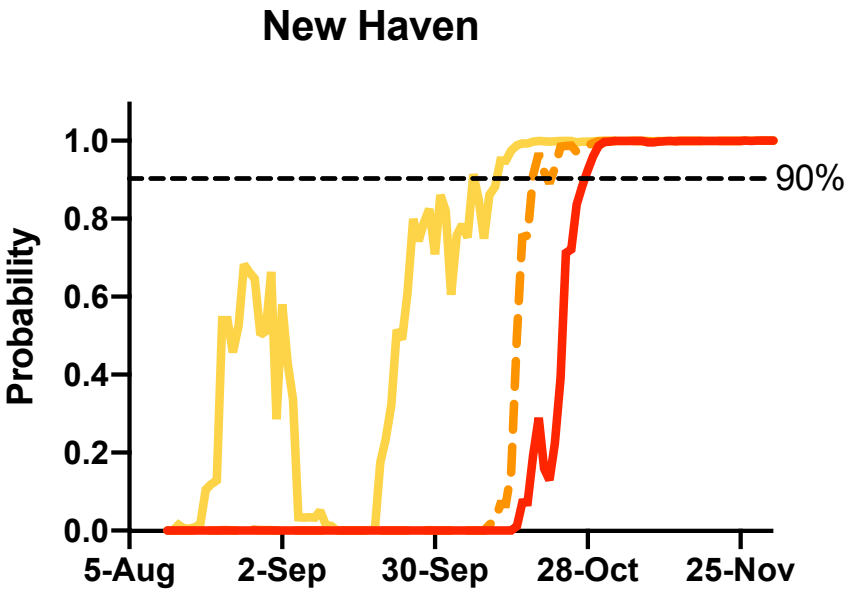
Nason et al. ChemRxiv.
https://doi.org/10.26434/chemrxiv.13562525.v1

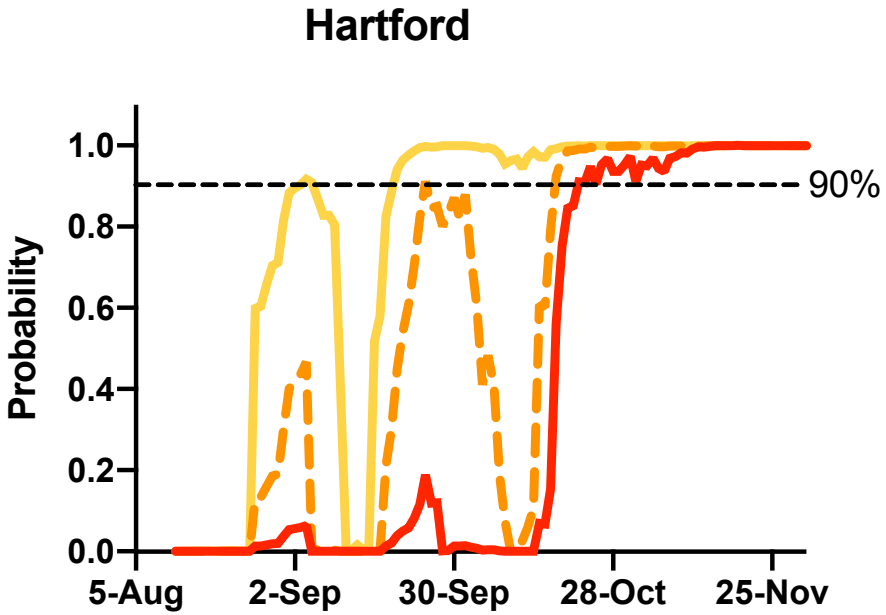
Chemical analysis of wastewater:



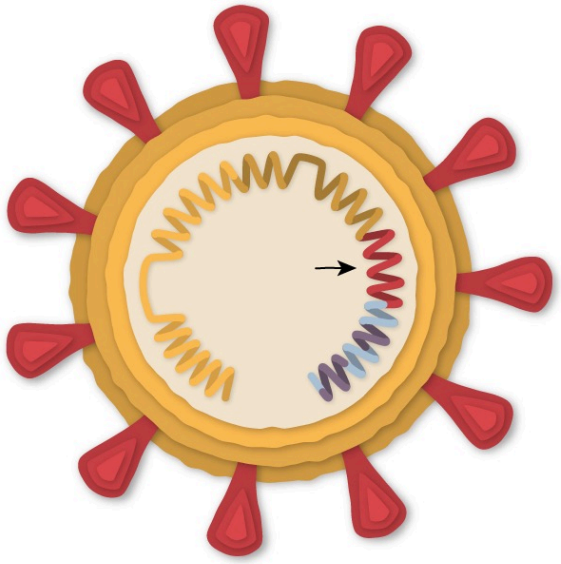
Nason et al. ChemRxiv.
https://doi.org/10.26434/chemrxiv.13562525.v1

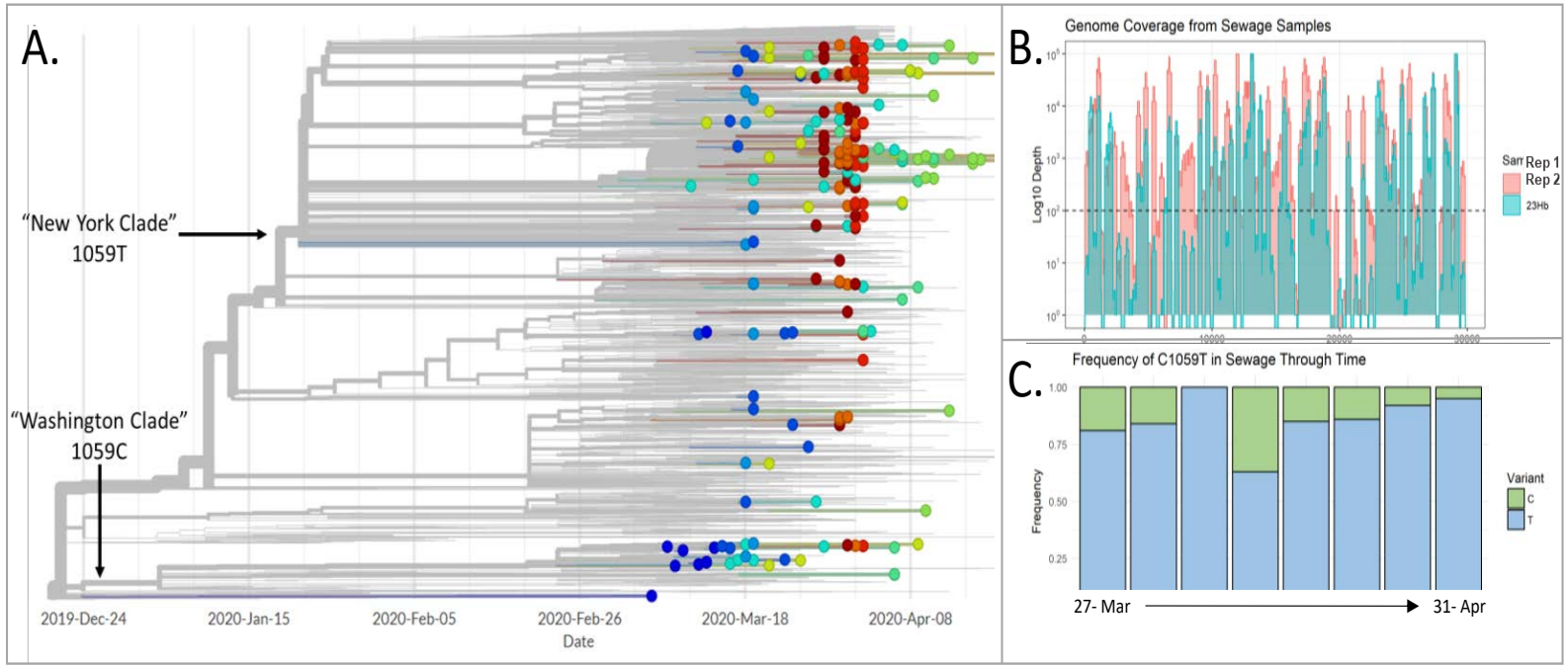
COVID-19 Wastewater Early Warning System



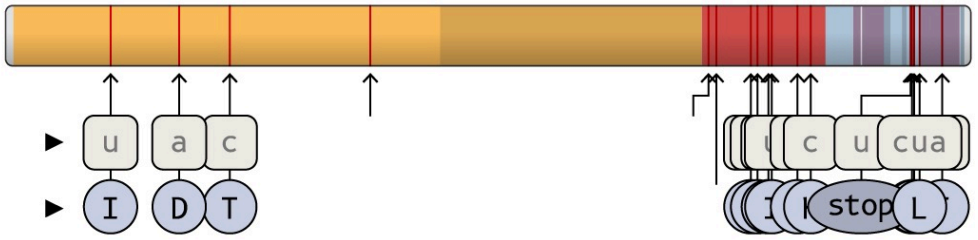


GENETICS





Wastewater sequencing of SARS-CoV-2 reflects clinical phylogenetics results.



Jonathan Corum NY Times |
Source: Andrew Rambaut et al.,
Covid-19 Genomics Consortium U.K.

For Development

- Move testing toward automation
- Surveillance of the other infectious diseases for which there are no testing program.
- Genetics: tracking virus strains and evolution, gene expression in human cells as biomarkers of disease
- Modeling: developing predictive models using wastewater data (instead of cases) to understand infection dynamics
- Developing world

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Marcela Sanchez
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Doug Brackney
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YSPH

https://yalecovidwastewater.com/

or:

Google Yale covid wastewater

or:

COVID-19 wastewater