



# Virginia Wastewater Surveillance Program: Community of Practice Meeting

WWS Team

VDH | Office of Environmental Health Services

January 25, 2023





# Agenda

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Updates & Funding Opportunities

Topic(s) of Interest:

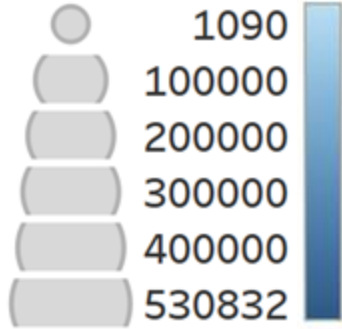
*Environmental Surveillance for SARS-CoV-2 and Other*

*Pathogens in Dhaka, Bangladesh, for Public Health Impact*

Open Discussion

# VA Sentinel Monitoring Facilities

## Population



## Northwest

- WWTP 3
- WWTP 12
- WWTP 13

## Northern

- WWTP 6
- WWTP 9
- WWTP 11
- WWTP 15
- WWTP 22
- WWTP 23
- WWTP 36

## Near Southwest

- WWTP 5
- WWTP 10\*
- WWTP 16
- WWTP 17
- WWTP 18
- WWTP 20
- WWTP 21

## Far Southwest

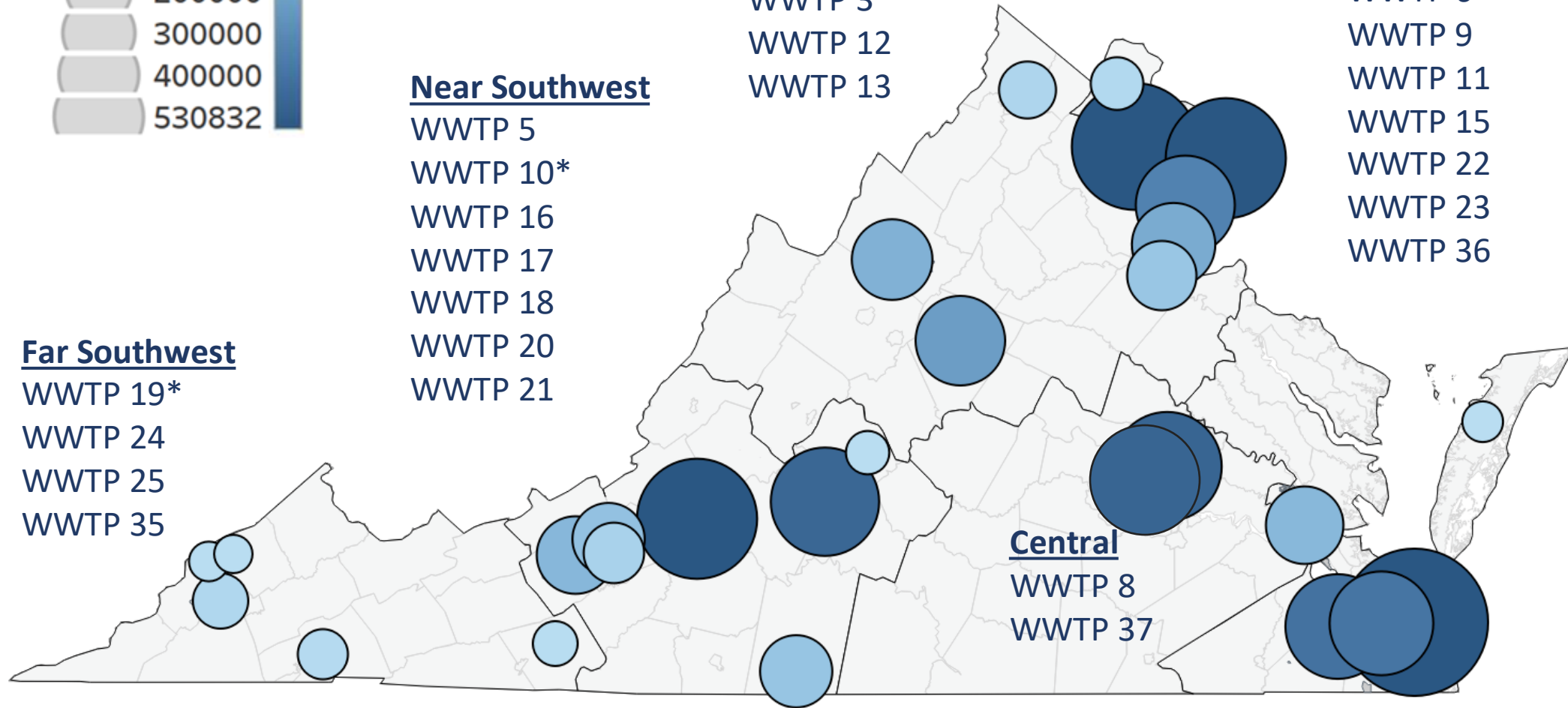
- WWTP 19\*
- WWTP 24
- WWTP 25
- WWTP 35

## Central

- WWTP 8
- WWTP 37

## Eastern

- WWTP 1-1/2\*
- WWTP 2\*
- WWTP 4\*
- WWTP 7\*
- WWTP 14\*



\*sample type: grab

# Program Updates

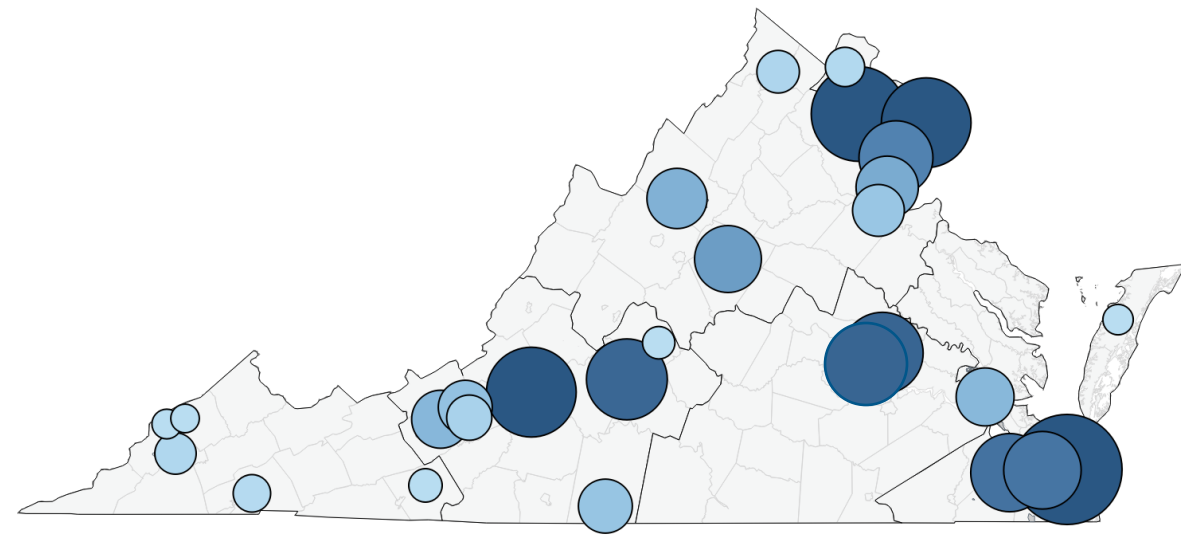
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## SARS-COV-2 MONITORING

- Total **27** wastewater treatment plants
  - 9 sampling *twice* weekly
  - 18 sampling *once* weekly
- *Still enrolling (up to 40 sites)*
- **Internal dashboard updated weekly!**

## ❖ VARIANT SEQUENCING

- 20-23 sites weekly (rotating some sites)
- **Working on internal sequencing dashboard!**



# Sampling and Funding Opportunities

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- ❖ Initiating statewide analysis of Monkeypox, Influenza A&B
- ❖ VDH WWS Autosampler Program
  - Advertise it on our website soon!
- ❖ **Localized Projects and Pilot Projects (\$200,000)**
  - Roanoke Project: Ready to start sampling
  - Chesapeake Project: Final developmental phase
  - Alexandria Renew Project: Initial developmental phase
- ❖ **CDC-Biobot Commercial Sampling**
  - 15 sites currently enrolled from Virginia
  - Generating data for Monkeypox
  - Sampling: twice/week

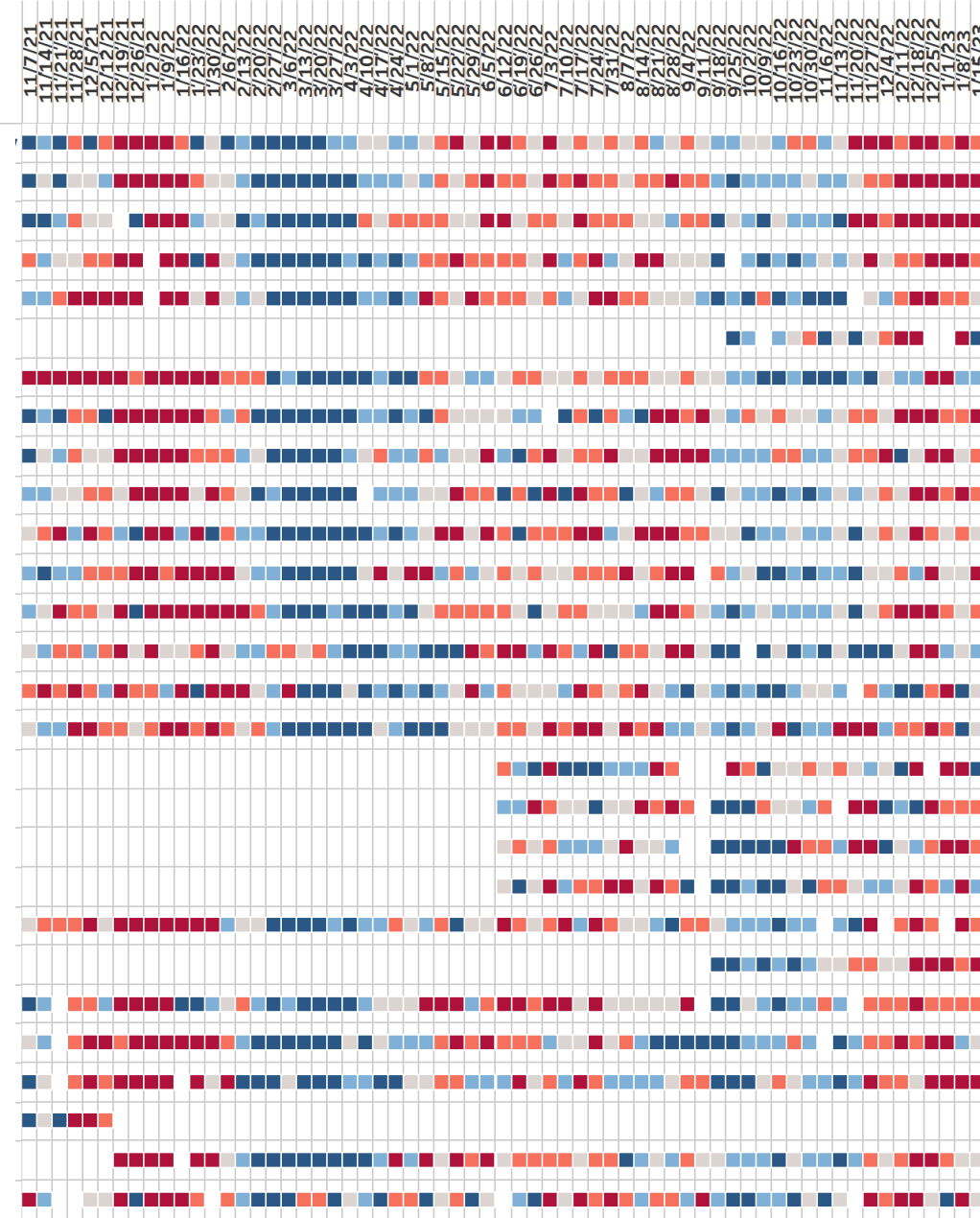
# Analysis Report: Sentinel Monitoring

## COVID-19 Wastewater Surveillance

### Classification

- Lowest
- Lower
- Middle
- Higher
- Highest

### Site-Specific Percentiles by Sampling Week

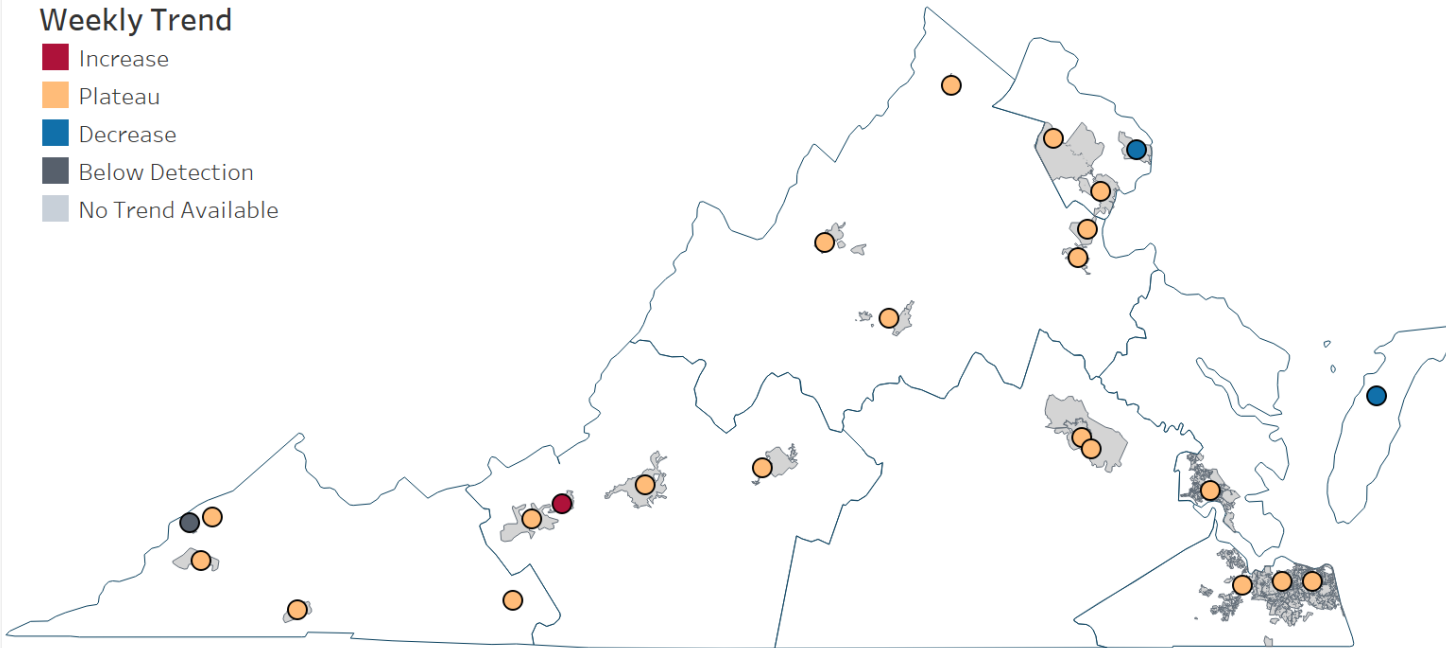


Start of Sample Collection Week

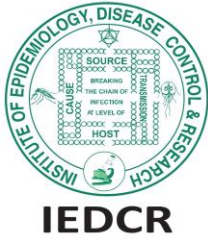
January 15, 2023

### Weekly Trend

- Increase
- Plateau
- Decrease
- Below Detection
- No Trend Available



# Environmental surveillance for SARS-CoV-2 and Other Pathogens in Dhaka, Bangladesh, for Public Health Impact



Imperial College  
London



Virginia Wastewater Surveillance Community of Practice (CoP)  
January 2023

**Mami Taniuchi, PhD**

Division of Infectious Diseases & International Health

Dept of Medicine

Dept of Biomedical Engineering

Dept of Civil and Environmental Engineering

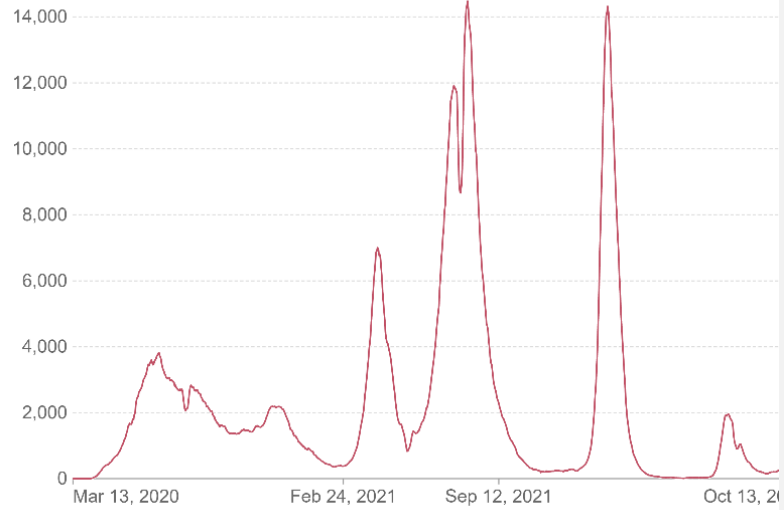
University of Virginia





## Daily new confirmed COVID-19 cases

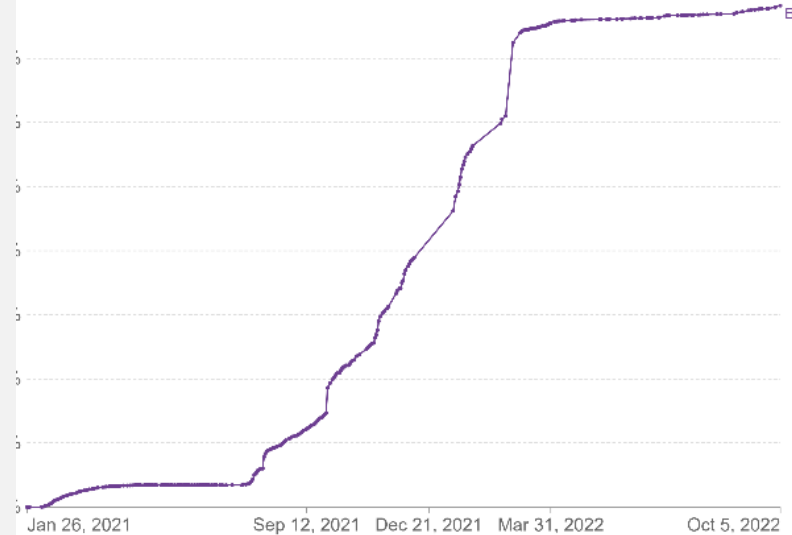
7-day rolling average. Due to limited testing, the number of confirmed cases is lower than the true number of infections.



Source: Johns Hopkins University CSSE COVID-19 Data

## Percentage of people who received at least one dose of COVID-19 vaccine

Number of people who received at least one vaccine dose, divided by the total population of the country.



Source: Official data collated by Our World in Data – Last updated 14 October 2022

OurWorldInData.org/coron

www.thelancet.com Vol 396 August 29, 2020

Work

## Bangladesh's COVID-19 testing criticised

Experts say that the government's approach to testing and surveillance, including charging patients a fee, is hampering the response. Sophie Cousins reports.

Public health experts in Bangladesh have expressed concern about the government's decision to charge people for COVID-19 tests amid a sharp decline in the number of tests being done. In late June, the government decided to charge 200 taka (£1.80) for testing done at government facilities and 500 taka (£4.50) for samples collected from home to "avoid unnecessary tests". The private sector charges 3500 taka (£32) per test. Almost one in four Bangladeshis live below the national poverty line.

Since the decision, testing rates have fallen to around 0.8 tests per 1000 people per day, with a low of just

condemned the government's decision. "Charging people for tests is really creating problems; it is creating barriers, especially for the poor", he said. "During the pandemic, people do not have work, they do not have money, they're at a huge disadvantage...Governments should not charge anyone for testing."

"...they've applied a charge for testing in the public sector, which just means that the poor are excluded."

Other barriers to testing, Rahman said, include the low trust people had in the health-care system. "We've had

"In a country of more than 165 million, that is performing a maximum of 15000 tests per day, it is nothing and largely those tests are just being done in Dhaka itself", he said. "This plague will stay for quite a long time. What I'm afraid of is when the Bangladeshi winter arrives. People are afraid."

Talukder said that the pandemic had further exposed the country's failing health-care system, which spends just 0.69% of the country's gross domestic product on health, making Bangladesh one of the lowest spenders on health globally. Moreover, two-thirds of health expenditure is out of pocket and borne by households, many of whom are

# COVID-19 Bangladesh

- Bangladesh second most affected COVID-19 country in South Asia, after India
- 2 million cases reported in Bangladesh compared to 44 million India (cases per million population 3-5 times lower in Bangladesh)
- Limited access to testing in Bangladesh: charge for tests from July 2020
- Vaccination started early 2021. as of now 72.8% two doses
- Dhaka high population density (~30k /km<sup>2</sup>)

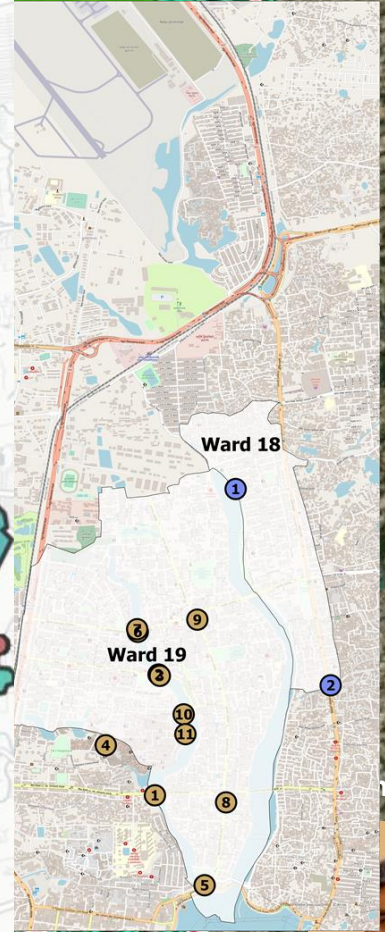
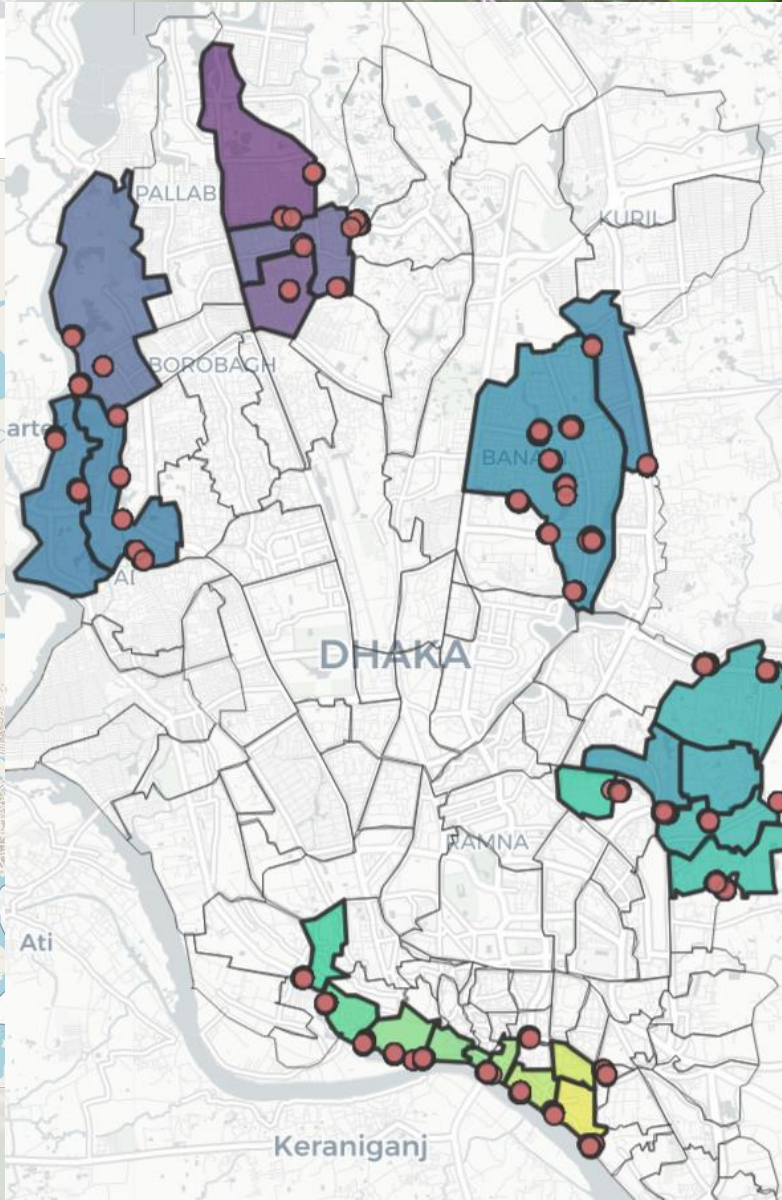
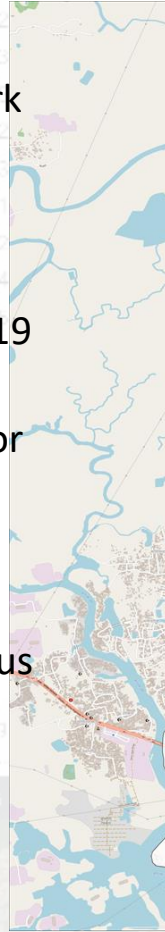
# Research Questions

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- ❖ Can detection of SARS-CoV-2 in sewage provide an early warning on changes in transmission?
- ❖ How variable is sewage detection in different locations compared to reported clinical cases?
- ❖ What additional information does genetic sequencing of sewage providing in understanding emergence and spread of variants of concern?

# Mapping and ES site selection

- Dhaka sewage network is mostly informal
- Blue line tracing and digitization of the sewage network
- Interactive maps created by Novel-T
  - [Environmental Sites](https://es.world/country/BGD) (<https://es.world/country/BGD>)
- 12 sites selected in middle-income area from June 2019 for multipathogen ES
- 33 sites since June 2020 in low to high income areas for COVID-19 ES
- Currently, 51 sites across Dhaka
- Study areas in Dhaka with varying socioeconomic status
  - Mirpur Wards 2, 3, and 5 (low-income area)
  - Mirpur Wards 8, 9, and 10 (middle-income area)
  - Gulshan/Baridhara area (high-income area)
  - Southern Dhaka (low-middle income area)
- Ward population 50,000 ~ 150,000
- Estimated catchment population per site 1000 ~ 590,000
- Estimated catchment area per site 0.04 – 7.01 km<sup>2</sup>



Nedul Islam

# Example ES Sites



Concrete Open Canal



Natural Narrow Canal



Wastewater Outlet

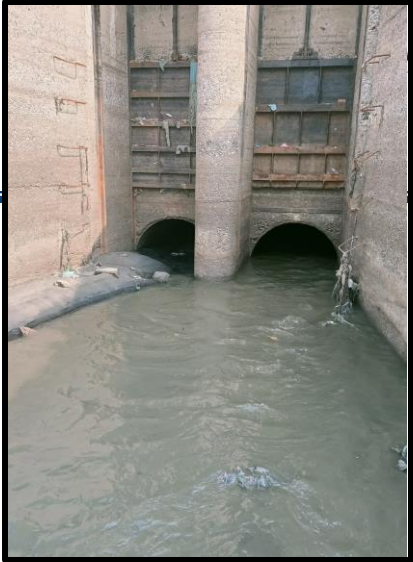


Small Sluice gate



Wastewater Outlet

**Blue-line tracing to map sewage network when data missing from DWASA**



Large Sluice gate



Manholes

## Bag Mediated Filtration System



6L grab sample  
\$138/sample

## NanoTrap Magnetic Virus Particles



40mL grab sample  
\$15/sample

## Detection Assays and instrumentation

- CDC N1 and N2 RT-qPCR assays for SARS-CoV-2
- Illumina Sequencing for VOC and VOI
- VOC RT-qPCR
- Digital RT-PCR (absolute quantification)
- TAC assay (enteric pathogen)



BioRad  
Opus for  
RT-qPCR



Qiagen  
QIAcuity for  
dRT-PCR



ABI ViiA7  
for TAC



Illumina  
MiSeq for  
sequencing

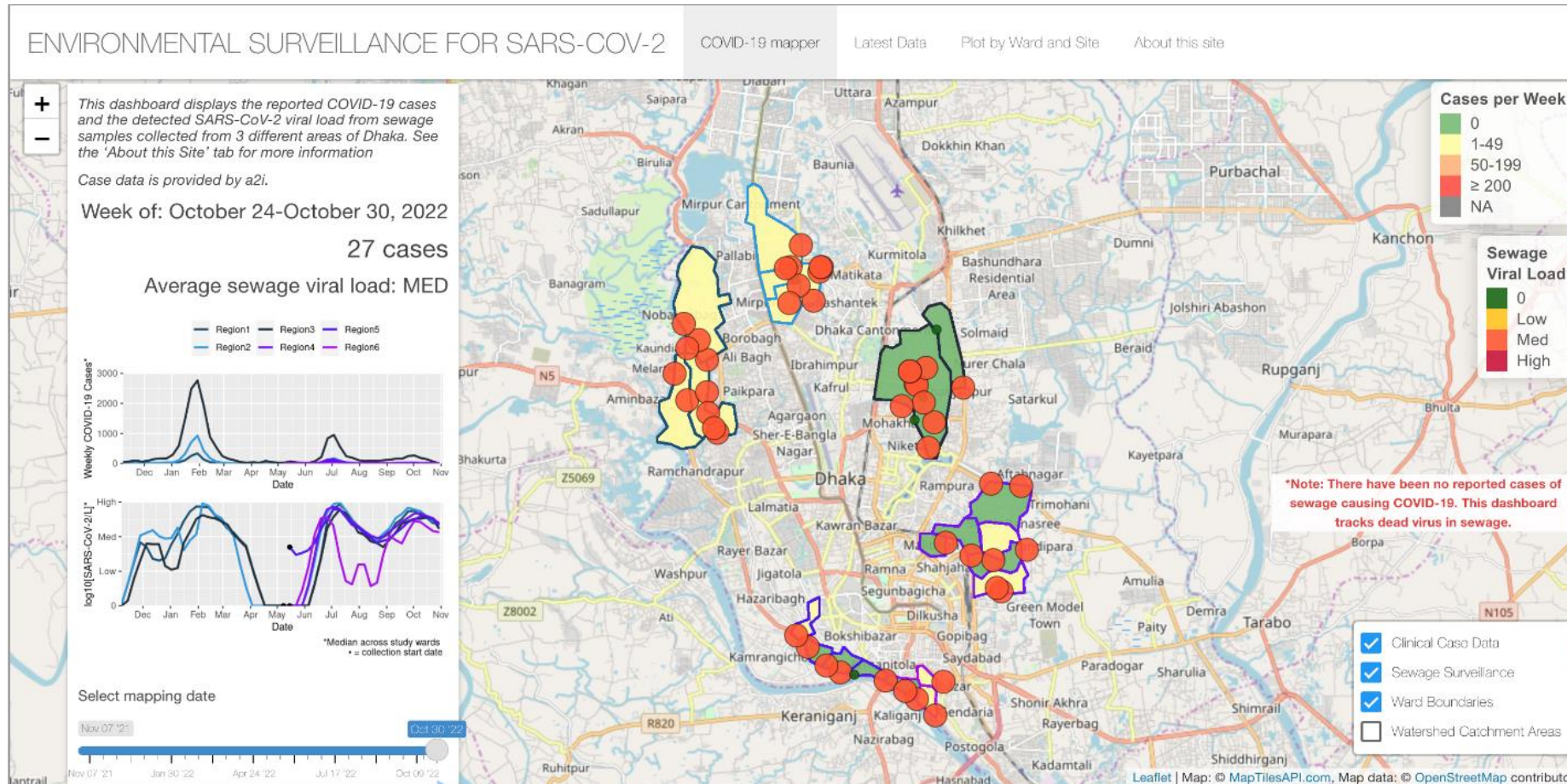


Illumina  
NextSeq for  
sequencing

# DASHBOARD

## Needed a way to disseminate lab data to public health stakeholders

Dashboard displays weekly sewage and case data in real-time



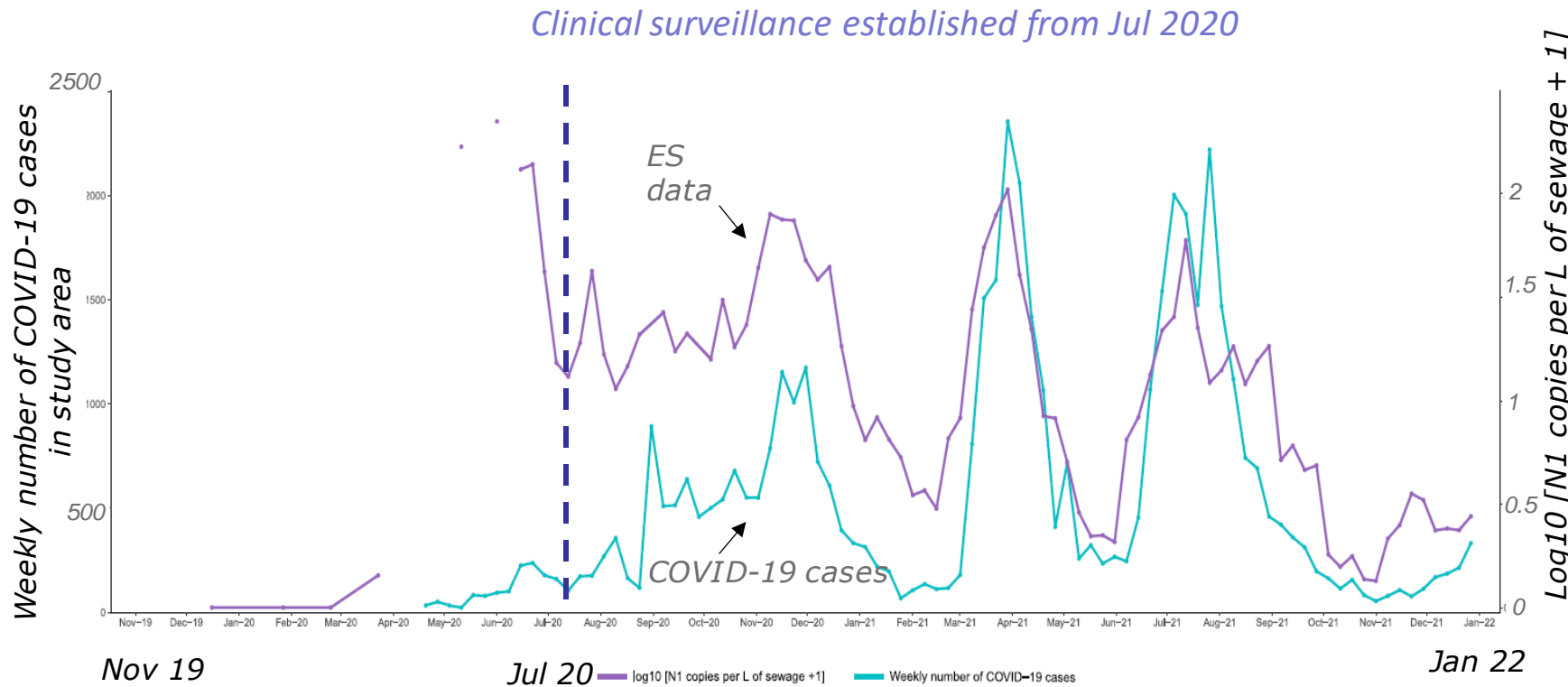
Developed by 4<sup>th</sup> year biomedical engineering undergrads at UVA

*Erin Wettstone  
Lauren Hughlett  
Claire Reagan*

51 sites over 5 study areas



# Magnitude of SARS-CoV-2 in sewage correlates with clinical cases over time

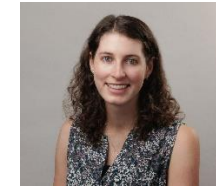


- Case data from study wards only
- Highest level of cross-correlation when sewage data precedes case data by 5 days
- During major waves rise in ES preceded cases by 1-2 weeks

Week of SARS-CoV-2 test and ES sample collection



Isobel Blake,  
Imperial

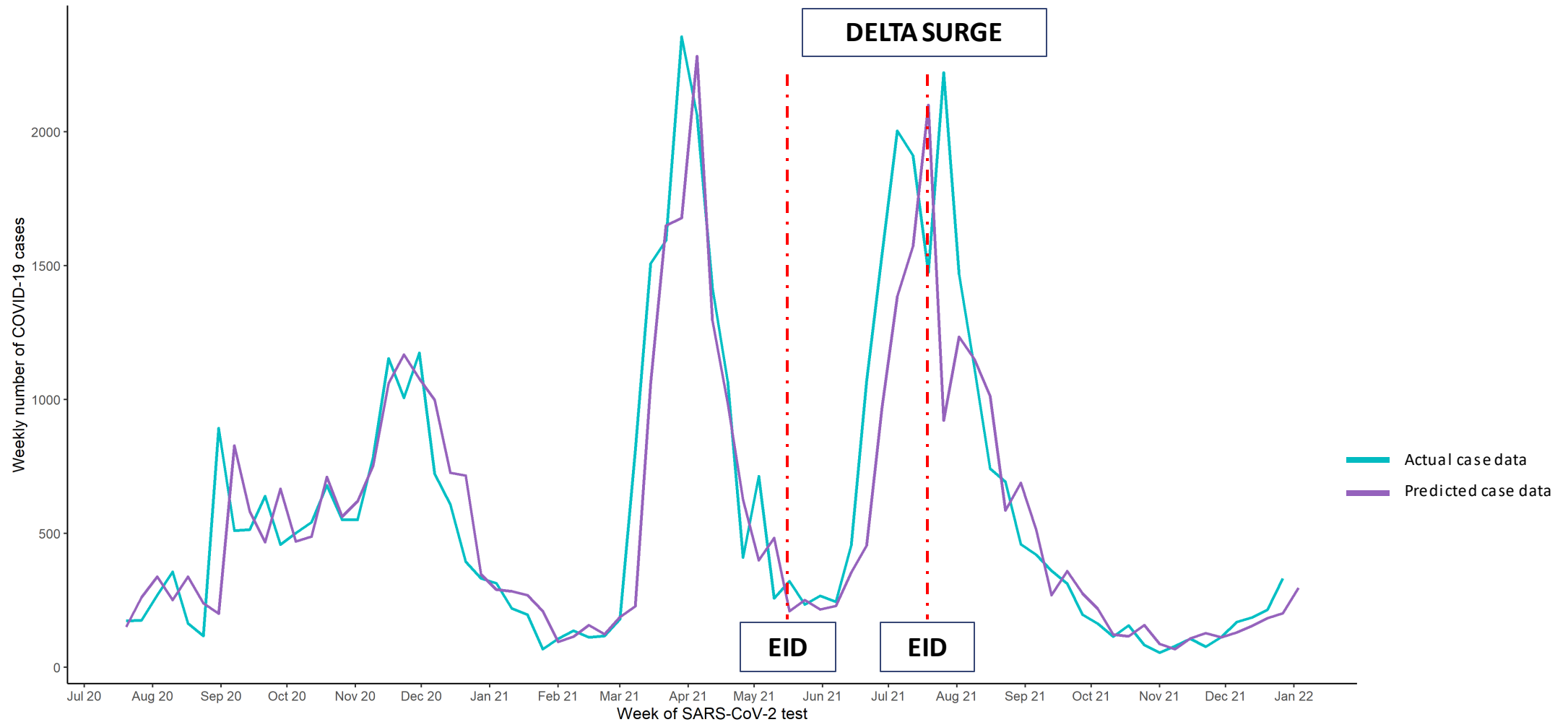


Liz Rogawski  
McQuade, Emory



Stephanie  
Brennhofer, UVA

# VARMA MODEL PREDICTIONS: STUDY-WIDE



vector autoregressive moving average model



Stephanie  
Brennhofner, UVA



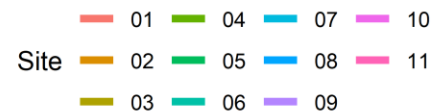
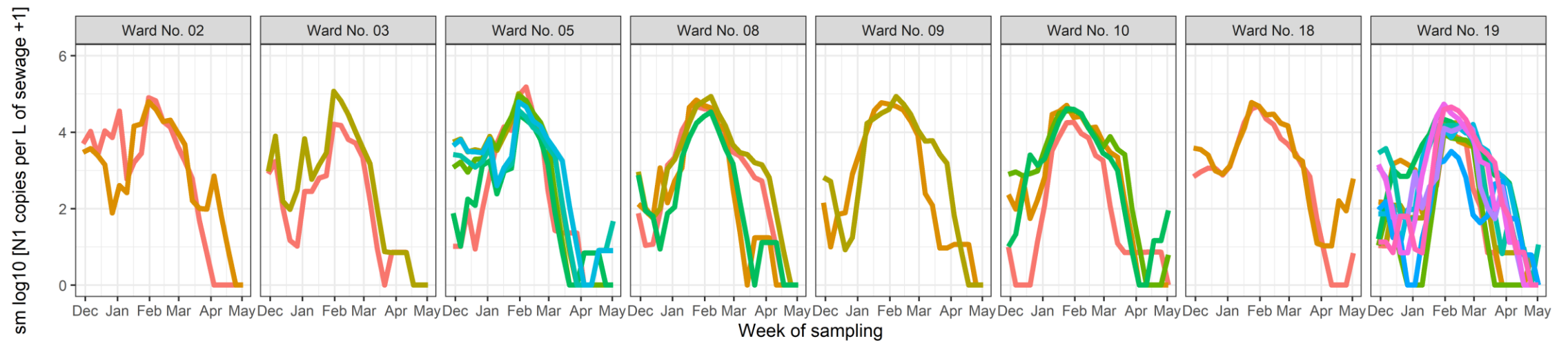
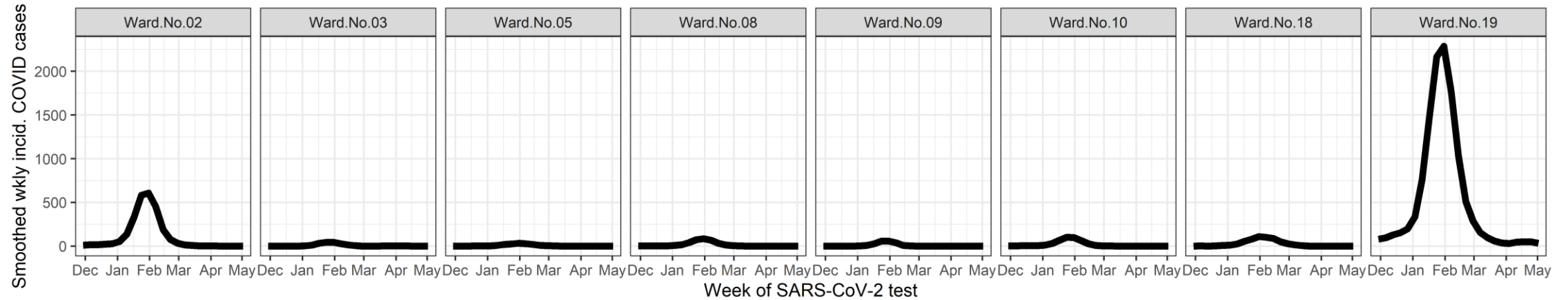
UNIVERSITY  
of VIRGINIA



# ES identifies SARS-CoV-2 circulation where case surveillance is limited

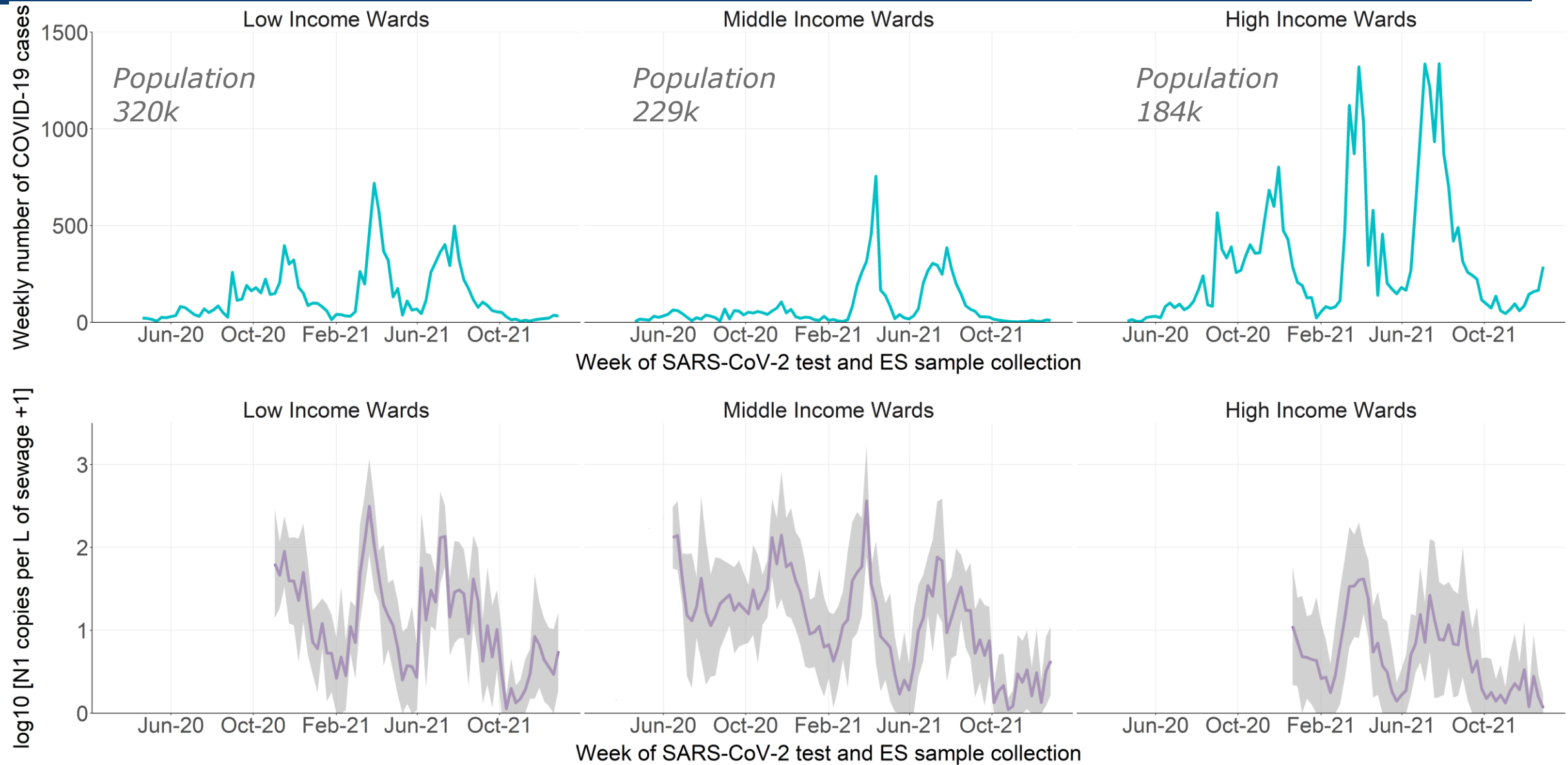


Isobel Blake,  
Imperial

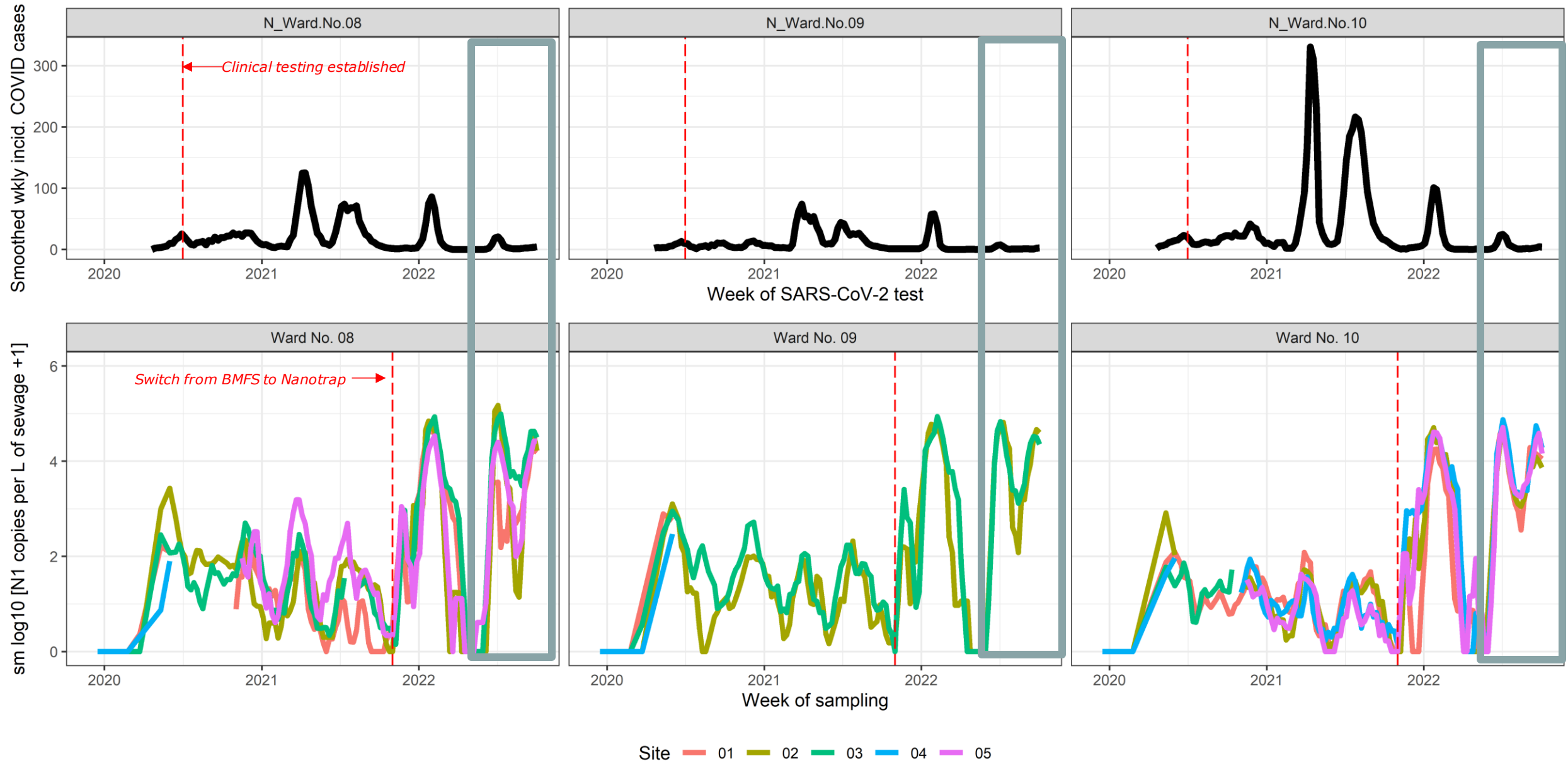


Ward 19 (high-income area) had 70 – 120 times the number of tests per population than other wards

# ES identifies SARS-CoV-2 circulation where case surveillance is limited



# Where we are at now



# Sequencing wastewater for VOCs and sub-variants

Clinical sequences (N = 843 nationwide consortium)

Sewage Illumina's CovidSeq (N = 263, Freyja platform to identify subvariants) (Nature 2022\*)

Similar distribution of subvariants across the two surveillance systems

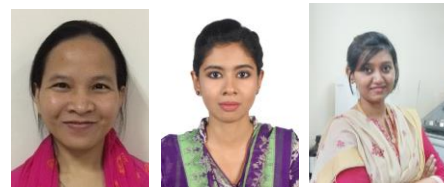
Consistent evidence of fast BA.2 replacement

BA.5 detected later in time in sewage when clinical genetic sequencing consortium finished

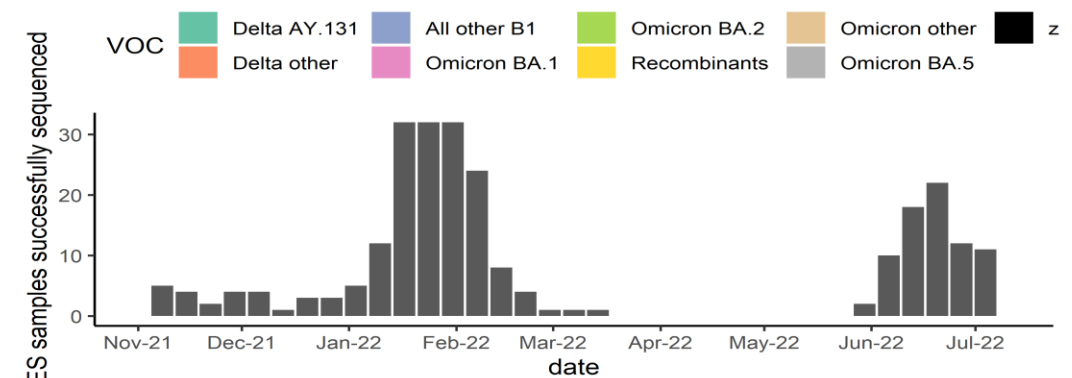
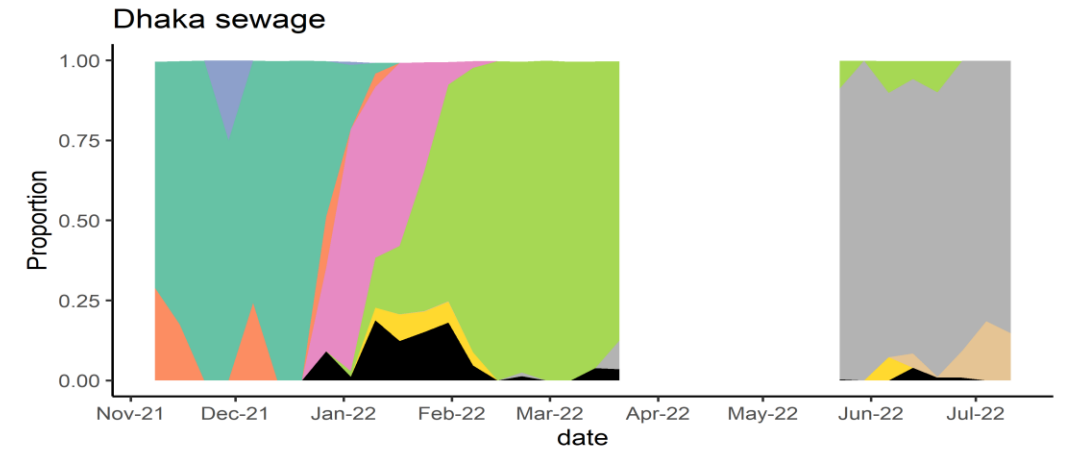
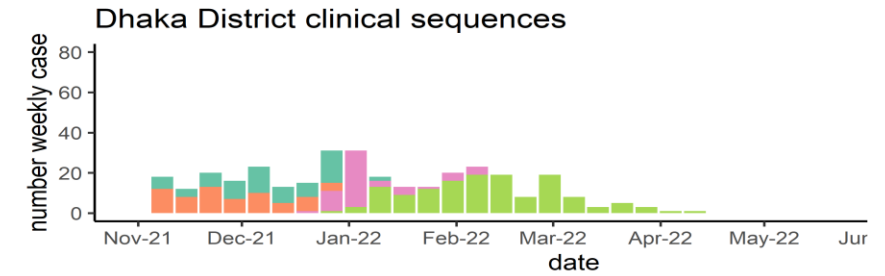
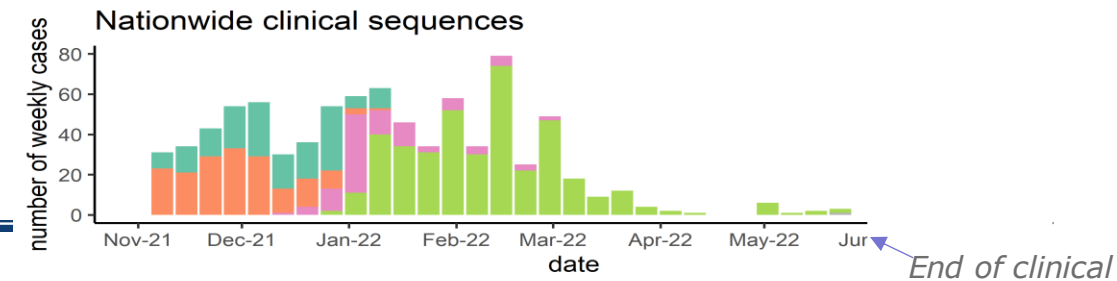


Developed by Joshua Levy at Scripps Research

\*Method: <https://www.nature.com/articles/s41586-022-05049-6>



Suporn Pholwat, UVA  
Tonima Rahman, icddr  
Tania Ferdousi, icddr



# Public Health Stakeholder Engagement

- Who is engaged?
  - IEDCR
  - Health Ministry (DGHS)
  - DWASA
  - DNCC and DSCC
  - Department of Public Health Engineering
  - Funders
- Weekly ES updates to the national COVID-19 task force via summary report and Dashboard
- Regular dissemination meetings
- Mass media

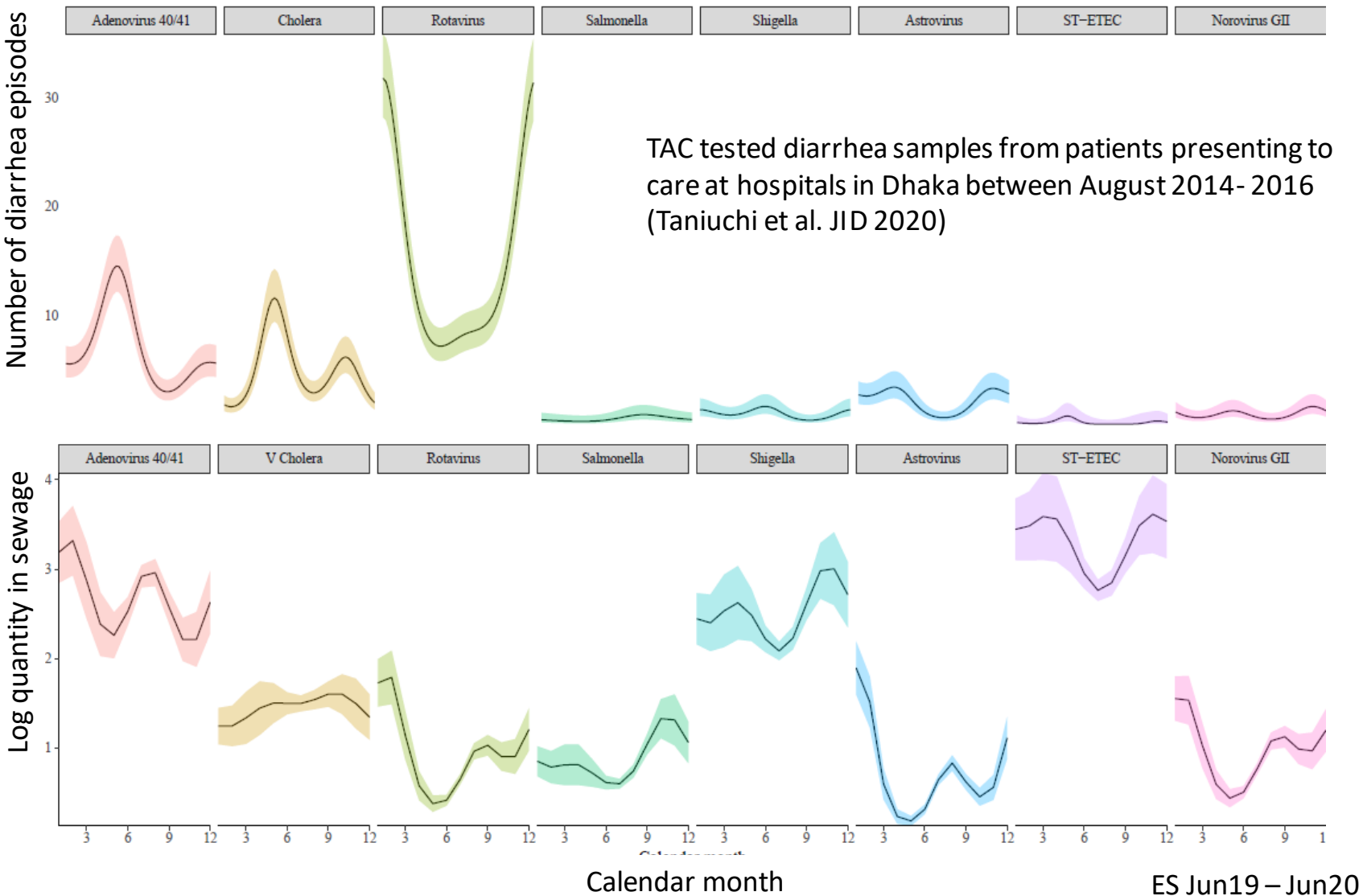


# Conclusions

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- ❖ Real-time ES established in multiple areas of Dhaka city
- ❖ ES provides early warning of increases in transmission for SARS-CoV-2 and identifies ongoing transmission in areas where cases surveillance is limited
- ❖ Variants of concern can be tracked in sewage, providing further evidence BA.2 Omicron rapidly overtook BA.1 lineage
- ❖ SARS-CoV-2 ES Dashboard used by public health officials as a complimentary surveillance system.
- ❖ ES will be an important tool to monitor SARS-CoV-2 as clinical testing recedes
- ❖ Future studies will focus on ES for multipathogens to identify which pathogens are useful to track in wastewater

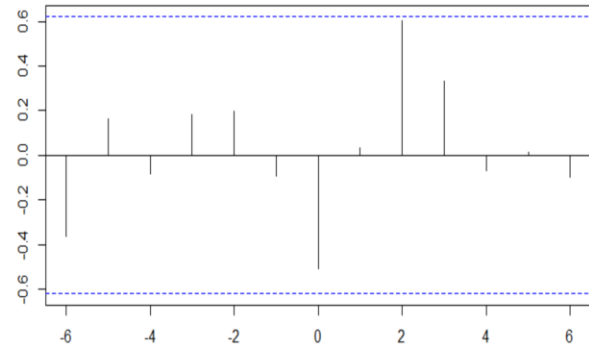
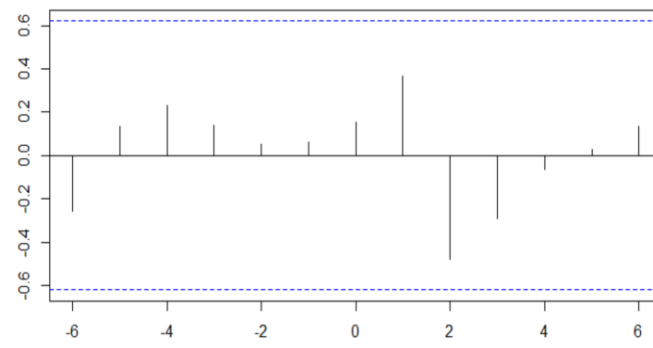
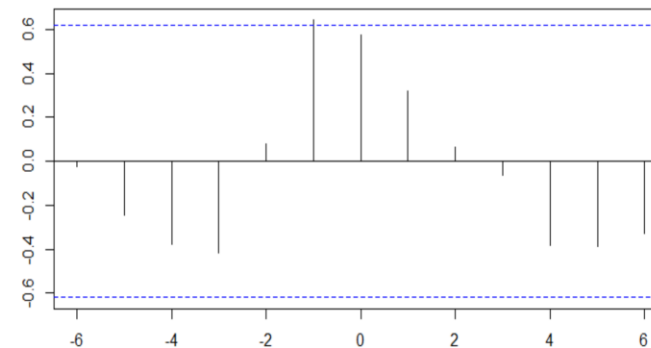
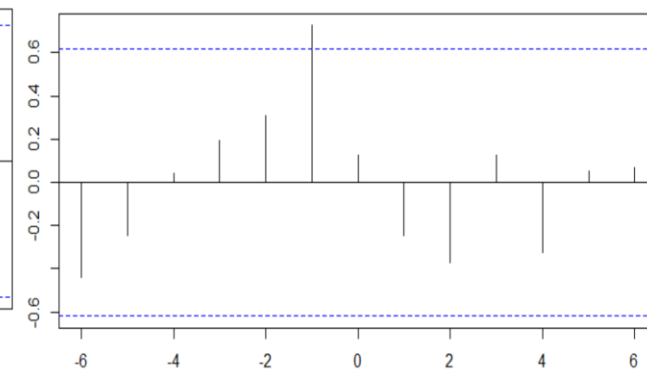
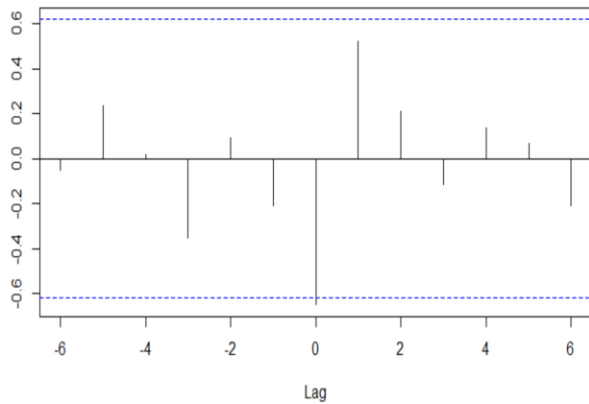
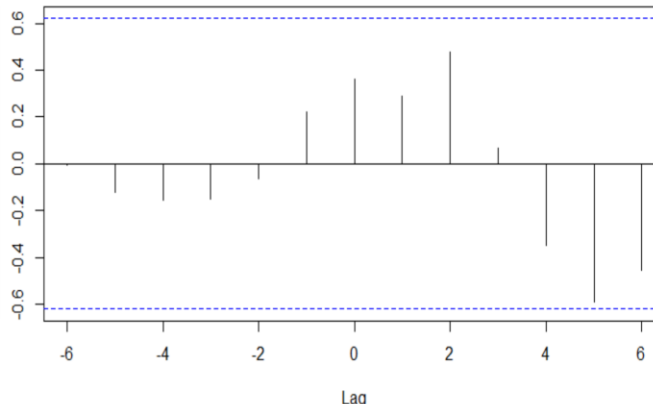
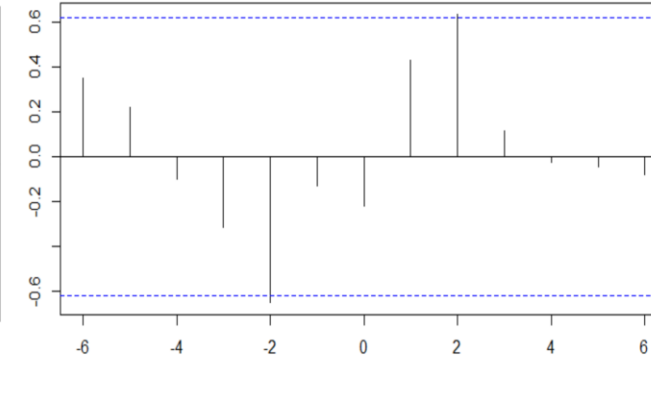
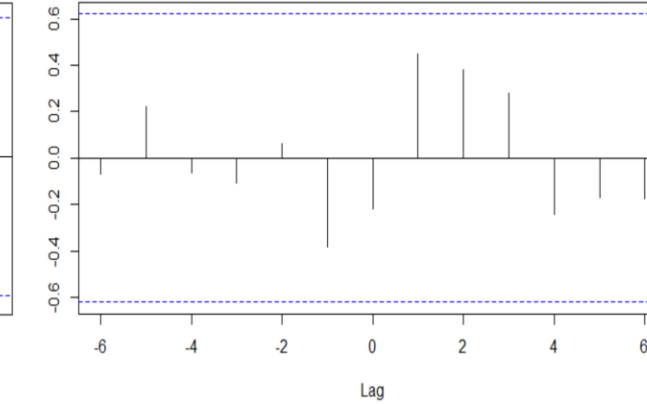
# Indication seasonal trend of Rotavirus and Salmonella ES detection correlates with attributable diarrhea hospitalisation



- Clinical data from different time period and larger location
- Significant cross correlation for Rotavirus and Salmonella (ES precedes cases by lag 1 month)
- Suggests ES may provide information on transmission pattern, but further data required from concurrent time periods and locations

Sarah Elwood, UVA



**Adenovirus 40/41****V Cholera****Rotavirus****Salmonella****Shigella****Astrovirus****ST-EPEC****Norovirus**

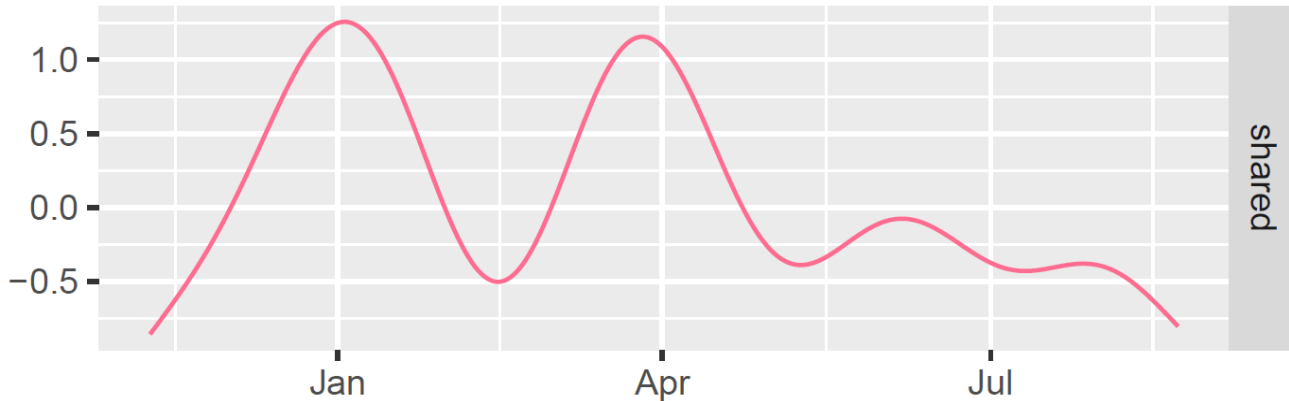
Cross correlations between average log pathogen quantity in sewage samples and the sum of episodes of pathogen attributable diarrhea from hospitalized patients in Dhaka. Y-axis shows the correlation coefficient, x-axis shows the lag between the months. The dotted blue lines values at which you could say with 95% confidence that the population cross-correlation is non-zero

**These plots suggest that sewage samples predict seasonal diarrhea attributable to rotavirus, salmonella, ETEC, and close for adenovirus 40/41 and Shigella as an early indicator of outbreaks.**



# Using GAM model: We see a long-term trend in detections, regardless of pathogen

Shared trend from the hierarchical GAM:

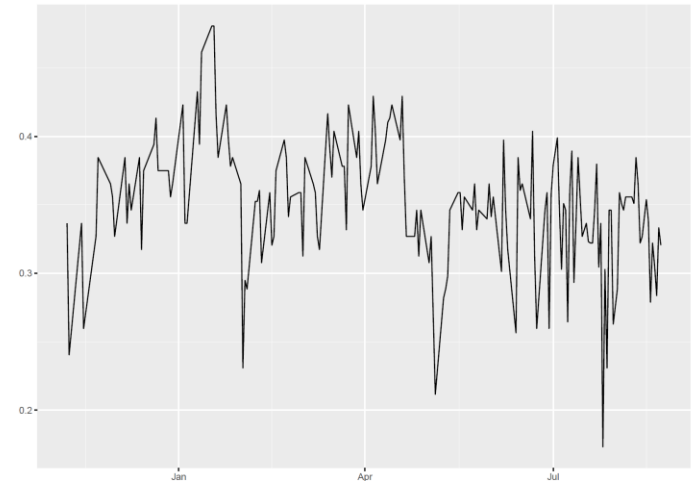


Goal: Extract time series of pathogens to examine time trends, correlation with clinical data, etc. that isn't biased by weather events or other changes over time

Questions: What is causing this? Does this correlate with any known weather patterns?

GAM = Generalized Additive Model

Total detection rates over time across pathogens (raw data):



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Infectious Disease Modeling at  
Bill and Melinda Gates  
Foundation

# The model extracted quite a few time trends!

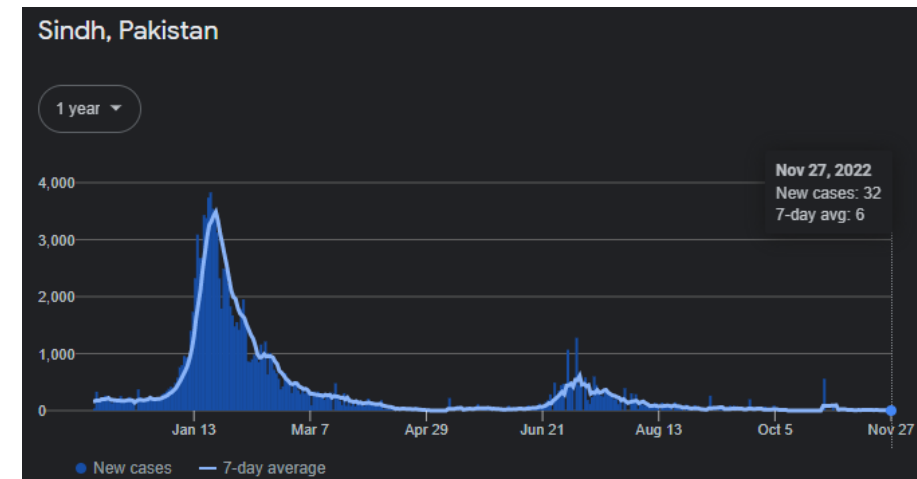
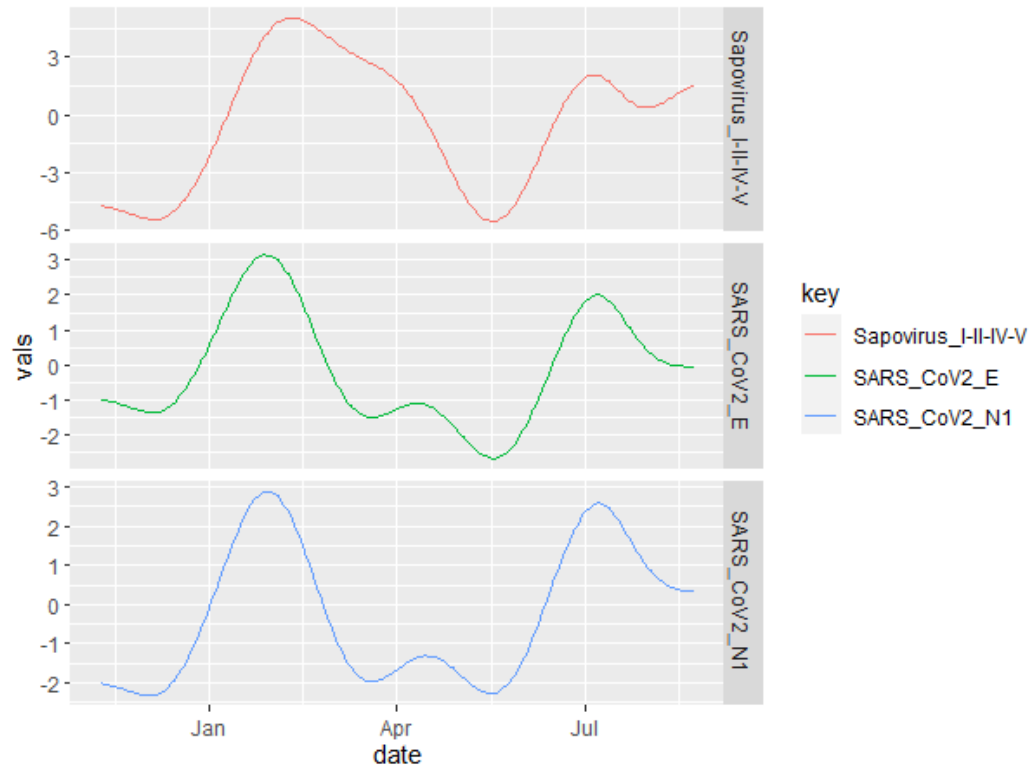
- A quick summary of those that are significantly different from the shared trend/not:
  - Not significantly different from shared trend: EPEC, ETEC, C. difficile, Sabin3, Shigella spp., VDPV1
  - Significant: Adenovirus 40-41, C.jejuni-coli, eAEC\_aaic, EAEC\_aatA, Giardia, Norovirus GI+GII, Pan-EV, S. flexneri, S. Typhi, Salmonella spp., Sapovirus I-II-IV-V, V. parahaemolyticus, SARS\_CoV\_N1, SARS\_CoV2\_E, SHV238
  - Not enough detections to be included: Cryptosporidium, E. histolytica, S. enteriditis, S. paratyphi A, S. sonnei, S. Typhimurium, Sabin1, SARS\_Cov2\_N2, VDPV3



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Infectious Disease Modeling at  
Bill and Melinda Gates  
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# Covid time trends looked similar for two different targets + correlated with clinical data:

Peaks in February/ July for both case data and detection rates:



For discussion: why does Sapovirus look so similar- is there a possible explanation for this?



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Infectious Disease Modeling at  
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# ES TEAM



MRC Centre for  
Global Infectious  
Disease Analysis

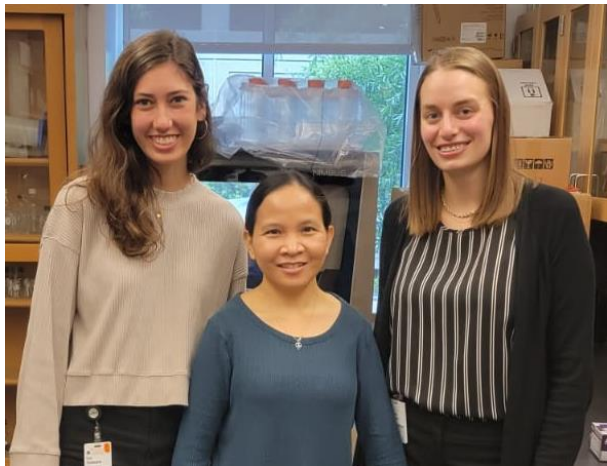
Imperial College  
London



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- Dr. Rashidul Haque (co-PI)*
- Md. Ohedul Islam*
- Md. Hamim Bhuiyan*
- Tonima Rahman*
- Sabrina Karim Resha*
- Puja Kapuria*
- Mostafizur Rahman*
- Syed SS Sony*
- Md. Safiqul Islam*
- Md. Ashiqul A Khan*
- Md. Rana Mia*
- Rahimul Islam Rabbi*
- Md Reyaj Patwary*
- Md. Sulaiman Nabi*
- Nasima Begum*
- Md. Kaium*



*Dr. Suporn Pholwat  
Erin Wettstone  
Stephanie Brennhofer  
University of Virginia*



# Acknowledgements



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Mahbubar Rahman*



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**Imperial College  
London**

*Isobel Blake (co-PI)*

**illumina**

*Damla Bilgin  
Vanessa Moeder*



*Suporn Pholwat  
Erin Wettstone  
Sarah Elwood  
Stephanie Brennhofer  
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**BILL & MELINDA  
GATES foundation**

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Ananda Bandyopadhyay  
Radu Ban  
Vincent Seaman  
Jillian Gauld*



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Christa Fagnant  
Alexandra Kossik  
Jeff Shirai*



*Rashidul Haque (co-PI)  
Shams-El-Arifeen  
Firdausi Qadri  
Mustafizur Rahman*

**Novel-t**  
Innovative solutions

*Philippe Veltsos  
Yoann Mira  
Lukas von Tobel*

# Wastewater Surveillance is in the News lately!

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<https://www.nytimes.com/2023/01/19/health/wastewater-surveillance-disease.html?smid=nytcore-ios-share&referringSource=articleShare>

<https://www.nationalacademies.org/news/2023/01/national-wastewater-surveillance-for-infectious-diseases-worthy-of-further-investment-says-new>

<https://www.cnn.com/2023/01/24/health/cdc-airplane-wastewater-covid-testing/index.html>

NBC News: [https://apple.news/AMcKe9b3rSX6d\\_xeAPD23w](https://apple.news/AMcKe9b3rSX6d_xeAPD23w)

## Featured Publication



2023

### Wastewater-based Disease Surveillance for Public Health Action

The COVID-19 pandemic spurred a rapid expansion of wastewater-based infectious disease surveillance systems to monitor and anticipate disease trends in communities. The Centers for Disease Control and Prevention (CDC) launched the National Wastewater Surveillance System in September 2020 to help coordinate and build upon those efforts. Produced at the request of CDC, this report reviews the usefulness of community-level wastewater surveillance during the pandemic and assesses its potential value for control and prevention of infectious diseases beyond COVID-19.

[Read Full Description](#)

#### RESOURCES

- [Report Highlights](#)
- [Report Release Public Briefing Slides](#)
- [Press Release](#)

Thank You



See you again!

Send inquiries / topics:

[rekha.singh@vdh.virginia.gov](mailto:rekha.singh@vdh.virginia.gov)