# Diving into the sewers to improve public health

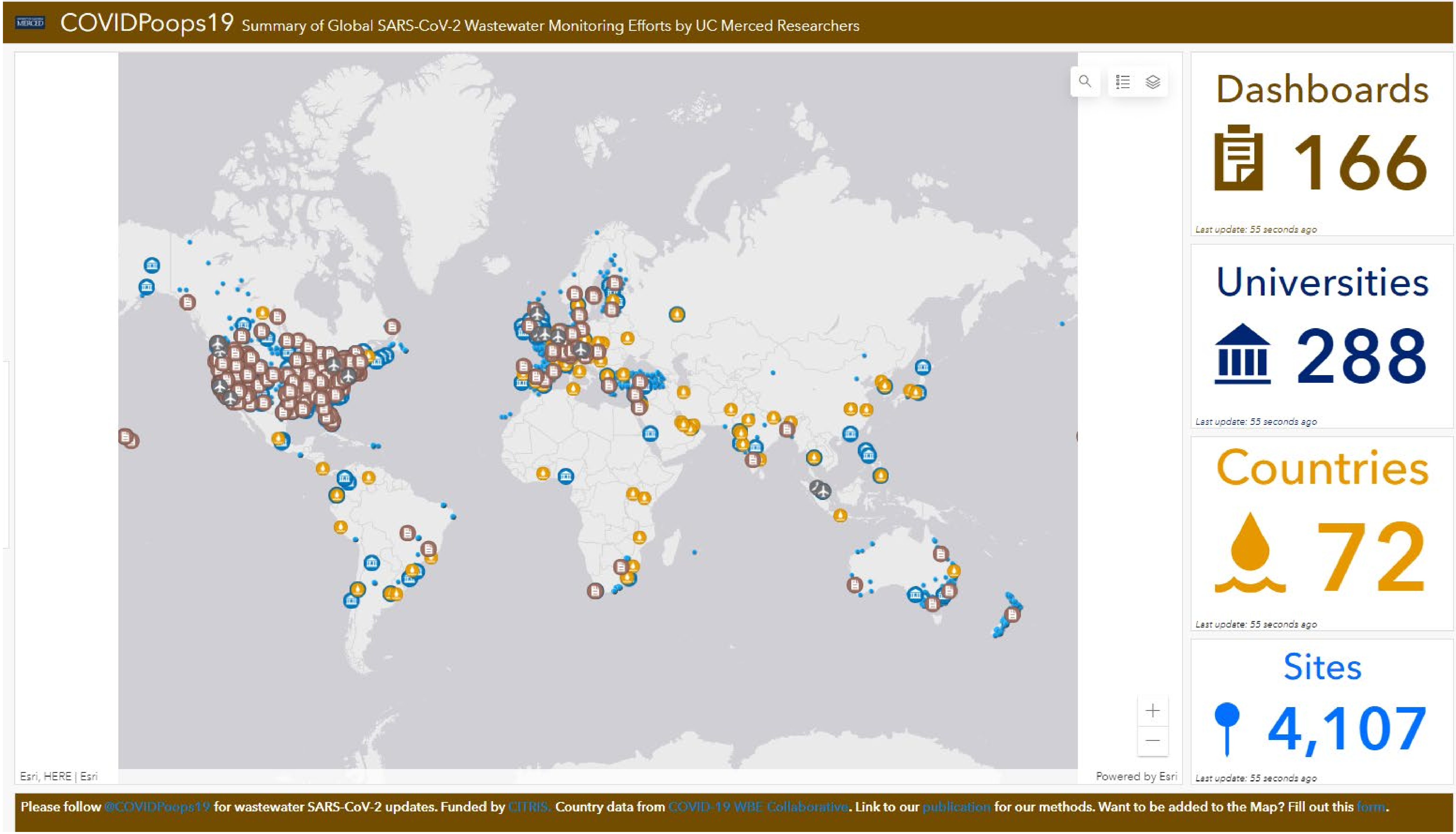
**Amy E. Kirby, PhD MPH**
National Wastewater Surveillance System Program Lead
Waterborne Disease Prevention Branch

Beyond TB Lecture
North American Region Annual TB Meeting
February 24, 2023

NATIONAL™ WASTEWATER SURVEILLANCE SYSTEM

cdc.gov/NWSS


WASTEWATER SURVEILLANCE
SO HOT RIGHT NOW
imgflip.com



COVIDPoops19 Summary of Global SARS-CoV-2 Wastewater Monitoring Efforts by UC Merced Researchers
Dashboards
166
Last update: 55 seconds ago
Universities
288
Last update: 55 seconds ago
Countries
72
Last update: 55 seconds ago
Sites
4,107
Last update: 55 seconds ago
Esri, HERE | Esri
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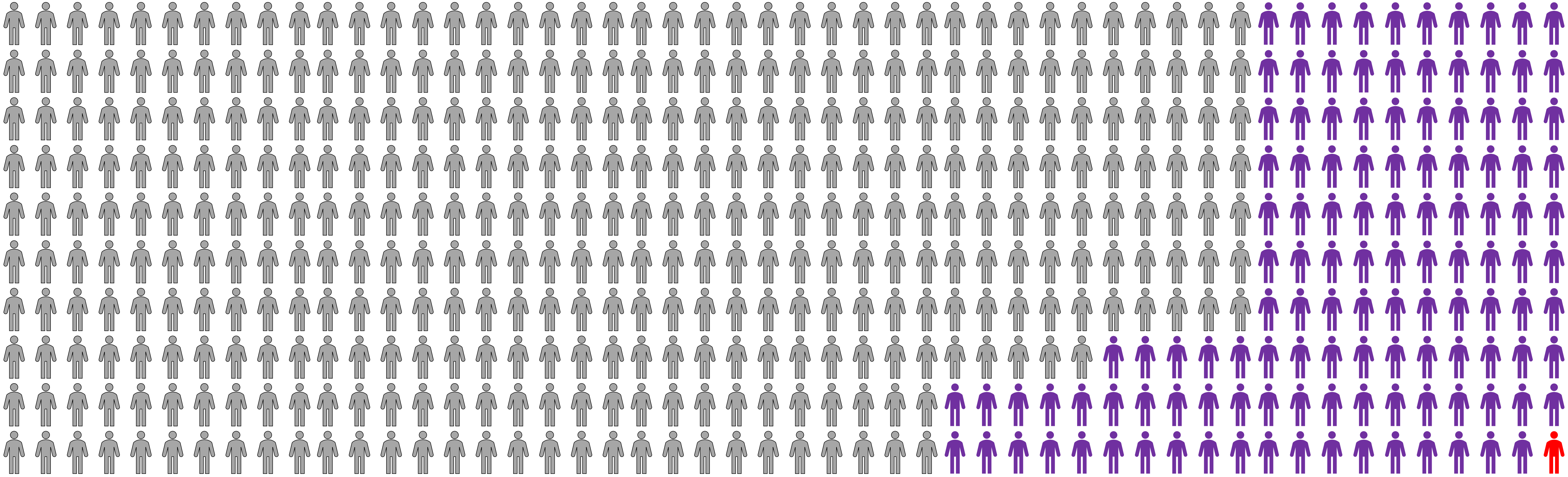
Please follow @COVIDPoops19 for wastewater SARS-CoV-2 updates. Funded by CITRIS. Country data from COVID-19 WBE Collaborative. Link to our publication for our methods. Want to be added to the Map? Fill out this form.


"Wellbee" says
BE WELL!
take
ORAL
POLIO
VACCINE
• tastes good
• works fast
• prevents polio



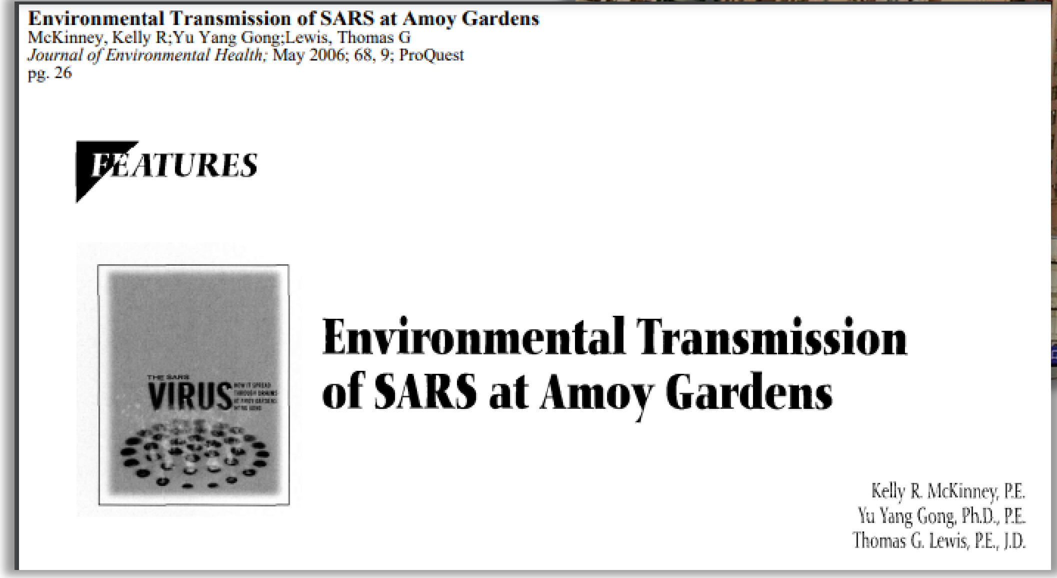
1988
Global Polio Eradication Initiative (GPEI) established

2015
Wild poliovirus 2 eradicated

2016
Sabin Type 2 virus withdrawn from OPV

2019
Wild poliovirus 3 eradicated

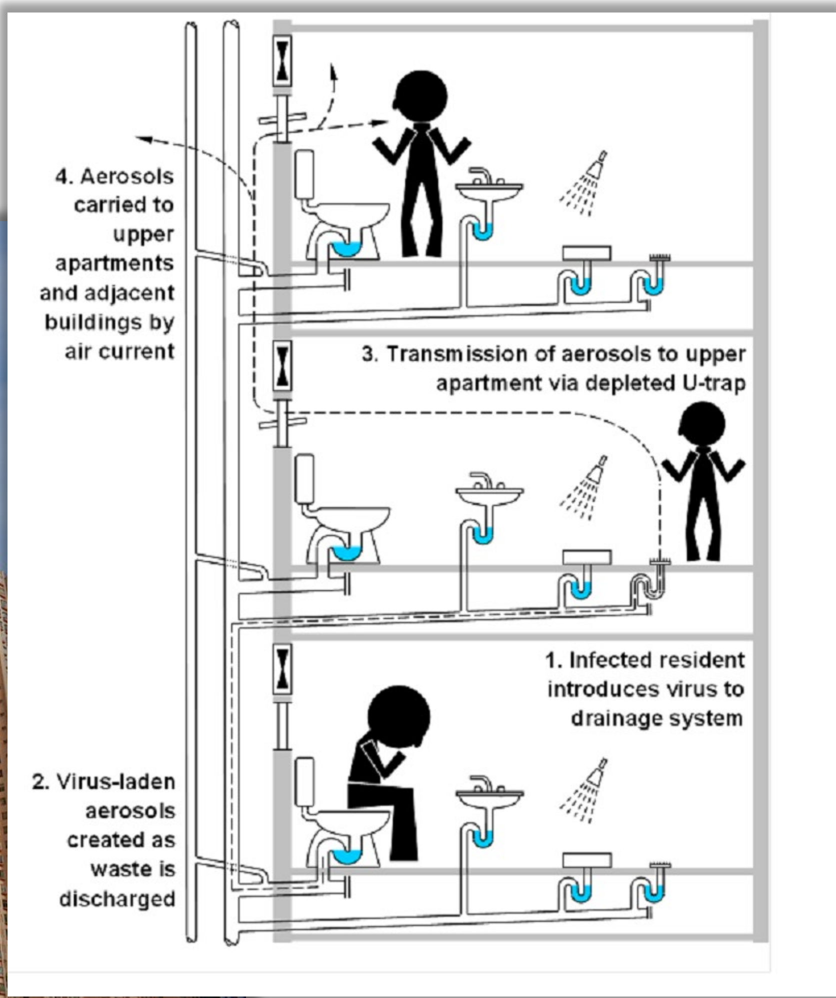
2022
Only 2 countries with endemic wild poliovirus 1; many vaccine-derived poliovirus outbreaks



**Environmental Transmission of SARS at Amoy Gardens**
McKinney, Kelly R;Yu Yang Gong;Lewis, Thomas G
*Journal of Environmental Health;* May 2006; 68, 9; ProQuest
pg. 26

FEATURES

# Environmental Transmission of SARS at Amoy Gardens

Kelly R. McKinney, P.E.
Yu Yang Gong, Ph.D., P.E.
Thomas G. Lewis, P.E., J.D.




Gormley et al. 2017

# The process of wastewater surveillance

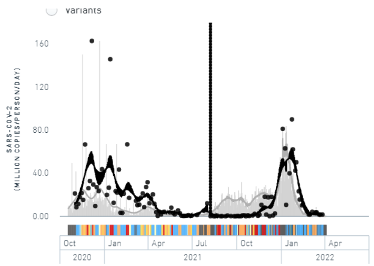
Individuals use toilet on sewer system

At a centralized treatment plant, or sampling point, a grab or composite sample is collected

The sample is processed, concentrated, and genomic material is extracted

RNA, the genomic material of SARS-CoV-2, is then amplified and detected

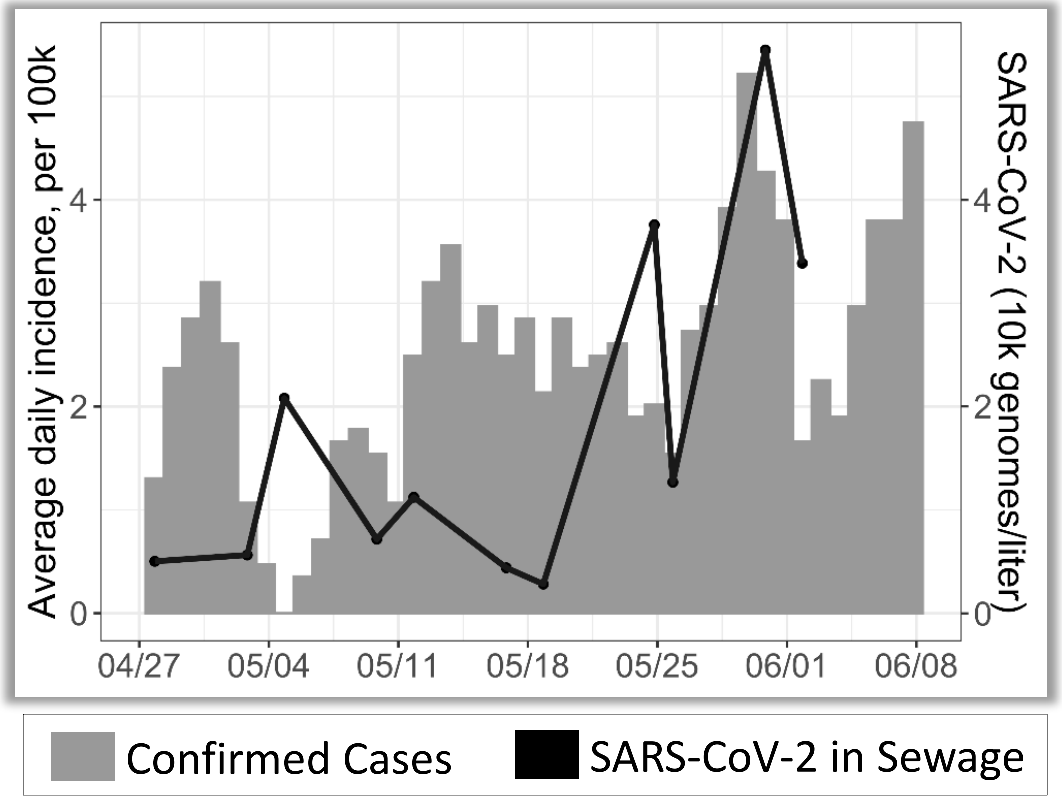
Raw data is received, analyzed, and visualized



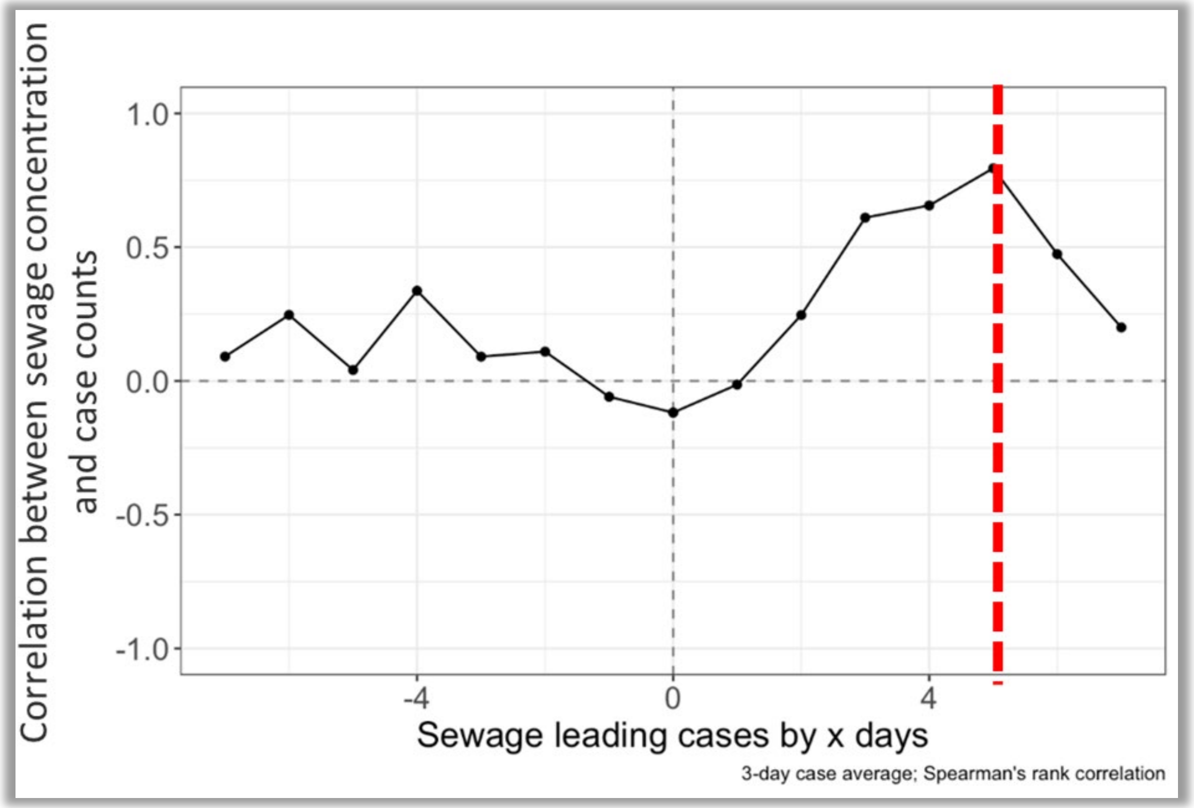
Metrics can be used to inform public health decisions

# Wastewater is a leading indicator of SARS-CoV-2 case trends

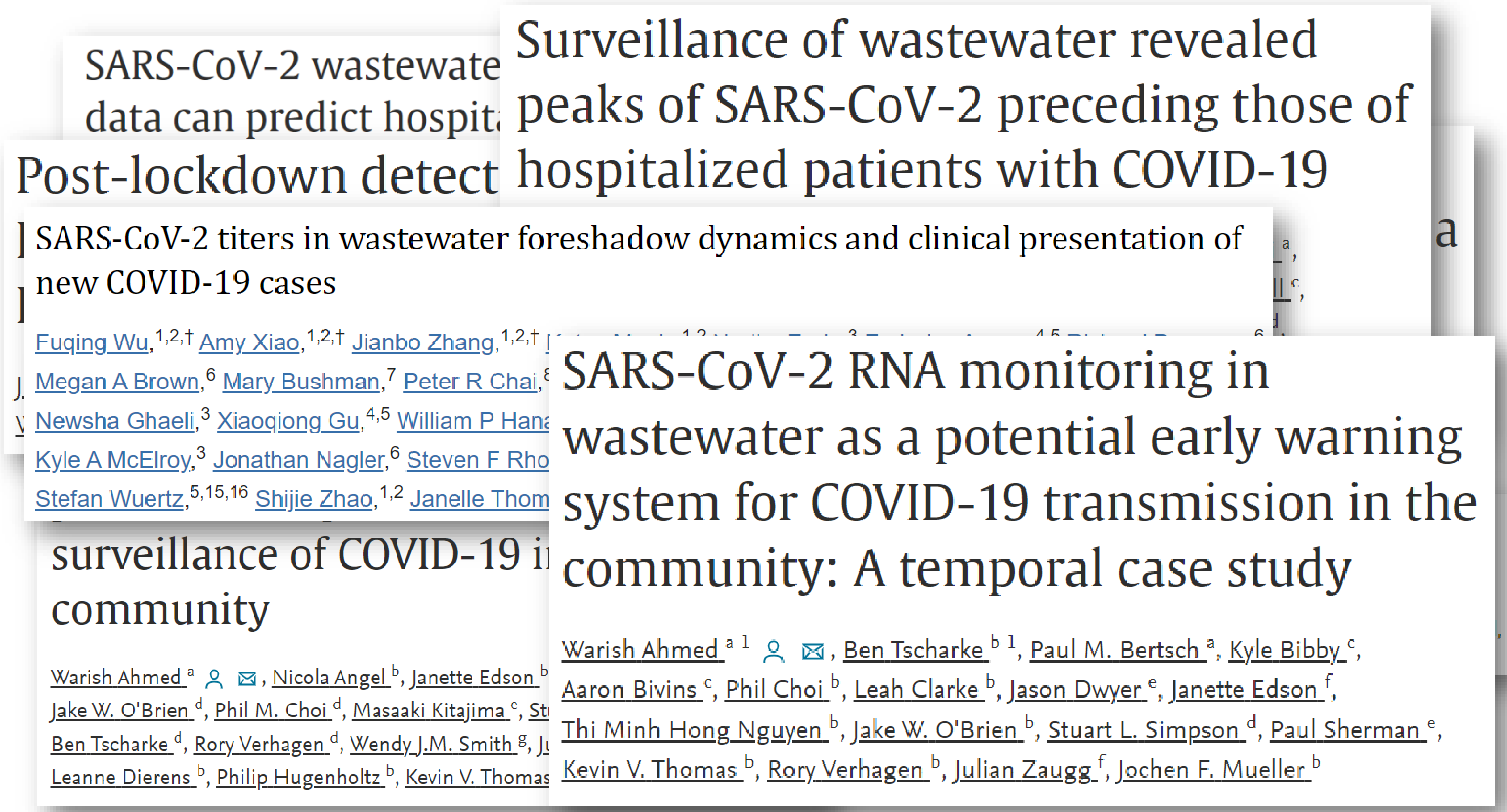
**Sewage concentrations correlate with confirmed cases ~4-6 days in the future.**



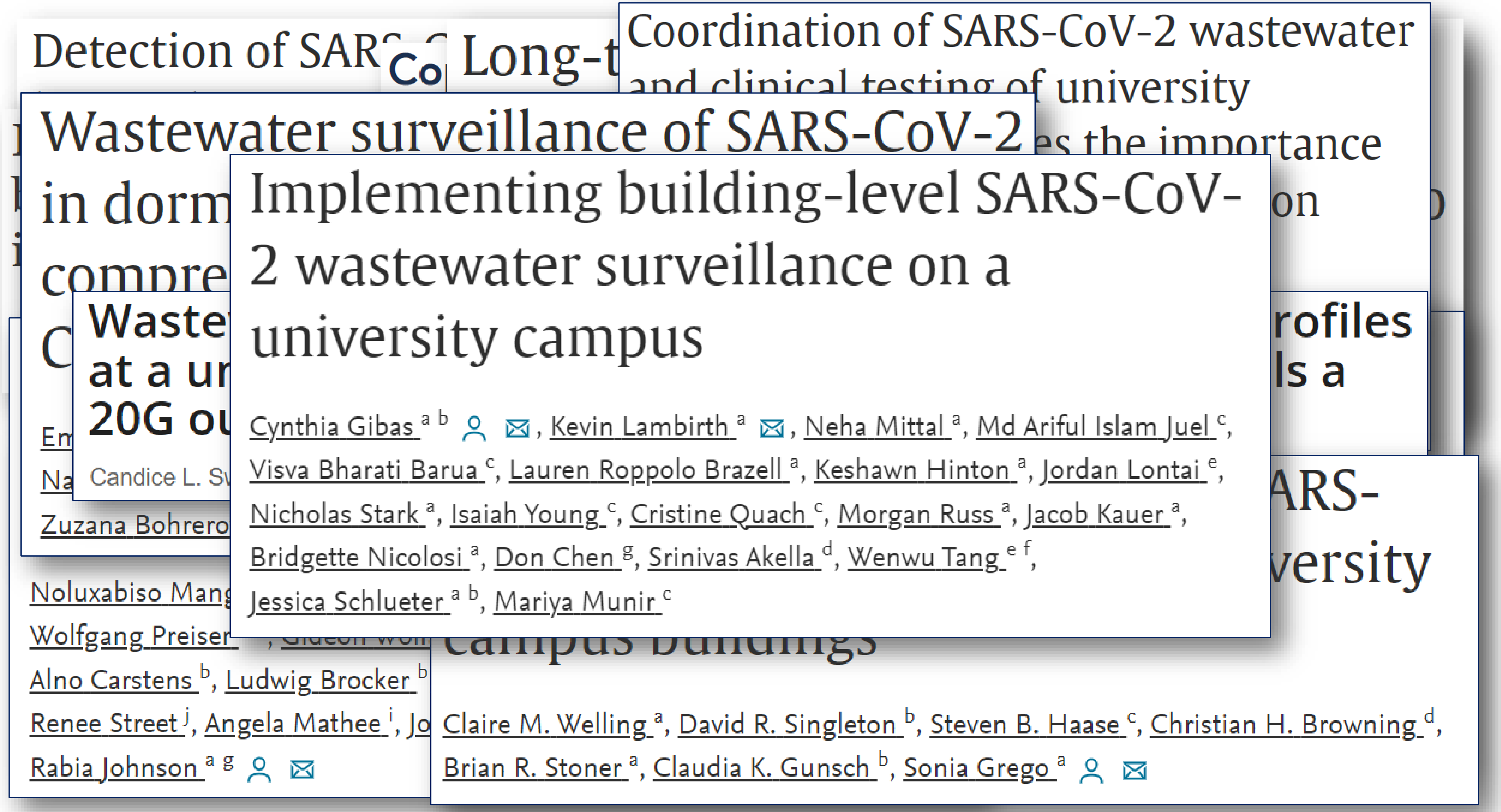

Time Series




Correlation



SARS-CoV-2 wastewate
data can predict hospit
Surveillance of wastewater revealed peaks of SARS-CoV-2 preceding those of hospitalized patients with COVID-19
Post-lockdown detect
SARS-CoV-2 titers in wastewater foreshadow dynamics and clinical presentation of new COVID-19 cases
Fuqing Wu, Amy Xiao, Jianbo Zhang,
Megan A Brown, Mary Bushman, Peter R Chai,
Newsha Ghaeli, Xiaoqiong Gu, William P Hana
Kyle A McElroy, Jonathan Nagler, Steven F Rho
Stefan Wuertz, Shijie Zhao, Janelle Thom
surveillance of COVID-19 i
community
Warish Ahmed, Nicola Angel, Janette Edson
Jake W. O'Brien, Phil M. Choi, Masaaki Kitajima, St
Ben Tscharke, Rory Verhagen, Wendy J.M. Smith, J
Leanne Dierens, Philip Hugenholtz, Kevin V. Thomas
SARS-CoV-2 RNA monitoring in wastewater as a potential early warning system for COVID-19 transmission in the community: A temporal case study
Warish Ahmed, Ben Tscharke, Paul M. Bertsch, Kyle Bibby,
Aaron Bivins, Phil Choi, Leah Clarke, Jason Dwyer, Janette Edson,
Thi Minh Hong Nguyen, Jake W. O'Brien, Stuart L. Simpson, Paul Sherman,
Kevin V. Thomas, Rory Verhagen, Julian Zaugg, Jochen F. Mueller



Coordination of SARS-CoV-2 wastewater
and clinical testing of university
Wastewater surveillance of SARS-CoV-2
Implementing building-level SARS-CoV-2 wastewater surveillance on a university campus
Cynthia Gibas [a b], Kevin Lambirth [a], Neha Mittal [a], Md Ariful Islam Juel [c], Visva Bharati Barua [c], Lauren Roppolo Brazell [a], Keshawn Hinton [a], Jordan Lontai [e], Nicholas Stark [a], Isaiah Young [c], Cristine Quach [c], Morgan Russ [a], Jacob Kauer [a], Bridgette Nicolosi [a], Don Chen [g], Srinivas Akella [d], Wenwu Tang [e f], Jessica Schlueter [a b], Mariya Munir [c]
Noluxabiso Mang
Wolfgang Preiser
Alno Carstens [b], Ludwig Brocker [b]
Renee Street [j], Angela Mathee [i]
Rabia Johnson [a g]
Claire M. Welling [a], David R. Singleton [b], Steven B. Haase [c], Christian H. Browning [d], Brian R. Stoner [a], Claudia K. Gunsch [b], Sonia Grego [a]

## *Notes from the Field*: Early Evidence of the SARS-CoV-2 B.1.1.529 (Omicron) Variant in Community Wastewater — United States, November–December 2021

*Weekly* / January 21, 2022 / 71(3);103–105

| | First Wastewater Detection | | First Clinical Cases |
|---|---|---|---|
| California | 11/25 | 1 site | Tested 11/28 |
| Colorado | 12/2 | 1 site | Tested 11/29 |
| Houston | 11/29 | 7 sites | Tested 12/1, 2 cases |
| New York City | 11/21 | 1 site | Tested 11/24 |

Wastewater detections indicated wider geographic presence than known at the time (California, Colorado, Houston)

Earliest evidence of the presence of Omicron in the US (New York City)

# Wastewater data informs public health action


- ✓ Independent confirmation of true increases or decreases in cases
- ✓ Use of data for public facing dashboards
- ✓ Public health messaging
- ✓ Regularly informing local public health leadership
- ✓ Distribution, siting of test capacity
- ✓ Surveillance data in communities where clinical testing is limited or not available
- ✓ Near-term forecasting of cases or hospital utilization
- ✓ Detecting the emergence of Variants of Concern

# Limitations of Wastewater Surveillance

- ~25% of US residences are not connected to sewer
- Decentralized wastewater treatment facilities will not be captured
- Low incidence may be below the limit of detection
- Cannot be used to “clear” a community or facility
- May be impacted by pre-treatment of sewage at facility level or at WWTP for odor or worker safety

NATIONAL ACADEMIES *Sciences Engineering Medicine*

# Wastewater-based Disease Surveillance For Public Health Action

*Guy Palmer, Committee Chair*

*Stephanie Johnson, Study Director*

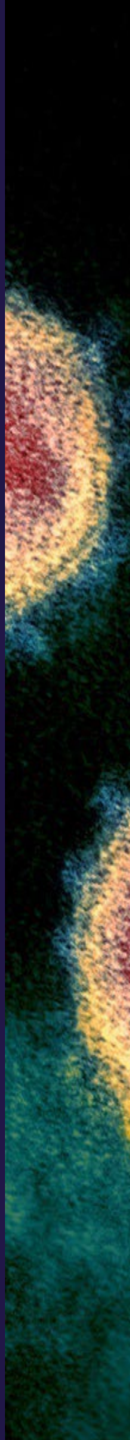
**Full report available online**

CONSENSUS STUDY REPORT

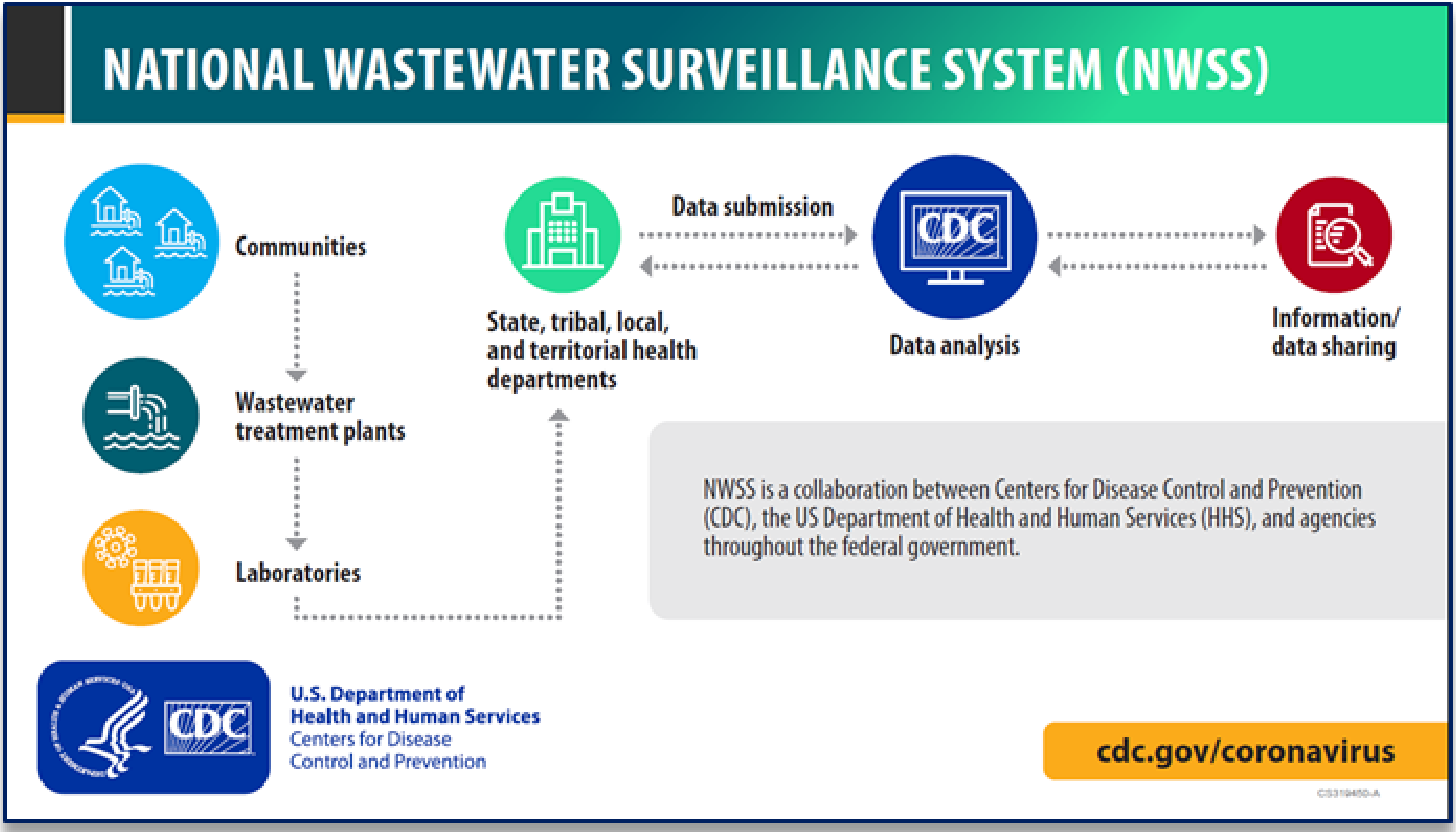
# Summary

- Wastewater surveillance has proven to be a valuable component of the COVID-19 pandemic response with increasing importance to understand trends and variants
- Looking forward, a national wastewater surveillance system should be equitable, sustainable, integrated, actionable, and flexible.
- CDC should develop a transparent process for prioritizing new targets and work to address privacy concerns
- Predictable and sustained federal funding and coordination/collaboration among many partners will be critical to the effectiveness

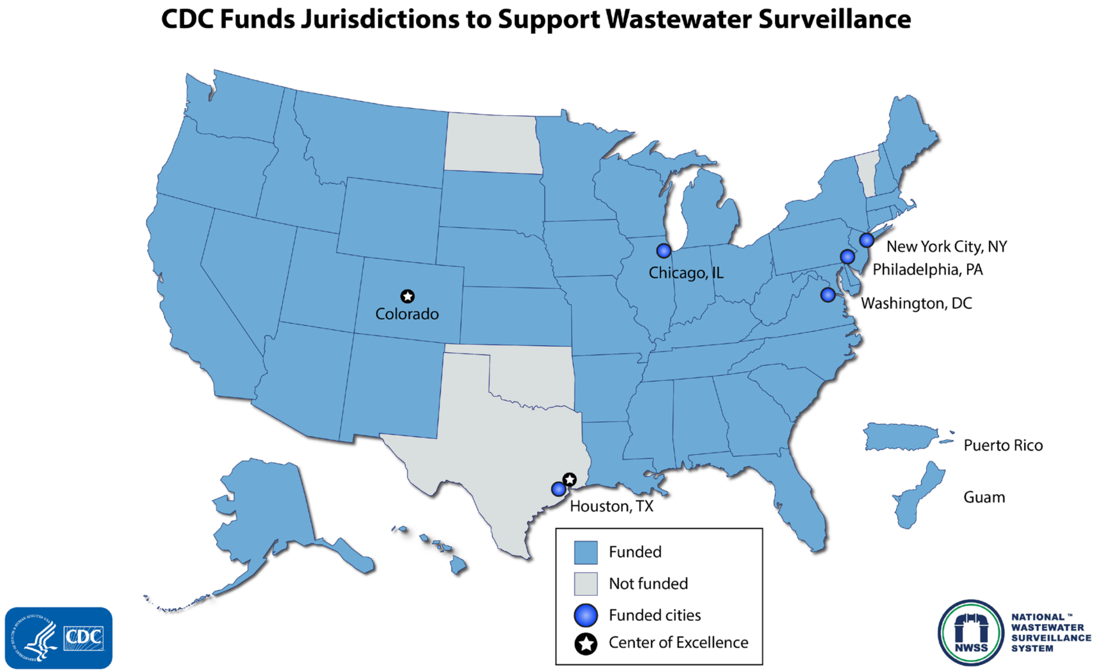
NATIONAL ACADEMIES *Sciences Engineering Medicine*

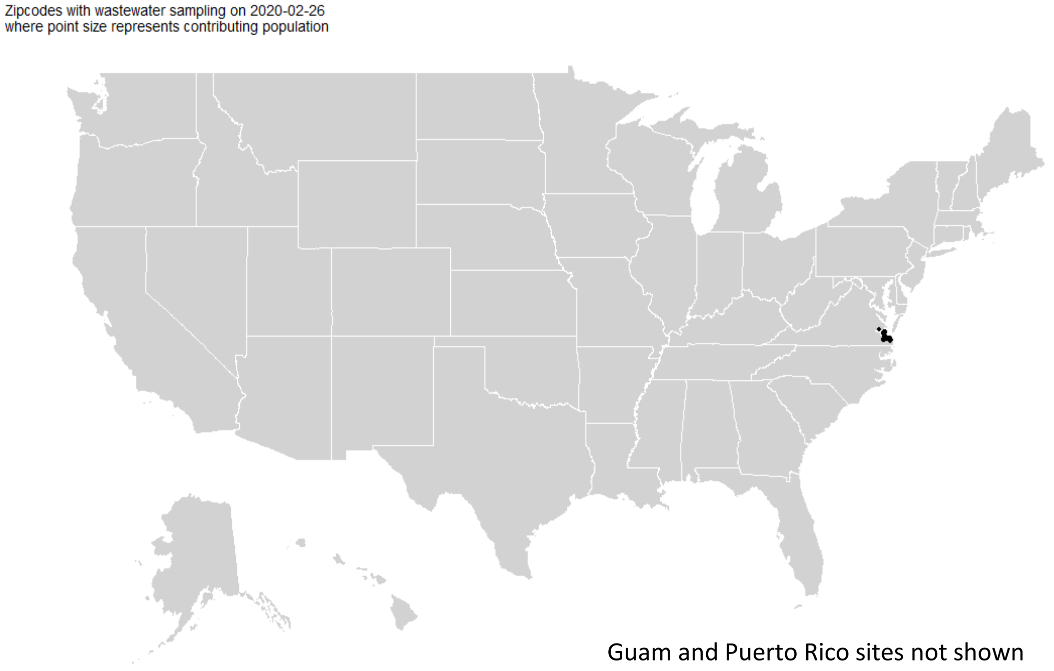


# Implementing wastewater surveillance at a national scale


NATIONAL WASTEWATER SURVEILLANCE SYSTEM (NWSS)
Communities
Wastewater treatment plants
Laboratories
State, tribal, local, and territorial health departments
Data submission
Data analysis
Information/ data sharing
NWSS is a collaboration between Centers for Disease Control and Prevention (CDC), the US Department of Health and Human Services (HHS), and agencies throughout the federal government.
U.S. Department of Health and Human Services
Centers for Disease Control and Prevention
cdc.gov/coronavirus

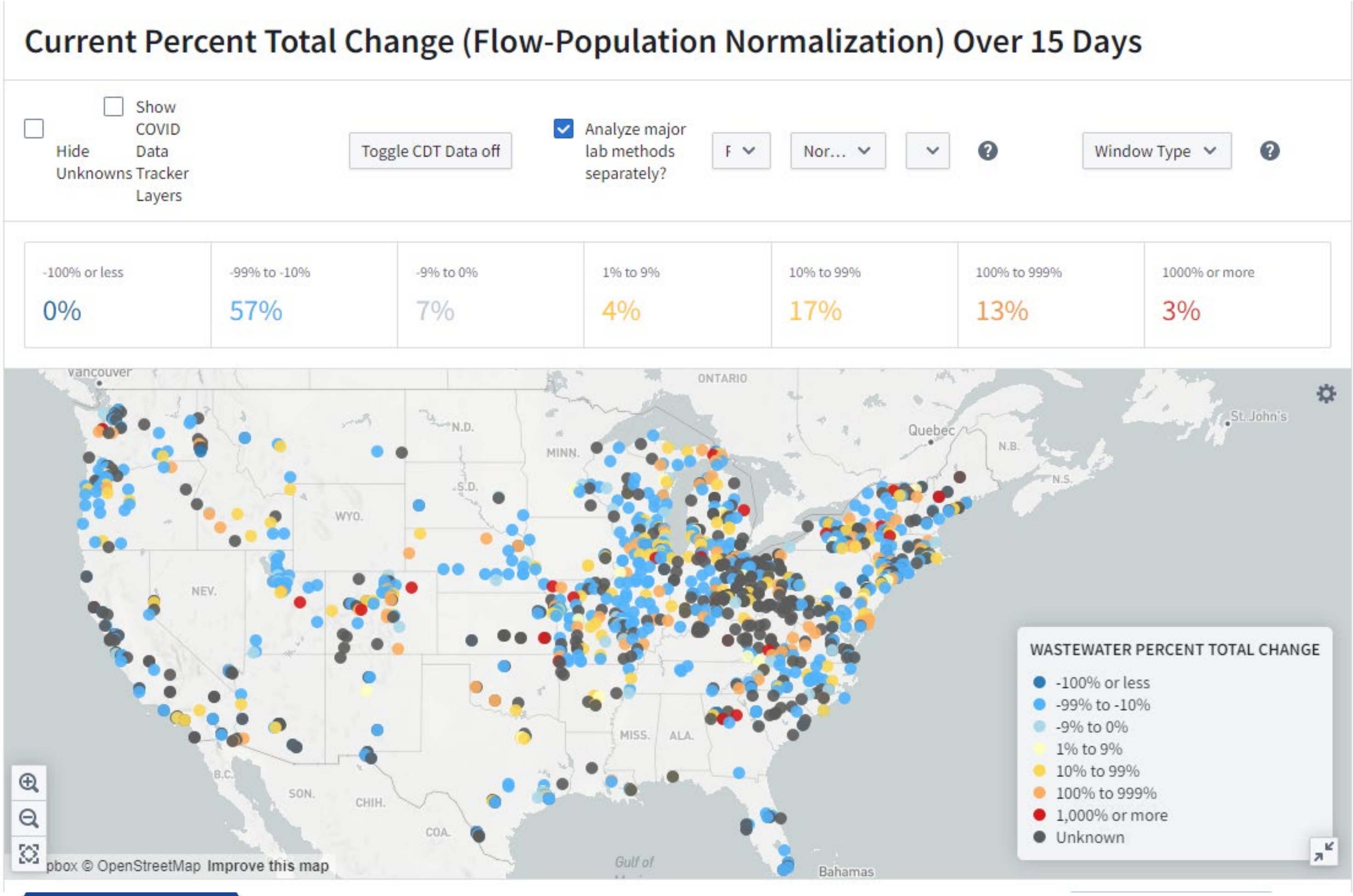
# NWSS Implementation | 2020 - 2023




- 46 states, 5 major cities and 2 territories using CDC funds for wastewater surveillance
- 2 Centers of Excellence
- >133,000 unique wastewater samples
- >1400 sites in 50 states, 3 territories and 7 Tribal communities
- Representing >140M people

# DCIPHER dashboard | One-stop shop for implementers



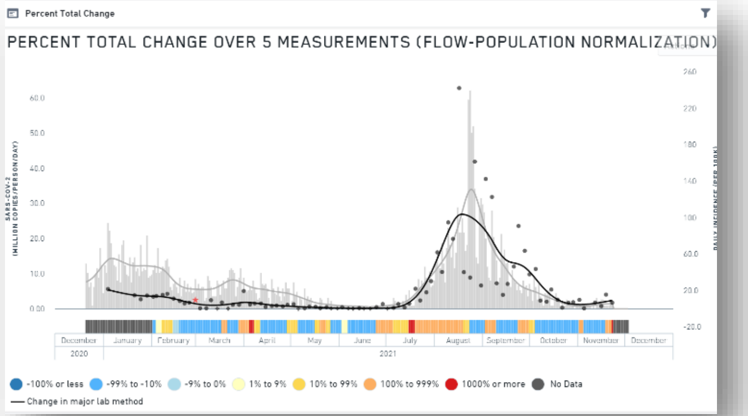

| Metric | What does this show us? |
|---|---|
| Percentiles | Relative levels of virus present in a community over time |
| Percent Change | Magnitude and direction of virus levels in a community |
| Detection Proportion | How frequently is the virus detected in a community |
| Variant Specific Metrics | If a known variant is present, and at what proportion |

Also includes-

- Resource library
- Contact list
- Automated QC reports
- Automated utility reports
- Support forum

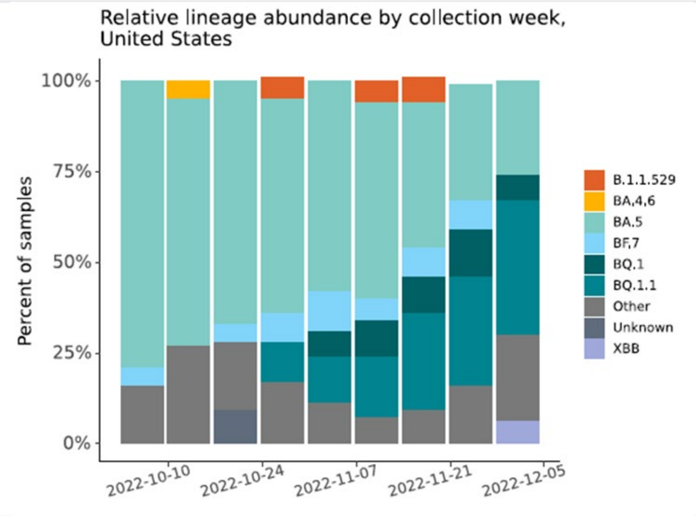
# NWSS platform is rapidly adaptable for additional analyses

SARS-CoV-2 Trends



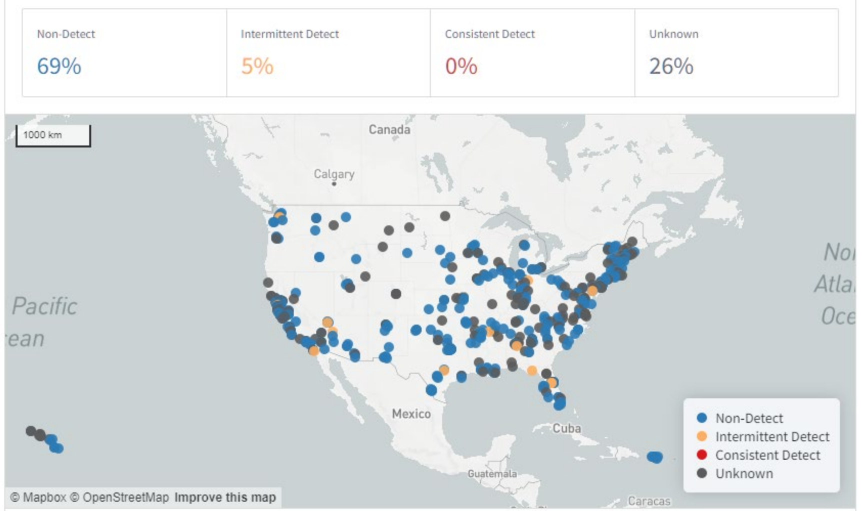

[COVID Data Tracker Wastewater Surveillance]()

SARS-CoV-2 Variants



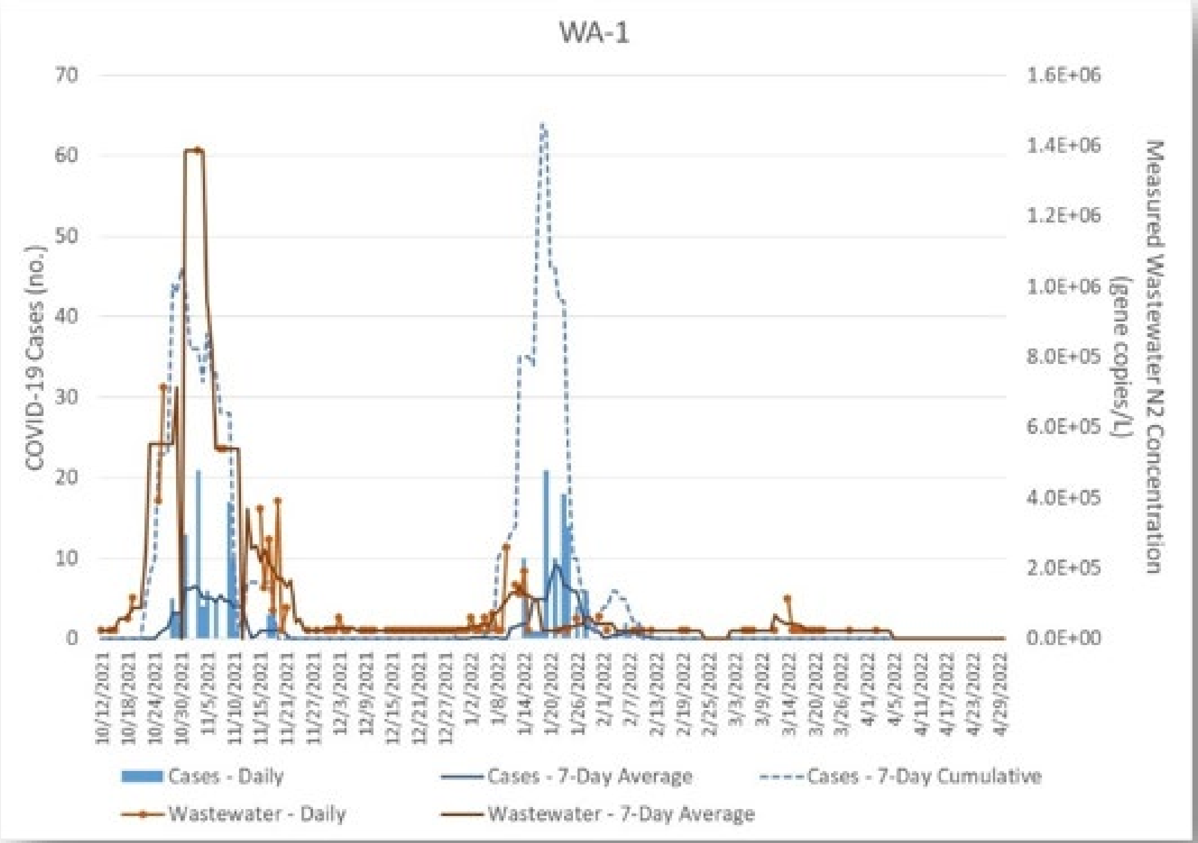

[COVID Data Tracker Variant Surveillance]()

Mpox Detections




[Mpox Wastewater Public Data]()

# On-site wastewater testing in correctional facilities can support COVID mitigation efforts

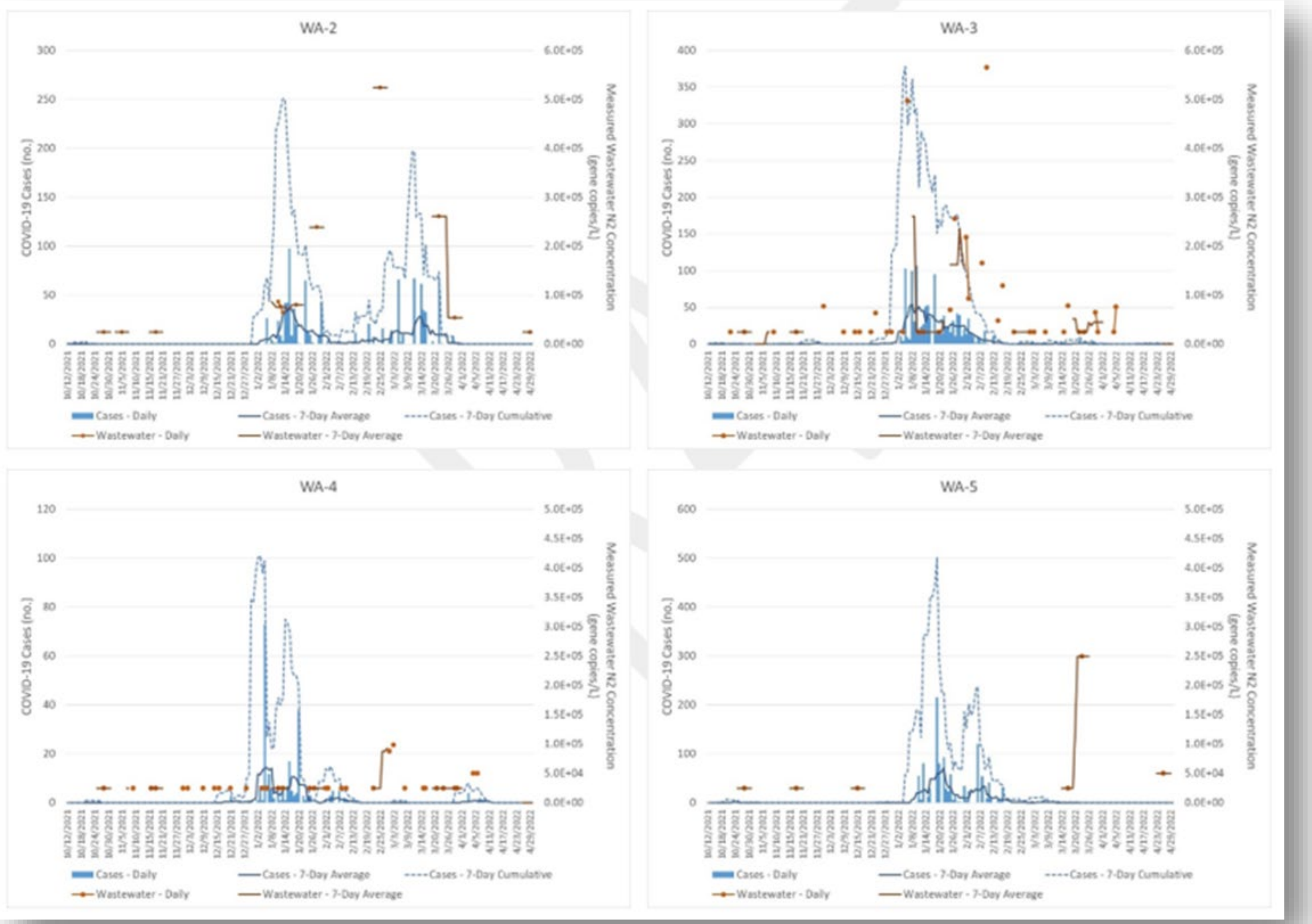



# Sampling location and consistency are critical for successful facility-level surveillance

Inconsistent testing

Poor sampling location or method

Alternative sanitation options?

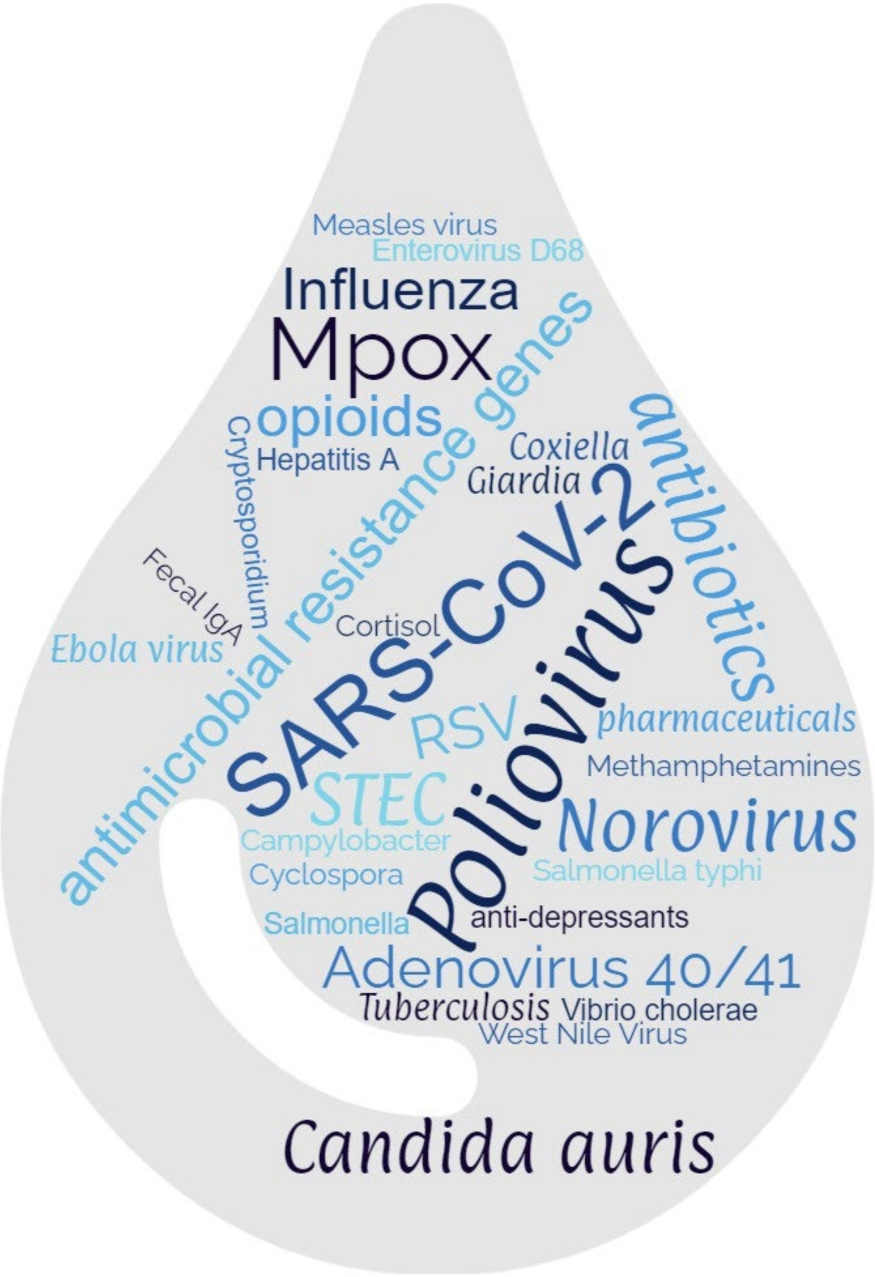



Population turnover

Poor sampling location or method

Inconsistent testing

# Wastewater surveillance beyond COVID


Measles virus
Enterovirus D68
Influenza
Mpox
opioids
Hepatitis A
Cryptosporidium
antimicrobial resistance genes
Coxiella
Giardia
antibiotics
SARS-CoV-2
Poliovirus
Fecal IgA
Cortisol
Ebola virus
RSV
pharmaceuticals
Methamphetamines
STEC
Norovirus
Campylobacter
Cyclospora
Salmonella typhi
Salmonella
anti-depressants
Adenovirus 40/41
Tuberculosis
Vibrio cholerae
West Nile Virus
Candida auris

Municipa

surveillar

outbreak

## Wastewater Surveillance Captured an Increase in Adenovirus Circulation in Milan (Italy) during the First Quarter of 2022

by Laura Pellegrinelli [1,*], Sara Colonia Uceda Renteria [2], Ferruccio Ceriotti [2], Emanuela Ammoni [3], Cristina Galli [1], Arlinda Seiti [1], Sara Castiglioni [4], Danilo Cereda [3],
Sandro Binda [1] and Elena Pariani [1]

## Antibiotic resistance in European wastewater treatment plants mirrors the pattern of clinical antibiotic resistance prevalence

KATARIINA M. M. PÄRNÄNEN, CARLOS NARCISO-DA-ROCHA, DAVID KNEIS, THOMAS U. BERENDONK, DAMIANO CACACE, THI THUY DO,
CHRISTIAN ELPERS, DESPO FATTA-KASSINOS, ISABEL HENRIQUES, [...], AND CÉLIA M. MANAIA +16 authors Authors Info & Affiliations

## Community-Scale Wastewater Surveillance of *Candida auris* during an Ongoing Outbreak in Southern Nevada

Casey Barber, Katherine Crank, Katerina Papp, Gabriel K. Innes, Bradley W. Schmitz, Jorge Chavez, Alessandro Rossi, and Daniel Gerrity*

s [d],

Lauren B. Stadler

# Evaluating a New Wastewater Target

- Is the virus shed into wastewater?
  - Fecal shedding prevalence, magnitude, duration, and infectivity?
- Can clinical assays be adapted for wastewater?
  - Can virus be recovered and quantified reliably?
  - Are other, non-specific targets detected (false positives)?
- What is the geographic distribution of cases?
  - Are there enough cases in a sewershed to be detectable?
  - What is the case ascertainment rate and timing?
- Do trends reflect case incidence or prevalence?
- Are there meaningful public health actions at the community level?

## Core

- Regular surveillance for endemic or **common** diseases, such as flu or antibiotic resistance genes
- Provides regular, consistent, cost-effective surveillance

## Emergency

- Rapid response for outbreaks, emergencies, natural disasters
- **Sporadic but expected** diseases, such as shigellosis or polio
- Rapidly deployable portfolio of validated assays

## Pandemic preparedness

- Horizon scanning for potential epidemic or pandemic threats
- Evaluation of potential **rare, unexpected** diseases such as Ebola or Mpox
- Biosecurity Early Warning

# NWSS Panel for Core Targets*

- Normalization Controls
  - Pepper Mild Mottle Virus
  - Crassphage
- Process Control
  - Bovine Coronavirus
- Antibiotic resistance genes
  - Carbapenemases (NDM, VIM, KPC, OXA-48, IMP
  - ESBLs (CMY, CTX-M-1, TEM, SHV)
  - Colistin resistance (*mcr-1*)
  - Vancomycin resistance (*vanA*)
- Respiratory viruses
  - SARS-CoV-2
  - Influenza A and B
  - Respiratory Syncytial Virus
- Enteric pathogens
  - Adenovirus 40/41
  - Shiga-toxin-producing *E. coli*
  - *Campylobacter*
  - Norovirus
  - Cyclospora cayetanesis
- Emerging pathogens
  - *Candida auris*
  - Mpox (non-Variola Orthopox)

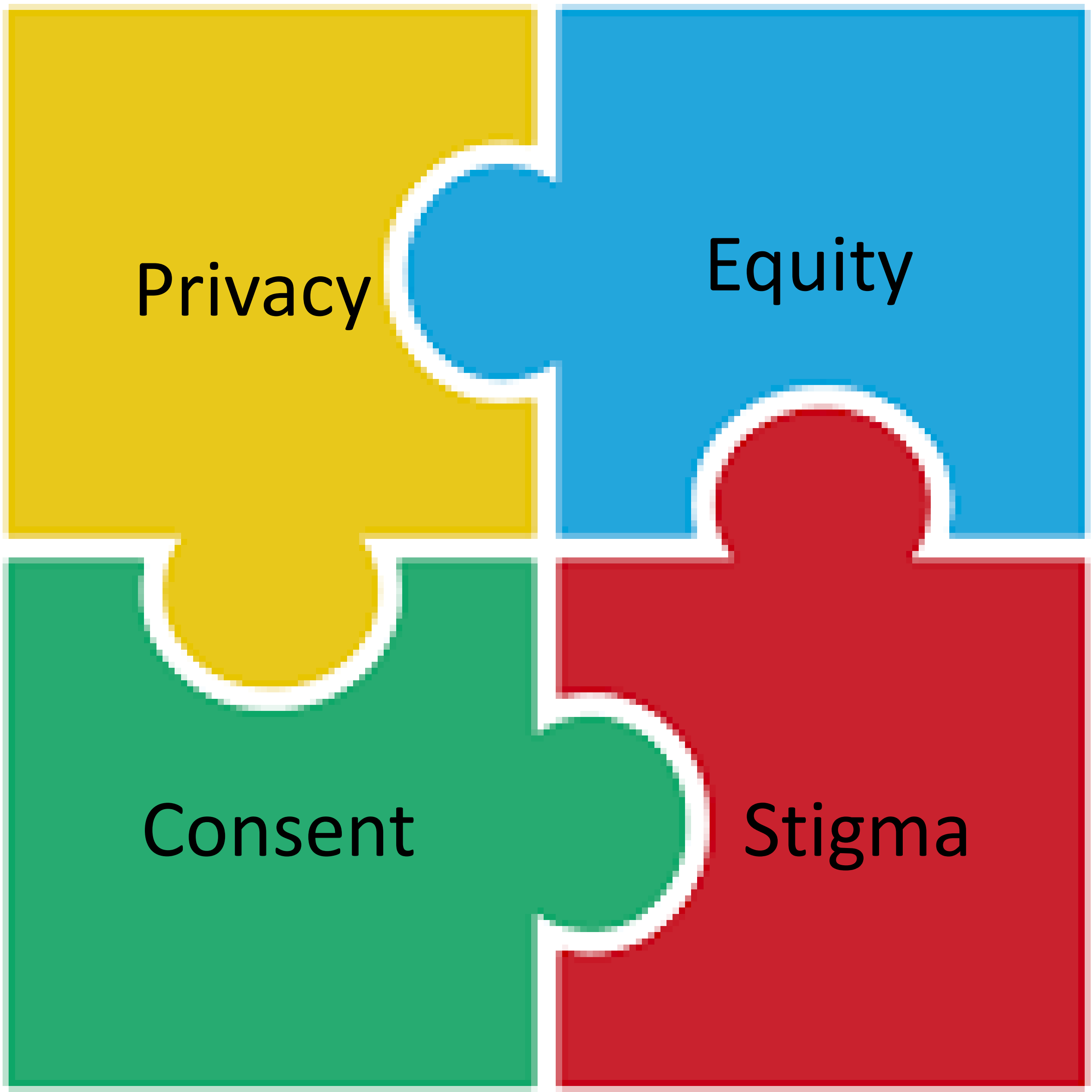
*Final panel composition may change based on technical or public health needs

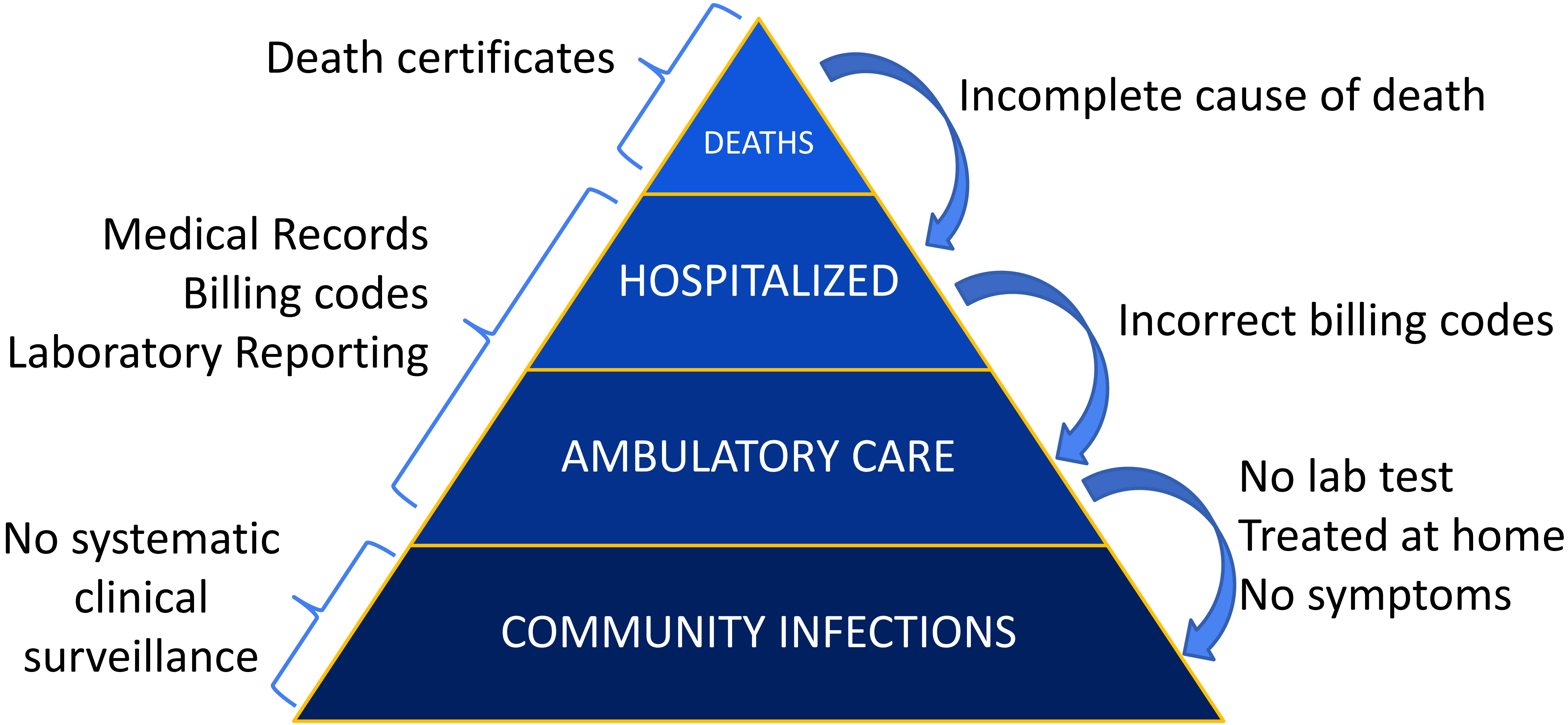
# Ethical considerations grow alongside the field

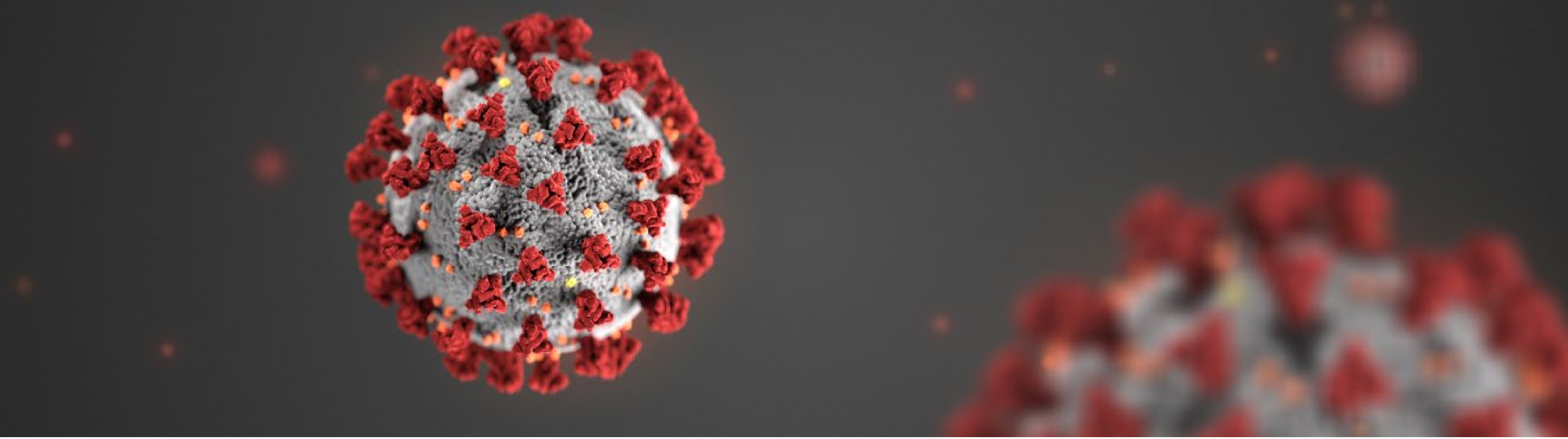
- Traceback
- Choosing surveillance targets
- Stigma/blame on communities
- Future use of archived samples
- Sample and data access
- Acknowledging past public health harms

# Challenges for NWSS development and sustainability

- Extending coverage, 20% unsewered
- Impact of vaccination and variants
- Optimal geographic and temporal sampling frame for multiple targets
- Improved data submission, dissemination, messaging
- Improved methods, streamlined workflow
- Ethical transparency, especially around sample archiving


Privacy
Equity
Consent
Stigma


Death certificates
Medical Records
Billing codes
Laboratory Reporting
No systematic
clinical
surveillance
DEATHS
HOSPITALIZED
AMBULATORY CARE
COMMUNITY INFECTIONS
Incomplete cause of death
Incorrect billing codes
No lab test
Treated at home
No symptoms



For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov

For more information: NWSS@cdc.gov
www.cdc.gov/NWSS

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.