Diving into the sewers to improve public health

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Waterborne Disease Prevention Branch

Beyond TB Lecture
North American Region Annual TB Meeting
February 24, 2023
COVIDPoops19 Summary of Global SARS-CoV-2 Wastewater Monitoring Efforts by UC Merced Researchers

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
Environmental Transmission of SARS at Amoy Gardens

Kelly R. McKinney, PE
Yu Yang Gong, PhD, PE
Thomas G. Lewis, PE, IDA

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

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.

SARS-CoV-2 titers in wastewater foreshadow dynamics and clinical presentation of new COVID-19 cases.

SARS-CoV-2 RNA monitoring in wastewater as a potential early warning system for COVID-19 transmission in the community: A temporal case study.
Detection of SARS-CoV-2 Long-term wastewater surveillance of SARS-CoV-2 and clinical testing of university students: the importance of SARS-CoV-2 wastewater surveillance in dormitory buildings

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
### First Wastewater Detection

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>Number of Sites</th>
<th>Date Tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>11/25</td>
<td>1 site</td>
<td>11/28</td>
</tr>
<tr>
<td>Colorado</td>
<td>12/2</td>
<td>1 site</td>
<td>11/29</td>
</tr>
<tr>
<td>Houston</td>
<td>11/29</td>
<td>7 sites</td>
<td>12/1, 2 cases</td>
</tr>
<tr>
<td>New York City</td>
<td>11/21</td>
<td>1 site</td>
<td>11/24</td>
</tr>
</tbody>
</table>

Wastewater detections indicated wider geographic presence than known at the time.

Earliest evidence of the presence of Omicron in the US.
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
Wastewater-based Disease Surveillance For Public Health Action

Guy Palmer, Committee Chair
Stephanie Johnson, Study Director

Full report available online
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.
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.

cdc.gov/coronavirus
NWSS Implementation | 2020 - 2023

- >133,000 unique wastewater samples
- >1400 sites in 50 states, 3 territories and 7 Tribal communities
- Representing >140M people

- 46 states, 5 major cities and 2 territories using CDC funds for wastewater surveillance
- 2 Centers of Excellence
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

SARS-CoV-2 Variants

Mpx Detections

COVID Data Tracker
Wastewater Surveillance

COVID Data Tracker
Variant Surveillance

Mpx 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?
Wastewater surveillance beyond COVID
Antibiotic resistance in European wastewater treatment plants mirrors the pattern of clinical antibiotic resistance prevalence

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*
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 cayetanensis

- **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
- Stigma/blame on communities
- Sample and data access
- Choosing surveillance targets
- Future use of archived samples
- Acknowledging past public health harms
Challenges for NWSS development and sustainability

Extending coverage, 20% unsewered

Optimal geographic and temporal sampling frame for multiple targets

Improved methods, streamlined workflow

Impact of vaccination and variants

Improved data submission, dissemination, messaging

Ethical transparency, especially around sample archiving
Death certificates
Medical Records
Billing codes
Laboratory Reporting
No systematic clinical surveillance

Incomplete cause of death
Incorrect billing codes
No lab test
Treated at home
No symptoms
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.