COVID-19 Wastewater-Based Epidemiology

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Source: Wastewater-Based Epidemiology: Global Collaborative to Maximize Contributions in the Fight Against COVID-19
Environmental Science & Technology

--- CONFIDENTIAL BUSINESS INFORMATION ---
Overview

- Safety moment
- Introduction to wastewater-based epidemiology
- Research approach and findings
- Discussion

https://www.ft.com/
**COVID-19 & wastewater: safety moment**

**Persistence of infectious SARS-CoV-2 unknown**

- **Stool**
  - 3 days for seeded SARS-CoV (Wang et al. 2005)
  - Live virus isolated from 0% (Wölfel et al. 2020) to 2.4% (Wang et al. 2020)

- **Raw wastewater**
  - “Not significant” (Rimoldi et al. 2020)

**CDC recommends “standard practices” for wastewater workers**

*Infected patients shed SARS-CoV-2: patient stool samples remained positive for 27.9 days vs. 16.7 days for throat swabs (Wu et al.)*

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Wang, W. et al. 2020. *JAMA*
Wastewater-based epidemiology

WBE is the analysis of substances in raw wastewater to obtain information on community health – *this is not a new science, but an area of rapid growth.*

Illicit drugs • Toxics exposure • Nutritional status • Stress levels • Viral diseases


WBE & COVID-19

- SARS-CoV-2 can be measured in wastewater using qPCR lab method
- Wastewater correlates with and even precedes clinical disease incidence
- Wastewater could potentially help fill the clinical testing gap

It is possible to detect COVID-19 at least 7 days faster as compared to testing individuals.

Δ = 7 to 16 days

Area of active focus

- Coordinated efforts
  - National: Australia, Canada, Finland, Germany, Netherlands, Pakistan and now US!
  - State-level: CO, NY, OH

- Research
  - Methods
  - Trends across time and space
  - Fate and transport in environment

- Google Scholar search for "sars-cov-2 wastewater"
  - About 973 results (0.06 sec)
Benefits of WBE approach for COVID-19

- Save money and time
- Provide an early warning
  - Take strategic action
  - Focus resources for clinical testing
- Minimize lockdown areas
- Prevent disease and economic loss
- Equity

Requires confidence in relationship between disease incidence and viral signal and reliable sample results with a fast turn-around time.

Cost Savings: The Germany Case

**Clinical Testing of Individuals**
- Population: 83 million
- Clinical testing capacity: 100,000/day
- Cost (reagents only): US$1.25 billion
- Required duration: 3 months

**Wastewater Testing**
- Number of WWTPs: 9,636
- Cost (reagents only): US$145,000
- Required duration: ~1 week

CDM Smith’s parallel research initiatives

1. City-wide approach
   ▪ Collaborating with GLWA & Xagoraraki lab at MSU
   ▪ Complex, many variables
   ▪ Goal is high confidence in relationship between disease incidence and viral signal

   Progress to date
   - On week 16 of sampling; 1x-3x per week
   - GLWA providing in-kind sampling labor
   - All 3 interceptors at GLWA WRRF influent
   - Field filtration using VIRADEL method
   - Further sample preparation based on method optimized in Xagoraki lab*
   - qPCR optimized for N1 target so far
   - Strong SARS-CoV-2 signal in all samples: $10^4$ to $10^5$ copies per L
   - Revised manuscript submitted to *J. Env Eng.*

*O’Brien et al. 2017. Water Research*
CDM Smith’s parallel research initiatives

2. Facility or site-specific approach
   ▪ Pilot for Brown University
   ▪ Simple, fewer unknowns
   ▪ Goal is validation of a reliable method with fast turn-around

Potential Facilities
   • Military vessels and/or bases
   • University dorms and/or campuses
   • Large industrial facilities
   • Residential healthcare facilities
   • Prisons

https://biomeme.com/
https://www.wbur.org/hereandnow/2018/03/28/opioids-test-wastewater
# SARS-CoV-2 wastewater surveillance studies*

<table>
<thead>
<tr>
<th>Study</th>
<th>Location</th>
<th>Population Served</th>
<th>Sampling Locations</th>
<th>Sample Number</th>
<th>Sampling Dates</th>
<th>% Positive</th>
<th>SARS-CoV-2 Genome Copies per L ($\log_{10}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahmed et al.</td>
<td>Brisbane, Australia</td>
<td>736,000</td>
<td>9</td>
<td>9</td>
<td>3/20-4/1</td>
<td>22%</td>
<td>1.3; 2.1</td>
</tr>
<tr>
<td>Haramoto et al.</td>
<td>Yamanashi, Japan</td>
<td>820,000</td>
<td>5</td>
<td>5</td>
<td>3/17-5/7</td>
<td>0%</td>
<td>--</td>
</tr>
<tr>
<td>Medema et al.</td>
<td>The Netherlands</td>
<td>2,800,000</td>
<td>8</td>
<td>28</td>
<td>2/5-3/25</td>
<td>62% (N1)</td>
<td>0.41 to 2.9</td>
</tr>
<tr>
<td>Miyani et al.</td>
<td>Detroit, USA</td>
<td>3,200,000</td>
<td>3</td>
<td>76</td>
<td>4/8-5/28</td>
<td>100%</td>
<td>4.5 to 5.6</td>
</tr>
<tr>
<td>Peccia et al.</td>
<td>New Haven, USA</td>
<td>200,000</td>
<td>1</td>
<td>Not reported</td>
<td>3/19-5/1</td>
<td>100%</td>
<td>3.2 to 5.7</td>
</tr>
<tr>
<td>Randazzo et al.</td>
<td>Murcia, Spain</td>
<td>750,000</td>
<td>6</td>
<td>42</td>
<td>3/12-4/14</td>
<td>83% (raw)</td>
<td>5.4 ± 0.21</td>
</tr>
<tr>
<td>Wu et al.</td>
<td>Boston, USA</td>
<td>2,300,000</td>
<td>2</td>
<td>10</td>
<td>3/20-3/25</td>
<td>100%</td>
<td>4.3 to 5.4</td>
</tr>
<tr>
<td>Wurtzer et al.</td>
<td>Paris, France</td>
<td>2,100,000</td>
<td>3</td>
<td>23</td>
<td>3/5-4/7</td>
<td>100%</td>
<td>&gt; 3</td>
</tr>
</tbody>
</table>

*Not intended to be a comprehensive list.
## Analytical methods still in development

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample Type</th>
<th>Sample Volume</th>
<th>Sample Processing</th>
<th>RNA Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahmed et al.</td>
<td>Raw; 24-hr composite</td>
<td>100-200 mL</td>
<td>Electronegative membrane</td>
<td>N_Sarbeco</td>
</tr>
<tr>
<td>Haramoto et al.</td>
<td>Raw; grab</td>
<td>200 mL</td>
<td>Electronegative membrane vortex</td>
<td>N_Sarbeco</td>
</tr>
<tr>
<td>Medema et al.</td>
<td>Raw; 24-hr composite</td>
<td>250 mL</td>
<td>Ultrafiltration</td>
<td>N1, N2, N3, E</td>
</tr>
<tr>
<td>Miyani et al.</td>
<td>Raw; grab</td>
<td>22-80 L</td>
<td>Electropositive filter</td>
<td>N1, N2</td>
</tr>
<tr>
<td>Peccia et al.</td>
<td>Primary sludge; grab</td>
<td>2.5 mL</td>
<td>Commercial kit for soil RNA</td>
<td>N1, N2, RP</td>
</tr>
<tr>
<td>Randazzo et al.</td>
<td>Raw, $2^0, 3^0$</td>
<td>200 mL</td>
<td>Al(OH)$_3$ adsorption/precipitation</td>
<td>N1, N2, N3</td>
</tr>
<tr>
<td>Wu et al.</td>
<td>Raw; 24-hour composite</td>
<td>Not reported</td>
<td>PEG 8000 concentration</td>
<td>N1, N2, N3</td>
</tr>
<tr>
<td>Wurtzer et al.</td>
<td>Raw</td>
<td>Not reported</td>
<td>Ultracentrifugation</td>
<td>E</td>
</tr>
</tbody>
</table>
Correlation with COVID-19 prevalence/incidence

- Cumulative or new cases?
- Discrepancy between reported health data and estimates based on wastewater signal
  - 0.026% reported vs. 0.1%-5% estimated for Boston (Wu et al. 2020)
- Health data scale (ZIP Code, county, city) vs. sewershed scale
Take-away themes

WBE is here to stay

- City-scale
- Facility specific
- Beyond COVID-19

How to stay up-to-date

- COVID-19 WBE Collaborative: https://www.covid19wbec.org/
- CDC/EPA National Wastewater Surveillance

https://the-scientist.com
Questions