COVID-19 Wastewater-Based Epidemiology

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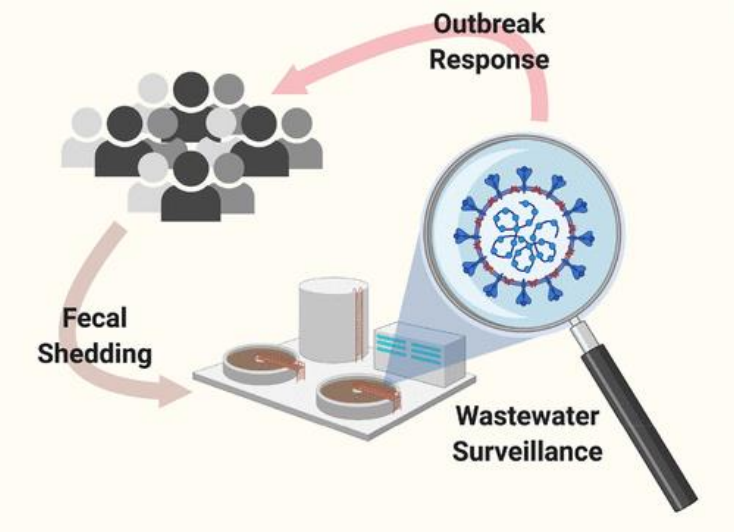


Source: Wastewater-Based Epidemiology: Global Collaborative to Maximize Contributions in the Fight Against COVID-19
Environmental Science & Technology

Overview

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

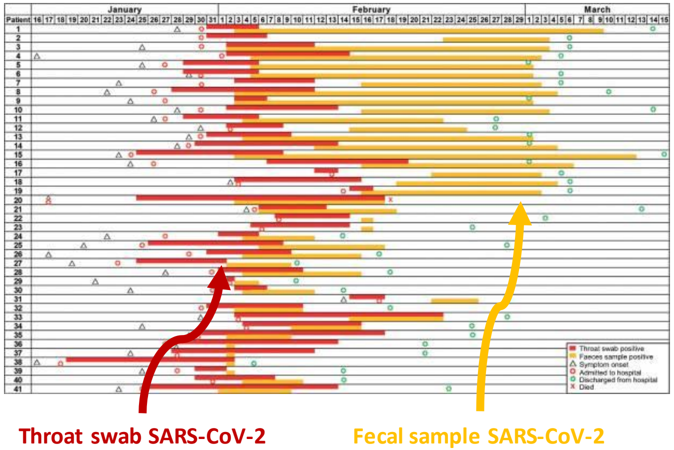
https://www.ft.com/

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



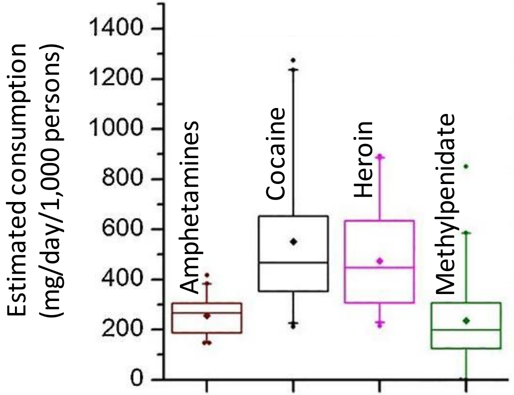
Infected patients shed SARS-CoV-2: patient stool samples remained positive for 27.9 days vs. 16.7 days for throat swabs (Wu et al.)

Rimoldi et al. **2020**. Preprint.
Wang, X.W. et al. **2005**. *J. Virological Methods.*
Wang, W. et al. **2020**. JAMA
Wölfel, R. et al. **2020**. *Nature.*
Wu et al. **2020**. *Lancet Gastroenterol Hepatol.*

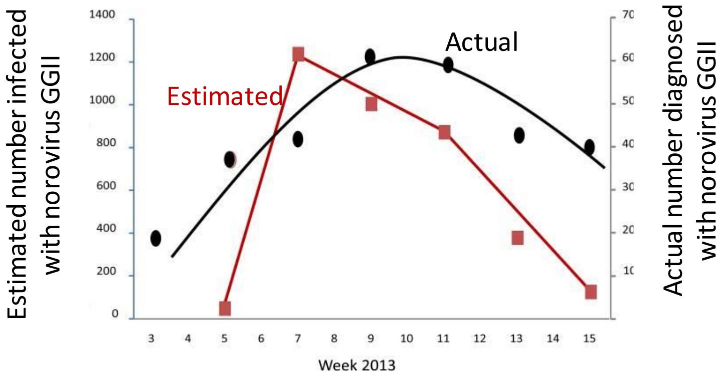
Wastewater-based epidemiology

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



Gushgari et al. **2018**. *J. Haz Mat.*



Hellmér et al. **2014**. *Appl. Environ.Microbiol.*

WBE & COVID-19

- SARS-CoV-2 can be measured in wastewater using qPCR lab method
- Wastewater correlates with and even precedes clinical disease incidence

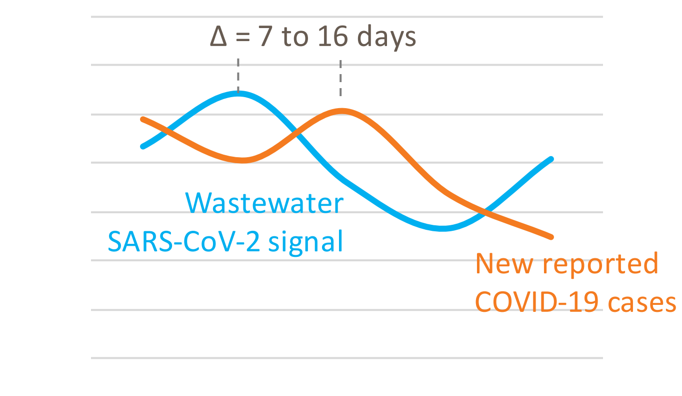
➔ Wastewater could potentially help fill the clinical testing gap

How sewer science could ease testing pressure and track COVID-19

Is It Safe to Come Out of Lockdown? Check the Sewer

How sewage could reveal true scale of coronavirus outbreak

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



Miyani *et al.* **2020**. Under peer review at *J Env Eng.*
Peccia *et al.* **2020**. Preprint from *MedRxiv.*
Randazzo et al. **2020**. *Water Research.*

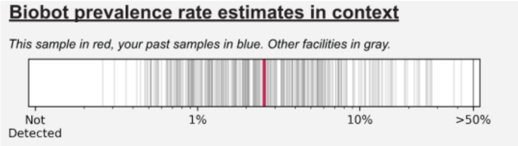
Area of active focus

- 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

10 YEARS Water Research AUSTRALIA

Canadian Water Network

THE Water Research FOUNDATION

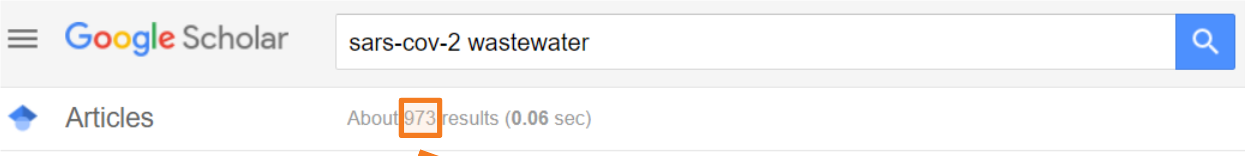


EPA

Finnish institute for health and welfare

National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

NATIONAL INSTITUTE OF HEALTH
ISLAMIC REPUBLIC OF PAKISTAN



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

Hart & Halden. **2020**. *Sci. Total Environ.*

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 Xagoraraki 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

https://biomeme.com/

https://www.wbur.org/hereandnow/2018/03/28/opioids-test-wastewater

Potential Facilities

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

SARS-CoV-2 wastewater surveillance studies*

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

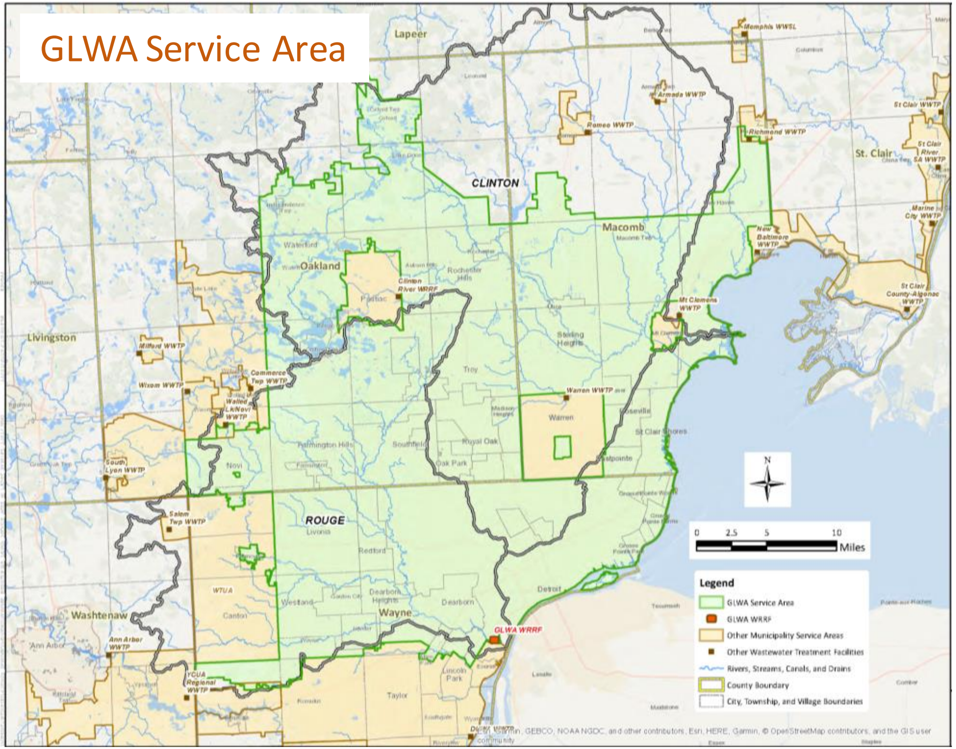
*Not intended to be a comprehensive list.

Analytical methods still in development

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

Correlation with COVID-19 prevalence/incidence

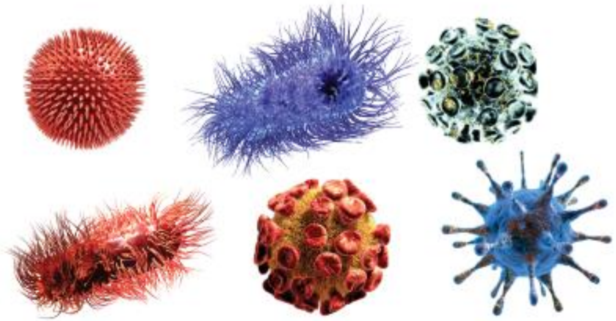
- Cumulative or new cases?
- Discrepancy between reported health data and estimates based on wastewater signal
  - 0.026% reported vs. 0.1%-5% estimated for Boston (Wu et al. 2020)
- Health data scale (ZIP Code, county, city) vs. sewershed scale



Take-away themes

WBE is here to stay

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



https://the-scientist.com

How to stay up-to-date

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

Questions