

Flush with Insight  
**The Future of Wastewater  
Surveillance**

July 31<sup>st</sup>, 2023

**Adam Gushgari**  
*Wastewater Surveillance Technical Expert*



Environment Testing

# U.S. Health & Healthcare Burdens

Employer Substance Abuse Burden:	<b>\$400 Billion</b>
2020 U.S. Opioid Abuse Burden:	<b>\$1.5 Trillion</b>
2021 U.S. Healthcare Spending:	<b>\$4.3 Trillion</b>
2020 to 2023 U.S. GDP Loss:	<b>\$14 Trillion</b>

# Data Collection Issues

## Current Methods of Data Collection May Not Adequately Empower Decisionmakers

- Data Collection is Costly and Burdensome
- Data May Not be Accurate
- Reduced Efficacy due to Delay in Data
- Cannot Rapidly Adjust and Adapt
- Impacted by an Individual's Actions & Biases

# Wastewater Surveillance

## Exposure

Pathogens  
Resistant genes  
Pharmaceuticals  
Lifestyle Choices



Population contributes to one WWTP

- **Pooled sample**

## MONITORING THE SPREAD OF DISEASE AND RESISTANCE AT THE FACILITY/COMMUNITY LEVEL



## Complementary to...

Sentinel and lab surveillance  
Hospital admission data  
Prescription data  
Human biomonitoring  
Mortality rates



## Sample collection

24-hour composite (time or flow proportional)



## Wastewater parameters needed

Biological oxygen demand (BOD)  
Chemical Oxygen Demand (COD)  
Temperature and pH  
flowrates

## Wastewater sample

### Chemical Markers

#### LC-MS/MS

Drugs of Abuse  
Pharmaceuticals + metabolites  
Biomarkers of inflammation and stress  
Biomarkers of Health

### Biological Markers

#### RT-qPCR

#### Next-Generation Sequencing

Pathogenic DNA/RNA  
Drug resistance genes  
Protein inflammation markers

Population size and flowrates accounted for, and correction factors applied

- **Daily mass loads calculated**

# History



# Coverage Today

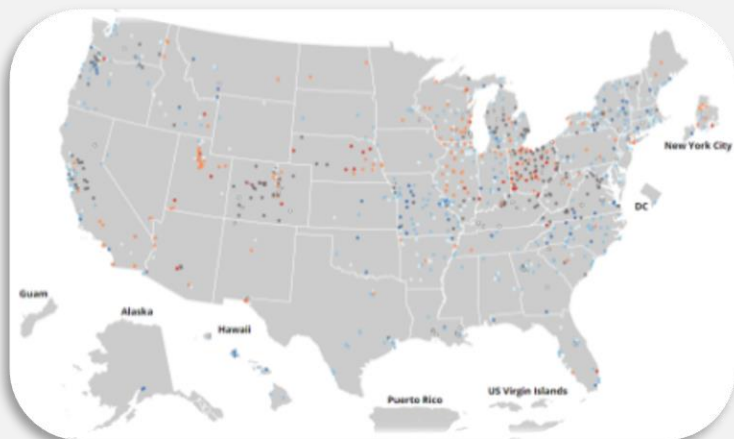


# Applications

- Disease Surveillance
  - SARS-CoV-2 <sup>1</sup>
  - Influenza A/B <sup>2</sup>
  - Norovirus <sup>3</sup>
  - Monkeypox <sup>4</sup>
  - RSV <sup>5</sup>
  - Poliovirus <sup>6</sup>
  - Hepatitis <sup>7</sup>
- Transportation Surveillance <sup>8</sup>
- Narcotics & Pharmaceutical Use <sup>9, 10, 11</sup>
- Antibiotic Resistance <sup>12, 13</sup>
- Hazard Exposure <sup>14, 15, 16</sup>
- Lifestyle Surveillance <sup>17, 18</sup>
- Agents of Terror Attacks <sup>19</sup>



# Current Initiatives



## CDC NWSS Program

- First U.S. National Wastewater Surveillance Program
- 500+ Sampling Sites
- 30% Population Coverage
- Future Expansion of Target Analytes



## Malawi Disease Surveillance

- Wastewater Surveillance Expansion into Developing Nations
- Improving Health Equity Distribution
- Collaboration Between Eurofins and University of Louisville



## Eurofins' Narcotic Surveillance

- Real-Time Narcotics Tracking
- Developed Specifically for U.S. Substance Abuse Crisis

**Fentanyl**  
**Heroin**  
**Oxycodone**  
**Hydrocodone**  
**Codeine**

**Morphine**  
**Cocaine**  
**Methamphetamine**  
**Xylazine**



# Current & Future Health Crises

Each year, **900,000 Americans die** prematurely from the five leading causes of death<sup>20</sup>


Preliminary data suggests **109,000 drug overdose deaths** in 2022 in the United States<sup>21</sup>


The COVID-19 pandemic resulted in **107,433,835 COVID-19 cases** and **1,169,139 deaths** in the United States<sup>22</sup>

There is a **27.5% chance** a pandemic as deadly as COVID-19 could occur in the next **10 years**<sup>23</sup>


# Future of Wastewater Surveillance

 Target Analytes

 Spatial Resolution

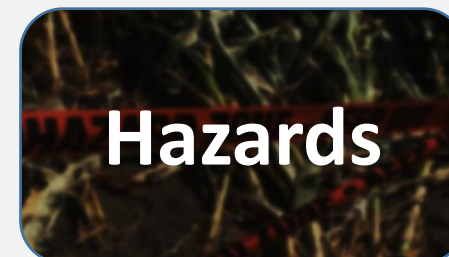
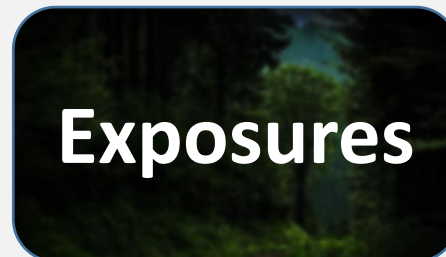
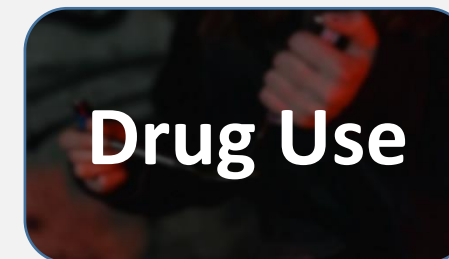
 Real-Time Sensors

 Analysis & AI/ML


 Health Equity

## The Amount of Latent Health Information Contained in Wastewater is


# Limitless





# Future of Wastewater Surveillance

 Target Analytes

 Spatial Resolution

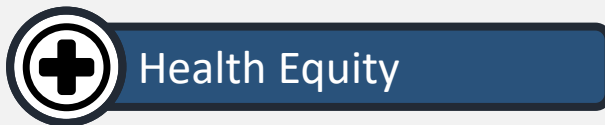
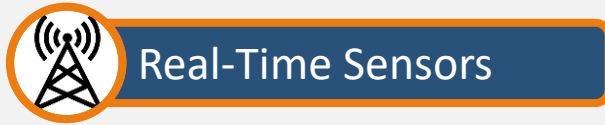
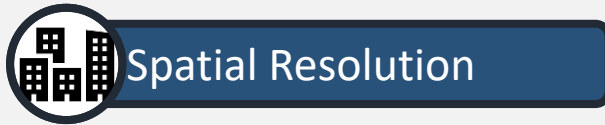
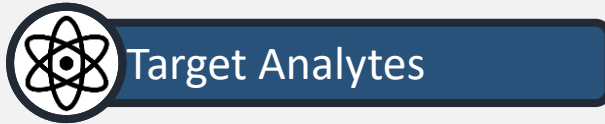
 Real-Time Sensors

 Analysis & AI/ML

 Health Equity



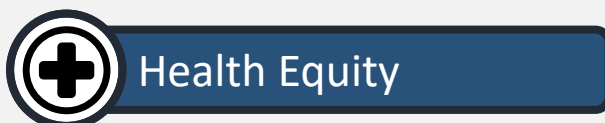
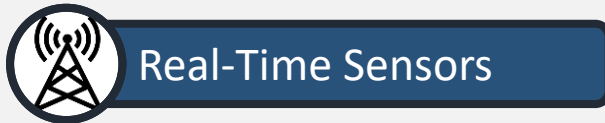
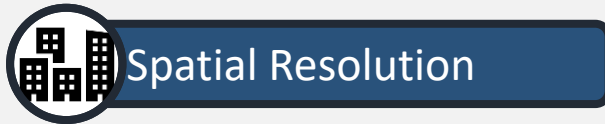
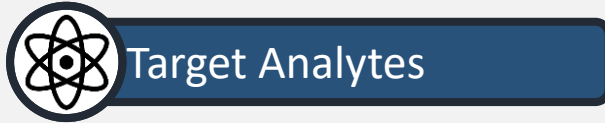
# Future of Wastewater Surveillance



## *In Situ* Wastewater Sensors will Enable True Real-Time Monitoring

- Feasible through Microfluidics Technologies
- Internet of Things (IoT) Integration
- Hurdles
  - Complex Environmental Matrix
  - High Sensitivity Must be Achieved
  - Variable Wastewater Flow


# Future of Wastewater Surveillance





## Integration of Artificial Intelligence and Machine Learning will **Revolutionize** Wastewater Surveillance

- Large Dataset Analysis
- Cross-Dataset Analysis
- Predictive/Anticipatory Modeling
- Digital Twin Technologies
- Aligns with Current Municipal AI Integration


# Future of Wastewater Surveillance

 Target Analytes

 Spatial Resolution

 Real-Time Sensors

 Analysis & AI/ML

 Health Equity

## A Regional Disease Outbreak is a **Global Health Concern**

## Developing Nations Have Been Largely Overlooked



### Malawi Wastewater Surveillance Initiative

# 30

**Number of U.S. Citizens Who Died from Preventable Causes  
During This Presentation**



Adam Gushgari, PhD, PE  
*Adam.Gushgari@et.eurofinsus.com*  
+1 (480) 490-3017

THANK YOU



Environment Testing



# References

1. Hewitt, Joanne, et al. "Sensitivity of wastewater-based epidemiology for detection of SARS-CoV-2 RNA in a low prevalence setting." *Water research* 211 (2022): 118032.
2. Wolfe, Marlene K., et al. "Wastewater-based detection of an influenza outbreak." *medRxiv* (2022).
3. Guo, Ying, et al. "Back-estimation of norovirus infections through wastewater-based epidemiology: A systematic review and parameter sensitivity." *Water Research* (2022): 118610.
4. Wolfe, Marlene K., et al. "Detection of monkeypox viral DNA in a routine wastewater monitoring program." *medRxiv* (2022).
5. Hughes, Bridgette, et al. "Respiratory syncytial virus (RSV) RNA in wastewater settled solids reflects RSV clinical positivity rates." *Environmental Science & Technology Letters* 9.2 (2022): 173-178.
6. Falman, Jill C., et al. "Evaluation of secondary concentration methods for poliovirus detection in wastewater." *Food and environmental virology* 11.1 (2019): 20-31.
7. Hou, Chenzhi, et al. "Estimating the prevalence of hepatitis B by wastewater-based epidemiology in 19 cities in China." *Science of The Total Environment* 740 (2020): 139696.
8. Ahmed, Warish, et al. "Wastewater surveillance demonstrates high predictive value for COVID-19 infection on board repatriation flights to Australia." *Environment International* 158 (2022): 106938.
9. Gushgari, Adam J., et al. "Tracking narcotics consumption at a Southwestern US university campus by wastewater-based epidemiology." *Journal of hazardous materials* 359 (2018): 437-444.
10. Gushgari, Adam J., et al. "Long-term tracking of opioid consumption in two United States cities using wastewater-based epidemiology approach." *Water research* 161 (2019): 171-180.
11. Boogaerts, Tim, et al. "Current and future perspectives for wastewater-based epidemiology as a monitoring tool for pharmaceutical use." *Science of the Total Environment* 789 (2021): 148047.
12. Riquelme, M. V., et al. "Wastewater Based Epidemiology Enabled Surveillance of Antibiotic Resistance." *medRxiv* (2021).
13. Mtetwa, Hlengiwe N., et al. "Wastewater-based surveillance of antibiotic resistance genes associated with tuberculosis treatment regimen in KwaZulu natal, South Africa." *Antibiotics* 10.11 (2021): 1362.
14. Rousis, Nikolaos I., et al. "Wastewater-based epidemiology to assess pan-European pesticide exposure." *Water research* 121 (2017): 270-279.
15. Gracia-Lor, Emma, et al. "Wastewater-based epidemiology for tracking human exposure to mycotoxins." *Journal of hazardous materials* 382 (2020): 121108.
16. Wang, Hao, et al. "Human exposure of bisphenol A and its analogues: understandings from human urinary excretion data and wastewater-based epidemiology." *Environmental Science and Pollution Research* 27.3 (2020): 3247-3256.
17. Choi, Phil M., et al. "Social, demographic, and economic correlates of food and chemical consumption measured by wastewater-based epidemiology." *Proceedings of the National Academy of Sciences* 116.43 (2019): 21864-21873.
18. Driver, Erin M., et al. "Assessing population-level stress through glucocorticoid hormone monitoring in wastewater." *Science of the Total Environment* 838 (2022): 155961.
19. LaJoie, A. Scott, et al. "Survey of nationwide public perceptions regarding acceptance of wastewater used for community health monitoring in the United States." *medRxiv* (2022).
20. <https://www.cdc.gov/media/releases/2014/p0501-preventable-deaths.html>
21. CDC Provisional Drug Overdose Death Counts (<https://www.cdc.gov/nchs/nvss/vsrr/drug-overdose-data.htm>)
22. <https://www.worldometers.info/coronavirus/country/us/>
23. <https://www.bloomberg.com/news/articles/2023-04-14/another-covid-like-pandemic-could-hit-the-world-within-10-years>