NEW YORK STATE
WATER RESOURCES INSTITUTE

Short Communication

Staying Ahead of the Curve: Wastewater Surveillance for Monitoring COVID-19 Outbreaks in New York State

by **Kristen Hychka[1], Rassil Sayess[1], Brian Rahm[1], Meredith Perreault[2], and Khris Dodson[2]**

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[1]NYS Water Resources Institute
B60 Riley-Robb Hall
Cornell University
Ithaca, NY 14853-5701
Tel: (607) 254-7163
Fax: (607) 255-4449
http://wri.cals.cornell.edu
Email: nyswri@cornell.edu

[2]Syracuse University
Environmental Finance Center
727 E. Washington Street, Syracuse, NY 13210

KEY DEFINITIONS:

SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus 2 (referred to here as "the virus")

COVID-19: coronavirus disease 2019 caused by SARS-CoV-2

Transmission: passing of a pathogen causing a communicable disease from an infected host individual or group to another individual or group

Infection: likely transmission of a pathogen to people and other organisms through the environment

Wastewater Treatment: collection and treatment of sewage through chemical, physical, and biological processes to remove biological and chemical pollutants before discharging effluent [7]

Wastewater Surveillance: monitoring the composition of community wastewater typically for public health purposes

SUMMARY

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), the virus causing coronavirus disease 2019 (COVID-19) [1], is highly infective, oftentimes is transmitted before symptoms appear, and has severe outcomes that overwhelm medical resources in many places. As a result, it has caused crippling socio-economic impacts that are rippling throughout the nation and across the world. During the unfolding of this pandemic, both developed and developing countries struggled with detection of cases due to the practical limitations of medical screening. One method for community level monitoring of the virus is wastewater surveillance – a powerful and relatively inexpensive informational tool that can provide data on how the virus is circulating within a community.

Surveillance of SARS-CoV-2 in wastewater has the potential to identify a possible outbreak one to two weeks before people with infections start exhibiting symptoms, allowing communities to initiate containment measures more virus [2, 3, 4]. The benefits of early warning of outbreaks are substantial. Recent studies show that implementing control measures—such as social distancing, travel restrictions, and quarantines or lockdowns—just one to two weeks earlier can reduce the number of cases and deaths by more than 50% [5, 6] .

WASTEWATER SURVEILLANCE

In NYS, greater than 75% of the population are served by wastewater treatment facilities [8]. Wastewater treatment involves collecting sewage and, in some cases, stormwater from homes and other buildings, transporting it to a treatment plant via pipe, and cleaning the water through a series of physical, biological, and chemical processes until it can be safely discharged back into the environment.
Wastewater surveillance—or monitoring the composition of community wastewater—has been effectively used before for public health purposes. Outbreaks of diseases such as polio and hepatitis A, and levels of community drug use, including opioids, cocaine, alcohol, and caffeine, have been tracked using wastewater surveillance (e.g. [9, 10, 11, 12, 13]).
Community-scale infection rates can be estimated by detecting and counting fragments of genetic material from SARS-CoV-2 in untreated wastewater. This is possible because (1) people infected with COVID-19 shed virus in their stools and (2) genetic material

can be detected—even at very low levels—in untreated wastewater (see Sayess et al. 2020[14] for a review of this research).Wastewater surveillance coupled with targeted clinical data and contact tracing could provide critical monitoring of SARS-CoV-2 transmission within a community including the beginning, tapering, or reemergence of an outbreak [15, 16]. This information can inform the extent and timing of targeted control measures ranging in scope from increased outreach with respect to social distancing all the way to more drastic actions such as such as school closures and quarantines.

COVID-19 TRANSMISSION PATHWAY

The virus gets into wastewater through the feces and urine of infected people (Figure 1). Typically, the virus is transmitted from one COVID-19 patient to another individual or group of individuals through the nose, eyes, or mouth, causing an infection [17]. The virus spreads through the body, often occurring heavily in the lungs. Consequently, the virus is shed into the digestive system. There, the container around the virus (capsid) often bursts, releasing genetic (RNA) fragments which mix with feces and urine. These RNA fragments will not cause an infection but can be detected using biomolecular techniques. As of the date of this writing, there have been two peer-reviewed studies that detected live SARS-CoV-2 virus in the stool samples of COVID-19 patients [18, 19]. While this suggests the possibility of fecal-oral transmission, there are no reports of infection through the fecal-oral route to date.

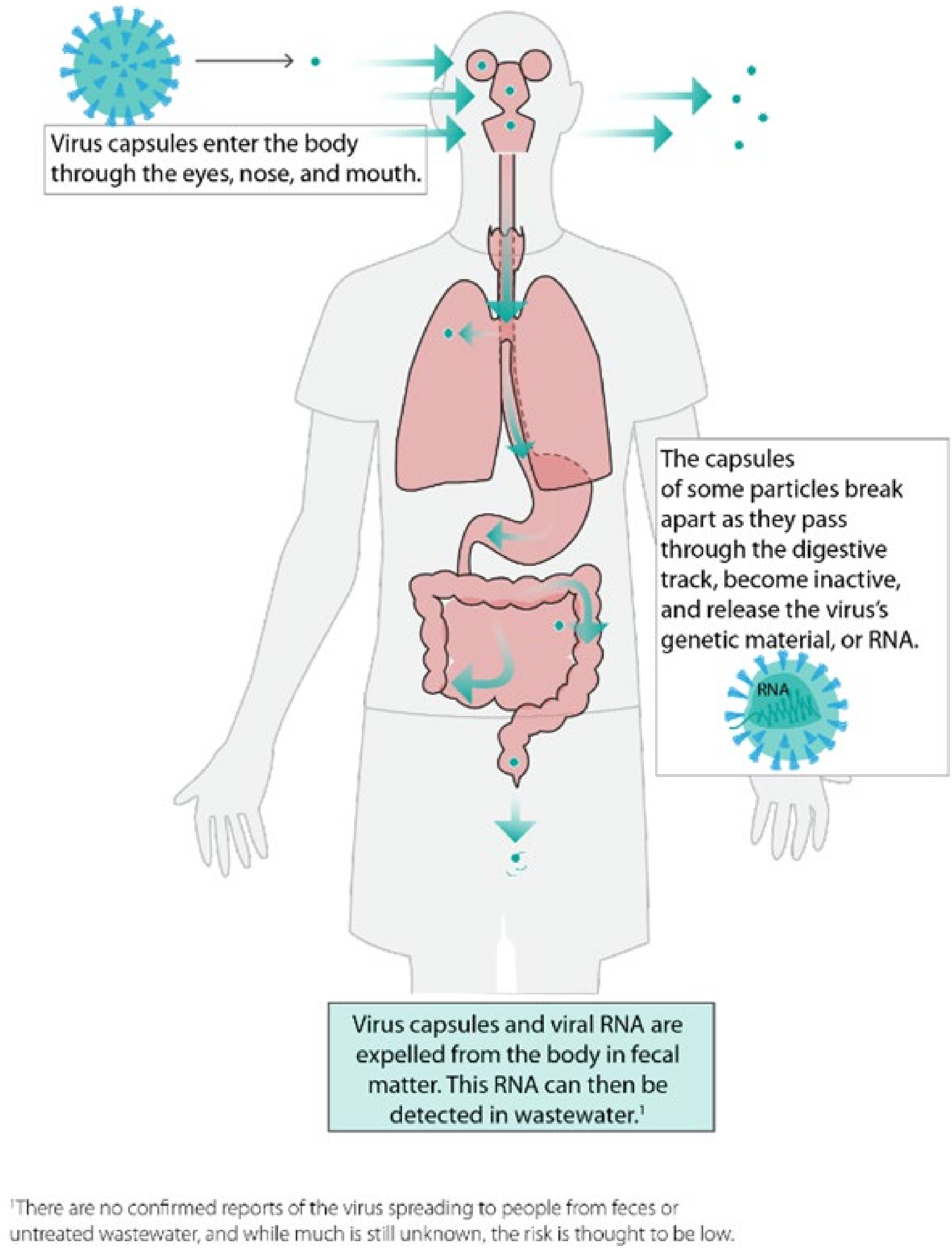

Figure 1: The COVID-19 transmission pathway.

HOW WASTEWATER SURVEILLANCE WORKS

The monitoring process begins with taking raw sewage samples at a wastewater treatment plant. The sample is a composite of all of the sewage from all the toilets that feed into the pipe where the sample is taken (Figure 2). Genetic material in the sample is then isolated and identified using biomolecular analysis (quantitative reverse transcription-polymerase chain reaction (RT-qPCR)). Viral concentrations in the wastewater are communicated to local health authorities and other decision makers to inform further testing and enaction of protective measures. To monitor trends or changes in the concentrations of the viral material in wastewater through time, this process is repeated on a regular basis.

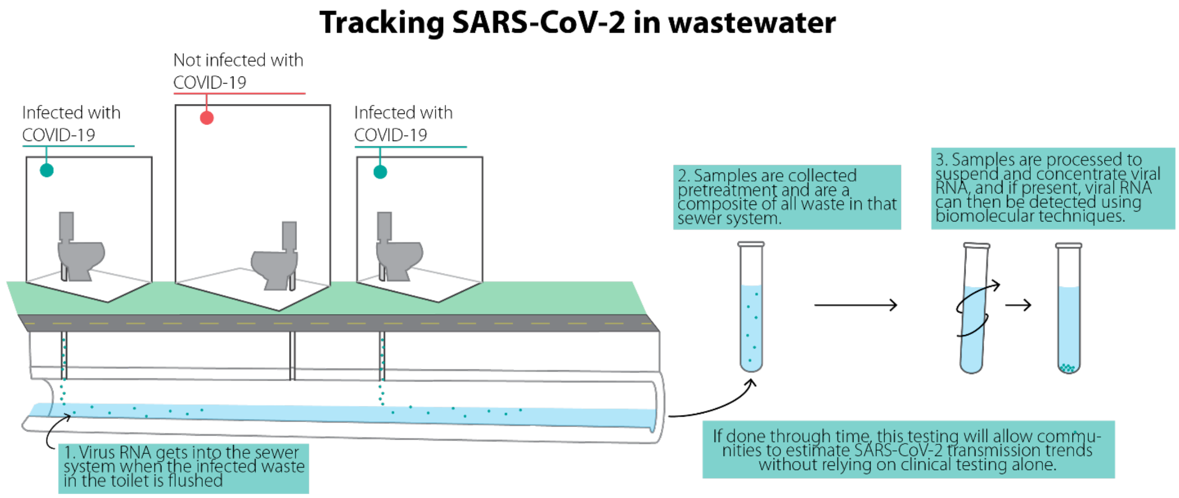

Figure 2: Sampling for SARS-CoV-2, the virus causing coronavirus disease 2019 (COVID-19), in the wastewater stream.

WASTEWATER SURVEILLANCE IMPACT

Monitoring wastewater at a building (large apartment complex or dormitory), district, or municipal scale could determine if there is spread within a community or particular facility and inform public health guidelines, because currently it:

Can	**Cannot**
be done cheaper and faster than comprehensive clinical screening [20, 16]	determine exactly who might be infected—samples are a composite of all facilities served by the pipe where it is collected
predict an outbreak about a week in advance of incidental contact testing [17, 5]	conclusively determine if an area is COVID-19 free
account for those who have not been tested and have mild or no symptoms [2, 16]	be used to monitor communities relying on onsite wastewater treatment systems such as septic systems
differentiate the beginning, tapering, or reemergence of an outbreak [2, 15]	
estimate the probability that an area may be COVID-19 free	

Scientists and public health officials are working to understand the exact relationship between detection rates in wastewater and the incidence of actual cases in the community. Wastewater RNA trends should always be looked at in conjunction with other coronavirus indicators such as test positivity, incident cases, hospitalizations, and deaths. The fundamental approach to wastewater surveillance of COVID-19 is built on a history of proven science, though how to apply this data in the rapidly changing landscape of COVID-19 will continue to evolve.

DEVELOPING A STATEWIDE WASTEWATER SURVEILLANCE SYSTEM

Researchers around the world, including teams in NYS, are working to develop the science behind wastewater surveillance of SARS-CoV-2. Establishing a functioning platform for surveillance for wastewater systems throughout NYS will rely on:

- a network of private and public researchers and practitioners operating from the state to local scales
- coordination and commitment of local practitioners engaged in sampling and application of the data, and
- continued research in establishing consistent and reliable sampling and testing protocols and evaluating the relationship between wastewater concentrations and population-level occurrence of COVID-19.

Sampling expertise exists throughout the state at the county level. And implementing a statewide surveillance system is relatively inexpensive when weighed against the potential costs of making public health decisions without this information.

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CONCLUSION

Wastewater surveillance can provide a relatively low-cost method for monitoring SARS-CoV-2 that accounts for people, including those who are pre- or asymptomatic, and can track the beginning, tapering, and reemergence of an outbreak. Without a viable vaccine, high herd immunity—when enough people become immune to a disease to make its spread unlikely, and effective treatment options for COVID-19, we need to make targeted and often very costly decisions about managing our communities.

Surveillance of SARS-CoV-2 in wastewater has the potential to identify a possible outbreak one to two weeks before people with infections start exhibiting symptoms, allowing communities to initiate control measures that can reduce the number of cases and deaths from COVID-19. Wastewater surveillance coupled with targeted clinical data and contact tracing can provide timely data to inform safe and effective guidance that can curb the spread and lessen the impacts of COVID-19 in NY State.

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