Using Wastewater Data to Communicate About Infectious Disease Dynamics in Communities

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There has been tremendous interest in monitoring wastewater for specific pathogens to support infectious disease surveillance for COVID-19 and other diseases in the United States and around the globe. Yet, for many audiences, the concept of wastewater surveillance is new, and the terminology is likely to be unfamiliar. This document describes how to communicate about wastewater-based surveillance to a variety of audiences and includes information on types of messages, data visualization, and modes of communication. It also provides guidance on explaining how the information from wastewater surveillance can support responses to infectious disease outbreaks at local to global levels. Evidence from multiple sources indicates that including wastewater data in public health messages about the COVID-19 pandemic is associated with greater acceptance by the public (Keshaviah et al. 2022; Centers for Disease Control and Prevention 2022). This document will use wastewater-based surveillance for COVID-19 as an example, but this guidance can also be applied to other infectious diseases.

How to determine your audience

Many stakeholders are interested in viewing and understanding wastewater data, just as a variety of stakeholders are interested in viewing case numbers during an outbreak. These stakeholders include government and public health leaders, health care providers, school administrators, and community members. Anyone who has benefited from viewing case information can also benefit from viewing wastewater surveillance data, but it is important that messages about wastewater data are tailored to each audience. The following section lists some key stakeholders.

Potential audiences for wastewater surveillance data

- Elected officials
- State and local public health authorities
- Health care providers and administrators
- Wastewater service providers
- School boards and administrators
- Institution leaders (corrections facilities, universities, and elder care facilities)
- General public (including special groups such as parents, community-based organizations, senior citizens, immunocompromised individuals, and other vulnerable populations)
- Media organizations

Effective communications outreach to lower-income communities is critical because these populations might be at greater risk of infection as a result of their employment (for example, frontline workers in essential industries who must physically be present in their workplace, who might need to interact with many people, or who might work in high-density settings). These same communities might also have limited access to vaccines, diagnostic testing, and health care.

Types of messages, message content, and functions

Communicating about wastewater surveillance might involve several types of messages with different functions, including the following:

1. **Informational messages.** Informational messages, using nontechnical language, explain what wastewater surveillance is, how it is implemented (through collection of wastewater samples and laboratory analyses), who is involved, and what the results can tell us. It is important to be aware of sensitive terms and avoid their use for some audiences. For example, for the general public, the term "surveillance" can have negative associations with invasion of privacy and spying. However, for a public health audience, the term "surveillance" is commonly used to describe tracking infectious diseases, and it implies data collection responsibilities and using the data for public health responses. This is an example of an informational message designed for the general public: *"Wastewater monitoring involves collecting samples of sewage and testing them for genetic markers of the SARS-CoV-2 virus to understand if COVID-19 cases are rising or*

falling in a community." Messages might be more accessible if they include photos, or if they are disseminated in video form (see the Resources section for two examples). Also, having trusted local institutions deliver messages can lead to greater receptivity in the community.

Informational messages should also provide guidance about how to interpret the wastewater results. This guidance should explain how to understand the results in context of reported numbers of COVID cases and other relevant information about the COVID-19 pandemic in the geographic area covered by the surveillance. It is important to explain why wastewater results might differ from anecdotal evidence about COVID-19 in the community or trends in the number of reported cases. Informational messages should clarify that (a) at-home testing leads to underreporting of clinical surveillance data, (b) SARS-CoV-2 ribonucleic acid (RNA) concentrations in wastewater might rise before there is a corresponding increase in COVID-19 cases, and (c) people infected with SARS-CoV-2 can excrete the virus in their stools before they develop symptoms and get tested. Because the results from community samples of sewage are often available before diagnostic test results are compiled and reported, if they are reported at all, informational messages might need to clarify how wastewater data can provide an early warning of changes in the COVID-19 status of a community.

2/ **Correcting misinformation.** Correcting misinformation about wastewater surveillance is also a critical aspect of communication. Members of the public might be concerned about the risks of becoming infected with SARS-CoV-2 from exposure to wastewater; confused about wastewater versus drinking water; confused about the potential to identify individual COVID-19 cases from wastewater data, especially if the wastewater samples are from a small population; or concerned about testing wastewater for genetic markers that might have sensitive information. There is also potential for wastewater surveillance results to be used to spotlight and shame high-risk communities. It is important to emphasize that these wastewater data are used to understand the levels of disease in a community, and do not provide information about infection risk from wastewater. You can address these concerns through a frequently asked questions document or section of a website (such as the example provided at the end of this brief) and by discussing concerns in community meetings. Acknowledging data limitations and uncertainty (in wastewater and case count data) is a critical element of honest communication with the public as our understanding of the virus and pandemic is evolving rapidly.

3/ **Recognizing community.** Wastewater surveillance programs require cooperation among multiple sectors of government, wastewater utilities, health authorities, and the community. Accordingly, communications about wastewater surveillance should acknowledge the contributions of the various partners involved, as this creates a sense of shared community responsibility for the results and builds greater trust among the public. Highlighting stories from or about local communities that demonstrate how the surveillance results are providing more accurate information about trends in COVID-19 cases can encourage greater trust and interest in the results.

4/ **Call to action.** The overall goal of wastewater surveillance is to provide information on population-level disease dynamics to the public, community leaders, and government and health authorities at multiple levels and in various sectors to guide decisions about how to respond to the pandemic. This information can also be useful for health care providers, schools, local businesses, workplaces, corrections facilities, and individuals to make informed decisions about potential activities and risks. Communication about wastewater surveillance results can be linked to messages whose main purpose is to prompt specific behaviors or actions, such as encouraging social distancing, effective hygiene practices, and other harm-reducing behaviors. For example, a message to the public might state: "*SARS-CoV-2 spikes in wastewater this week are a warning sign that COVID-19 cases in your community are rising. Consider wearing a mask when you are in crowded indoor public spaces.*" A message to local health care providers might state: "*SARS-CoV-2 spikes in wastewater this week are a warning sign that COVID-19 cases in your community are rising. Be prepared for additional demands on the health care system in your area in the coming one to two weeks.*"

Key principles for clear data visualization and communication

- Try to communicate results in as **simple** and relevant a manner as possible. Tailor communications for various stakeholders, and start with a summary before communicating more complex, detailed information. Information that is too detailed or technical might prevent users from effectively engaging.
- Use **color coding** to communicate results in a simple manner. People often associate red with negative outcomes, so using it to indicate the presence or severity of a pathogen can be intuitive. However, about 4% of the U.S. population has some degree of color blindness. Make sure to avoid colors that can be difficult to differentiate, such as red versus green. Color scales can be an effective alternative. In these scales, darker shades indicate higher concentration or presence of the pathogen or disease, and lighter shades indicate lower concentration or presence.
- Wastewater surveillance information can be more effective when **combined with other information to provide context**—such as number of reported COVID-19 cases in the geographic area, diagnostic test positivity rate, number of COVID-related hospitalizations, percentage of hospital beds occupied, school or workplace absenteeism, and so on. With this approach, wastewater data can supplement information from other health indicators. These other sources might also help users disentangle day-to-day variation from more meaningful trends (for more information, see Anderson et al. 2022).
- Communicate clearly **which geographic areas are represented** by wastewater monitoring. People might not know the name or location of sampling sites that service their community. They also might not understand the different geographic scales represented by the results, and they are more likely to be interested in wastewater results from areas closest to them. If possible, tailor wastewater messages geographically to the populations represented by the results from specific sampling sites.
- **Interactivity** can make the information more relevant and improve retention. For example, enable users to click on a map to see data for various communities in their region, such as this map with wastewater results for Houston. Consider putting more detailed information for deeper understanding in tool tips and drop-down menus.

Sharing key messages and visualizations

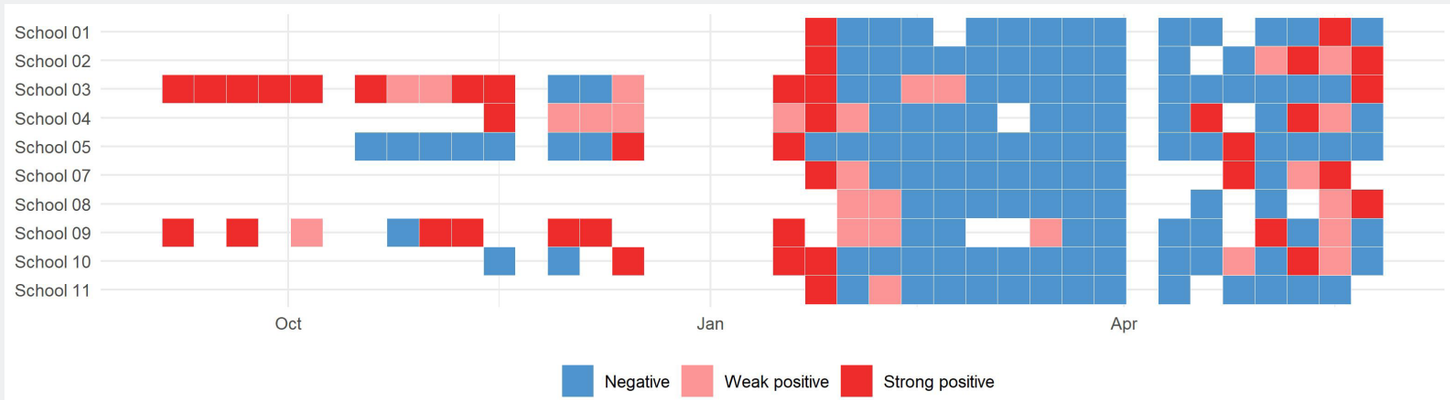
The main uses of wastewater monitoring data are to provide information on the presence of COVID-19 cases (or other target diseases) or new outbreaks in a community, and to demonstrate changes in infection levels over time. Depending on how wastewater samples are collected and analyzed, the data might also be used to compare infection levels across communities or neighborhoods. To achieve this goal, there are many ways to visualize and share data with the public.

1/ **Assessing the presence of a health threat.** To assess if an infectious disease or new variant of a pathogen is present in a community, it can be helpful to visualize the presence or absence (detection or nondetection) of the targets associated with this disease (usually genetic markers of a specific pathogen) in wastewater over time in various geographic regions (example in Figure 1).

2/ **Assessing changes in the prevalence of a health threat over time.** Research has shown that changes in wastewater concentrations of pathogen genetic markers (such as SARS-CoV-2 RNA) over time align well with changes in the number of cases reported in the geographic areas covered by wastewater monitoring (example in Figure 2). Note that in order to compare pathogen measurements over time, it might be necessary to adjust the concentrations of pathogen markers to account for sample-to-sample differences in the wastewater flow rate, fecal content of the wastewater, population size represented by the wastewater sample, or assay sensitivity.

3/ **Assessing the overall magnitude of a health threat in a community.** Generally, the absolute concentration of a pathogen marker in wastewater cannot be used to directly estimate the number of cases in the community. However, observing differences in concentrations and comparing concentrations with those recorded during previous surges or declines in cases can provide context (example in Figure 2). Concentrations of a pathogen marker are especially helpful when used in conjunction with other information, such as case reports or the percentage of diagnostic tests that are positive.

Figure 1. Tile graph of SARS-CoV-2 detection in wastewater samples from schools over time



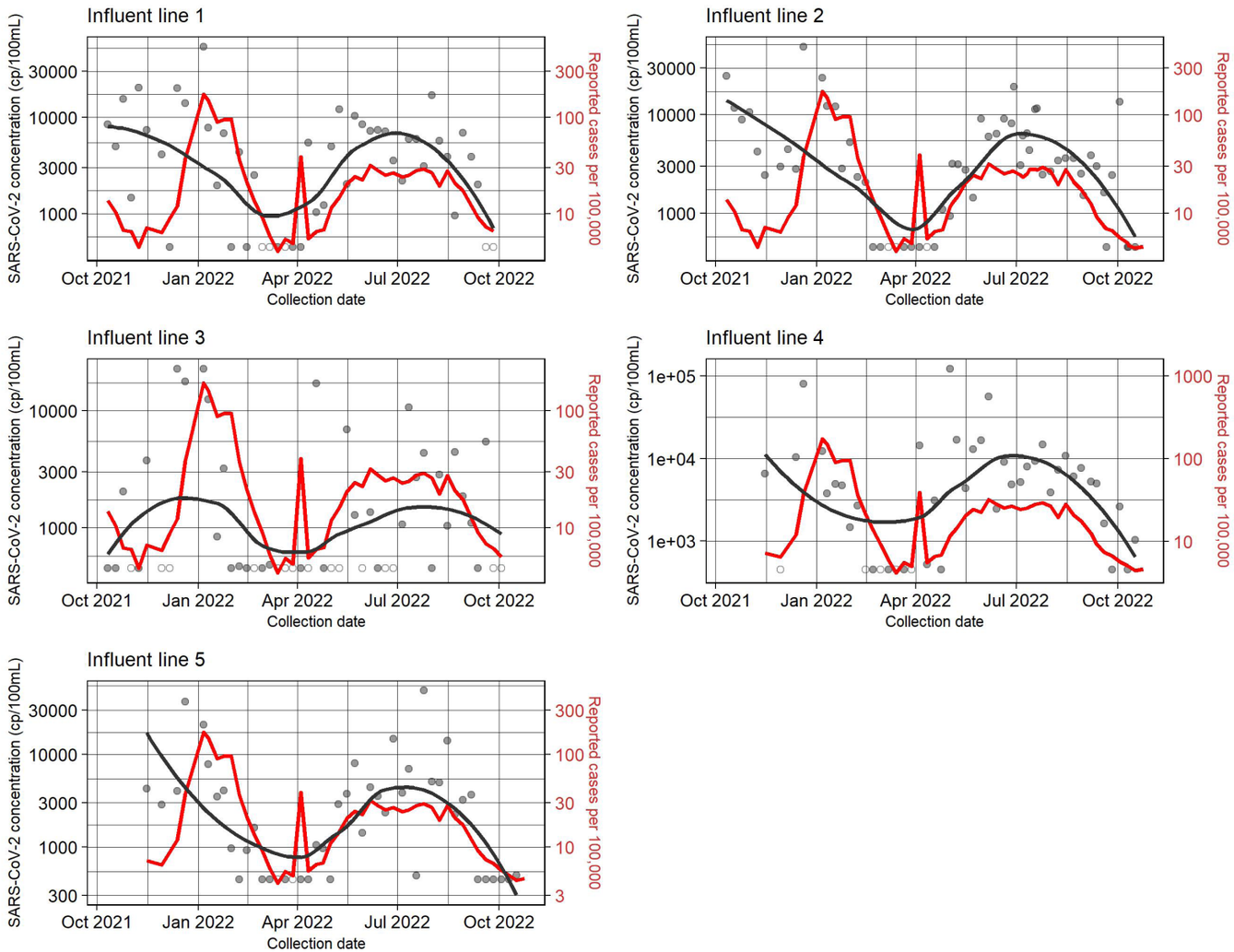
Notes: Each block represents the results of a wastewater sample collected at a school in a large metropolitan area. Samples were collected weekly for an entire school year, starting with 2 schools and gradually increasing to 11 schools per week. The color of the block indicates the strength of the pathogen detection signal (that is, SARS-CoV-2 RNA detection by polymerase chain reaction [PCR] from the wastewater sample). White blocks indicate that no sample was collected during that week.

4/ **Assessing the geographic distribution of a health threat in a community.** Mapping wastewater metrics across various geographic locations can help users see spatial patterns in the data and understand how the data that is most relevant to their location compares with data from neighboring communities. One challenge most users face with these messages is understanding what data are most relevant for them. Maps that show which areas are covered by the wastewater monitoring are particularly useful for visualizing information at a snapshot in time. When wastewater data are collected at different scales, it might be useful to use polygons to represent the results from samples that monitor large areas and overlay points to represent data from specific neighborhoods or institutions within those areas (Figure 3).

Modes and frequency of communication

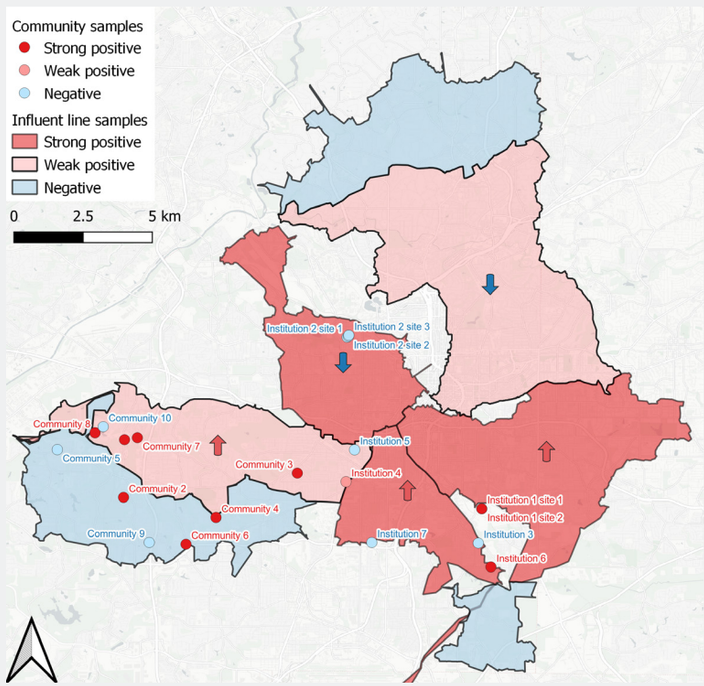
Because infectious disease case rates and wastewater pathogen concentrations can change rapidly, communications about wastewater surveillance need to provide real-time information in order to be useful for public health responses. For example, planning the allocation of health care resources based on wastewater surveillance data from the previous month is not likely to be relevant. Modes of communication that can be quickly updated to present the latest results, such as websites and dashboards, are well suited to this purpose. However, it is important to recognize that different audiences require different outreach strategies informed by what people have access to or feel comfortable with, and which sources they trust in their community. Taking time to understand information flows within a community can guide communication strategies and promote more effective outreach.

Figure 2. Reported COVID-19 prevalence at a county level (cases per 100,000 people) and SARS-CoV-2 concentrations (genome copies per 100 milliliters [mL]) in wastewater samples from influent lines at wastewater treatment facilities over time in one metropolitan area



Notes: The y-axis indicates estimated concentration of SARS-CoV-2 RNA (copies per 100 mL of wastewater). The x-axis indicates time. The gray points are measured concentrations of SARS-CoV-2 RNA in wastewater samples at specific time points. The black line represents the concentration estimates smoothed over time, and the red line indicates numbers of COVID-19 cases per 100,000 people reported to the county health authorities over time. Influent lines are large sewer pipes that collect wastewater from the sewerage system in a specific geographic area and transport it into the wastewater treatment facility. Comparing the SARS-CoV-2 concentrations trends over time among various influent lines enables the user to examine changes in COVID-19 cases in various geographic areas of the city. For example, from April to July 2022, there was a rise in the prevalence of COVID-19 cases reported by the county and a corresponding rise in the SARS-CoV-2 RNA concentration in wastewater samples in all five influent lines; the smallest increase in SARS-CoV-2 RNA concentration during this period was observed in samples from Influent Line 3—suggesting that there were fewer new COVID-19 cases in the geographic area served by this influent line.

Figure 3. Spatial differences in SARS-CoV-2 detection in influent line sewerage areas and arrows indicating change in virus detection signal from the previous week



Notes: Each polygon represents the sewerage area served by a specific influent line entering a wastewater treatment facility. The color of the polygon indicates the strength of the pathogen detection signal (that is, SARS-CoV-2 RNA detection by PCR) from a wastewater sample collected from the influent line, and the arrows indicate the change in the signal strength compared with wastewater samples from the same location during the previous week. The points represent the results from specific community wastewater samples collected at manholes or institutions (for example, schools). The color of the point indicates the strength of the pathogen detection signal (that is, SARS-CoV-2 RNA detection by PCR).

For example, analyzing social media tweets about COVID-19 in one city revealed that the public school system was a trusted source of information, as tweets from the school system had more engagement by the public than other community groups we identified.

We recommend working with local community-based organizations, faith-based groups, school systems, local city council members, and others who have the trust of communities that have historically been underserved to determine the types and modes of communication that are best suited for quickly and appropriately sharing wastewater surveillance information. Local news media is also an important partner. In the past two years, the news media at the national and local levels has played a critical role in explaining wastewater surveillance to the public and occasionally reporting the results of wastewater surveillance when a new SARS-CoV-2 variant or other pathogen (for example, mpox or poliovirus) was detected in local wastewater. Working closely with the news media can help ensure that wastewater data are used to encourage the public to take appropriate action (for example, vaccination) rather than instill panic.

Examples of public service announcements, social media toolkits, and websites with resources for COVID-19 communications are available in the resources section at the end of this document.

Periodic evaluation of communication strategies

The impact of a communications campaign might vary by the characteristics of the population and the status of the infectious disease pandemic. To guide the design and implementation of a communications strategy, it can be helpful to understand the key characteristics of the populations you want to reach and what public health communication tools have been effective for these populations in the past. To date, there is limited data on the effectiveness of communication campaigns specifically about wastewater surveillance for COVID-19 and other diseases. However, the following general principles and best practices can help you evaluate public health communication campaigns.

- Incorporate evaluations into the communication program at inception.

Modes of communication

In-person events (community gatherings, health fairs, parent–teacher association meetings, and faith groups)

Websites and dashboards

Email lists and direct reports to stakeholders

Electronic newsletters

Social media (Twitter, Instagram, TikTok, and so on)

Radio and television

Podcasts

Main communication points

Areas monitored by wastewater surveillance

Wastewater results at each location

Quick analysis of whether or how trends are changing

Recommended response – if appropriate

- Define the levels of influence you want to examine in your evaluation, such as the intrapersonal level, interpersonal level, and community level. These levels might encompass institutional factors, community factors, and public policy factors.
- Define the outcomes of interest (such as: knowledge, attitudes, risk perception, self-efficacy, and behavior change). Studies indicate that health communications tend to have a greater effect on knowledge and attitudes than on behaviors.
- Collect pre- and post-communication campaign data to measure changes in knowledge, attitudes, and practices related to the target infectious disease over time. Tools for data collection include interviews, focus groups, and surveys. However, given the dynamic nature of infectious disease epidemics (for example, COVID-19 and mpox), this approach might be confounded by other factors that change over time. A better approach might

be to compare changes in knowledge, attitudes, and practices related to the target infectious disease between two communities with similar demographic characteristics, where one community received the communication campaign and the other community did not. Finding an appropriate comparison community might be challenging because even communities with similar demographic characteristics might have sharply different experiences during a disease epidemic that affect their perspectives about the disease.

- Collect information on implementation success. Are the messages reaching target audiences? Are audiences understanding the messages? Do the messages trigger appropriate action?

In summary, wastewater monitoring for specific pathogen markers of disease is a low-cost, efficient, sensitive tool for infectious disease surveillance at the population level. Use of this powerful approach is rapidly expanding to more geographic regions and multiple disease targets. Effective communication about wastewater-based surveillance of infectious diseases is critical for the communities where this approach is being implemented. We provide the following recommendations for using wastewater data to communicate about infectious disease dynamics in communities:

- Know your target audiences
- Develop clear messages with language and data visualizations tailored to specific audiences
- Explain how wastewater data can be useful for various audiences
- Be transparent about areas of uncertainty and the strengths and limitations of wastewater data
- Use appropriate dissemination channels for each of your audiences
- Periodically evaluate whether the messages are reaching the target audiences and are having the intended effect on knowledge, attitudes, and actions (at a personal level or institutional level) related to the disease highlighted by the campaign

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Resources for further information

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Videos

- Dr. Amy Kirby: Sewage Surveillance for COVID
- Testing Wastewater for COVID-19: The Clearest Path to Understanding Community Infection

Useful websites

- COVID-19 Testing Communications Toolkit: A platform that has free downloadable images custom-made for COVID-related communications
- Canva: A website that helps users create professional designs for presentations, videos, and social media
- Public Service Announcements: National Association of Broadcasters website where users can download radio, TV, and podcast public service announcements and scripts that highlight how your community can help prevent the spread of COVID-19
- Centers for Disease Control and Prevention (CDC) Social Media Tools, Guidelines & Best Practices: CDC resources for reaching audiences on social media
- Ohio Coronavirus Wastewater Monitoring Network – COVID-19 Dashboard: Example of a website with COVID-19 wastewater surveillance data for Ohio, developed by the Ohio Department of Health, that includes dashboards, interactive maps, and general information on wastewater monitoring and how to interpret the results

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Frequently Asked Questions

Adapted from Healthy Davis Together handbook

FOR THE GENERAL PUBLIC

Question	Answer
1. Why test and monitor wastewater?	Wastewater testing is a way of sampling for circulating diseases in an entire community, anonymously, without behavior change, and regardless of access to the health care system. Thus, it is an inexpensive way to get information on population-wide infection trends over time. This means that wastewater data can indicate where COVID-19 cases might be on the rise. Locating spikes helps inform where additional resources, such as diagnostic testing, vaccination resources, and increased health care capacity, might be required.
2. What does wastewater monitoring detect—just SARS-CoV-2 or other pathogens also?	Wastewater is widely used for monitoring SARS-CoV-2, but health authorities can monitor a wide variety of other pathogens in wastewater to contribute to infectious disease surveillance. Researchers continue to develop tools and supporting evidence for interpretation of new targets. Testing is now also widely available for influenza, respiratory syncytial virus (RSV), and mpox. These tests typically work by isolating and identifying the genetic material of the pathogen, rather than isolating an infectious virus.
3. Can wastewater monitoring detect drug use in a home?	Wastewater monitoring is valuable because it can used to sample an entire community at the same time. Thus, wastewater monitoring should not be used for detection of biological or chemical targets in individuals or individual households. Some organizations might conduct testing for drugs and other chemicals, but this use is distinct from wastewater monitoring for pathogens such as SARS-CoV-2.
4. Will my neighborhood ever be quarantined because of SARS-CoV-2 detection in the wastewater?	Wastewater data should be used to supplement the information that public officials use to take public health actions within their jurisdiction. The commonly used or permissible public health actions in response to outbreaks differ across U.S. states and the world. Regardless of local laws regarding quarantines and lockdowns, we recommend that wastewater data alone should not be considered sufficient to enact quarantine measures.
5. Is my drinking water contaminated if the wastewater tests positive for SARS-CoV-2? Should I worry about my drinking water?	No. Wastewater and drinking water systems are entirely separate. Wastewater is tested to ascertain disease in the community precisely because it is contaminated with many bodily fluids that could contain pathogens, and therefore it is taken to a treatment plant so that it can be made safe to release to the environment. Drinking water is cleaned and distributed to a community using separate systems and resources. SARS-CoV-2 is not transmitted by drinking water and is not likely to be infectious even in wastewater. Furthermore, wastewater treatment processes inactivate SARS-CoV-2 and most other pathogens.
6. If the wastewater monitoring results in my neighborhood are negative, does that mean I can stop wearing a mask?	Wastewater monitoring can provide some information about the presence, magnitude, and trend of the target infectious disease cases in a general geographic area and can help inform personal decisions about activities. However, it is possible that there are cases below the detection limit (which varies based on the approach to monitoring) or people whose infections are not captured in the wastewater (for example, because they did not use the bathroom during the time when wastewater samples were collected, because they might not shed the pathogen into their stools even if infected, or because they might contribute to a wastewater treatment plant not currently being monitored).
7. Where can I get more information about the wastewater monitoring results in my area?	CONTEXT-SPECIFIC ANSWER

FOR THE PUBLIC HEALTH AUTHORITIES

Question	Answer
1. How can I use wastewater monitoring data? How would this information change what I am already doing?	How you use wastewater monitoring information depends in part on the locations and frequency of wastewater sample collection. If many locations in a community are sampled simultaneously, wastewater surveillance data can provide information on geographic hot spots of SARS-CoV-2 infection and other diseases, and health authorities can use this information to target diagnostic testing, health messaging, and vaccination campaigns to these areas. Because wastewater data can capture the infections of people who are asymptomatic and those who might not otherwise get tested, wastewater surveillance data can also provide early warning of a surge in COVID-19 cases that enables health authorities to ramp up capacity at health care facilities and prepare for increased health care needs. Finally, with increased use of at-home testing and declines in clinical surveillance, which create gaps in reported case count data, wastewater monitoring can provide additional unbiased, population-level information about COVID-19 and other disease trends in the community that can support public health decisions regarding disease response.
2. What about surveillance needs for other diseases?	Depending on the community, wastewater monitoring is in place for other pathogens, including influenza, respiratory syncytial virus (RSV), mpox virus (MPXV), and others. SARS-CoV-2 is still the most commonly monitored pathogen, but you can use the same samples and testing platforms to test for additional disease targets. Any pathogen that is regularly shed in secretions that travel down the drain (toilet, sink, shower, and so on) is a potential candidate for wastewater monitoring.
3. Are there any long-term benefits to wastewater surveillance?	Because effective wastewater surveillance requires close collaboration between health authorities and water/wastewater utilities, the working relationships established through wastewater monitoring can have secondary benefits. In addition, establishing wastewater surveillance systems can enhance outbreak preparedness, as seen in the rapid addition of mpox testing to many wastewater monitoring sites at the beginning of the 2022 outbreak in several locations around the world. This data can also provide long-term information on trends of seasonal diseases that improves seasonal predictive modeling to inform public health response.
4. Who will pay for wastewater surveillance in my community?	Many state health departments and public health labs have received funding from the Centers for Disease Control and Prevention to establish wastewater surveillance for COVID-19. Sustained funding from national, state, and municipal governments will be needed to institutionalize wastewater surveillance.