To find out where the covid pandemic is headed, look here: The sewer

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The first clues appear in sewer water. And those clues are piling up.

© Cheney Orr/Bloomberg To find out where the covid pandemic is headed, look here: The sewer

As the United States enters year three of the coronavirus pandemic, disease trackers are trying to stay one step ahead of the constantly evolving virus — by hunting for it in feces.

In Maine, hospitals are on alert for a potential surge of patients, tipped off by consistently rising levels of the coronavirus in wastewater. In Ohio, which has used sewage surveillance to identify new variants, authorities are tracking substantial increases at a dozen of the state's 71 monitoring sites, including south of Columbus. In Houston, steady increases have not been accompanied by a rise in hospitalizations, the first time in almost two years, suggesting that vaccinations and previous infection may be keeping people out of hospitals.

The secrets of the virus can be found in wastewater because most infected people shed tiny pieces of virus when they use the toilet. So regularly analyzing wastewater from sewage treatment plants allows scientists to measure when those levels are rising or falling — and what variants are present — about four to six days before people start testing positive.

Wastewater surveillance has long been used to contain polio outbreaks, and its potential for helping stanch the coronavirus was recognized at the start of the pandemic. Now, sewage monitoring has gained increasing importance as prevention measures — mask mandates and social distancing, for instance — vanish in much of the country at the same time that the highly transmissible omicron subvariant known as BA.2 fuels a rise in coronavirus cases in some regions, including the Northeast.
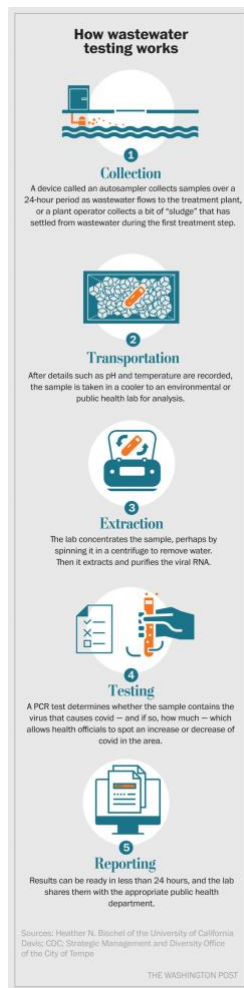
With official reporting of cases and testing data becoming less frequent and less reliable, especially as people test at home, officials need other ways to track the virus.

A reporting network that the Centers for Disease Control and Prevention set up in fall 2020 monitors wastewater from hundreds of sites covering about 100 million people. About two-thirds of the sites that regularly send data have reported sustained increases in virus levels in recent weeks.

In some communities, virus levels have doubled, but even with those increases, overall presence of the virus in water remains at a low level, said Amy Kirby, who heads the CDC system. Still, in some communities, Kirby said, "We've seen increases consistently over the past few weeks, and we're following those more closely."

That includes states in the Northeast, primarily Rhode Island and parts of Maine, Kirby said. But they're not the only ones showing increases — so are cities, colleges, companies and states that also monitor virus levels in sewer water outside of the CDC network.

"The only behavior that wastewater surveillance is dependent on is that you're using the bathroom in a toilet that's connected to a sewer system, right? And in 80 percent of households in the U.S., they are on sewer systems," Kirby said. "So that gives us great power to be able to understand what's going on."

How wastewater testing works

1 Collection
A device called an autosampler collects samples over a 24-hour period as wastewater flows to the treatment plant, or a plant operator collects a bit of "sludge" that has settled from wastewater during the first treatment step.

2 Transportation
After details such as pH and temperature are recorded, the sample is taken in a cooler to an environmental or public health lab for analysis.

3 Extraction
The lab concentrates the sample, perhaps by spinning it in a centrifuge to remove water. Then it extracts and purifies the viral RNA.

4 Testing
A PCR test determines whether the sample contains the virus that causes covid — and if so, how much — which allows health officials to spot an increase or decrease of covid in the area.

5 Reporting
Results can be ready in less than 24 hours, and the lab shares them with the appropriate public health department.

Sources: Heather N. Bischel of the University of California Davis; CDC; Strategic Management and Diversity Office of the City of Tempe

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It has many advantages. It is anonymous. It is efficient — instead of an individual test, a single wastewater sample tests a population that could represent millions of people. It can also be cost-effective: The average price for a single PCR-based coronavirus test at a U.S. hospital is about $140 vs. about $300 for a lab to analyze a wastewater sample representing a whole community.

Wastewater sampling detects virus from people who have no symptoms and may not even know they are infected, and does not depend on people seeking medical care or testing. Sampling can be done anywhere there's a public sewage system. (The virus's genetic material in the sewer water can't make you sick.)

Wastewater surveillance shows increase in coronavirus

Almost two-thirds of wastewater stations reporting to the Centers for Disease Control and Prevention have shown increases in coronavirus levels during the most recent 15 days and nearly half doubled in virus concentration. Both trends are at their highest since the peak of the winter omicron surge. About 500 to 600 stations are included in the daily update.

— More than doubled — Increased

65%

45%

60%

40

20

0

Jan.
2022

Feb.

March

April
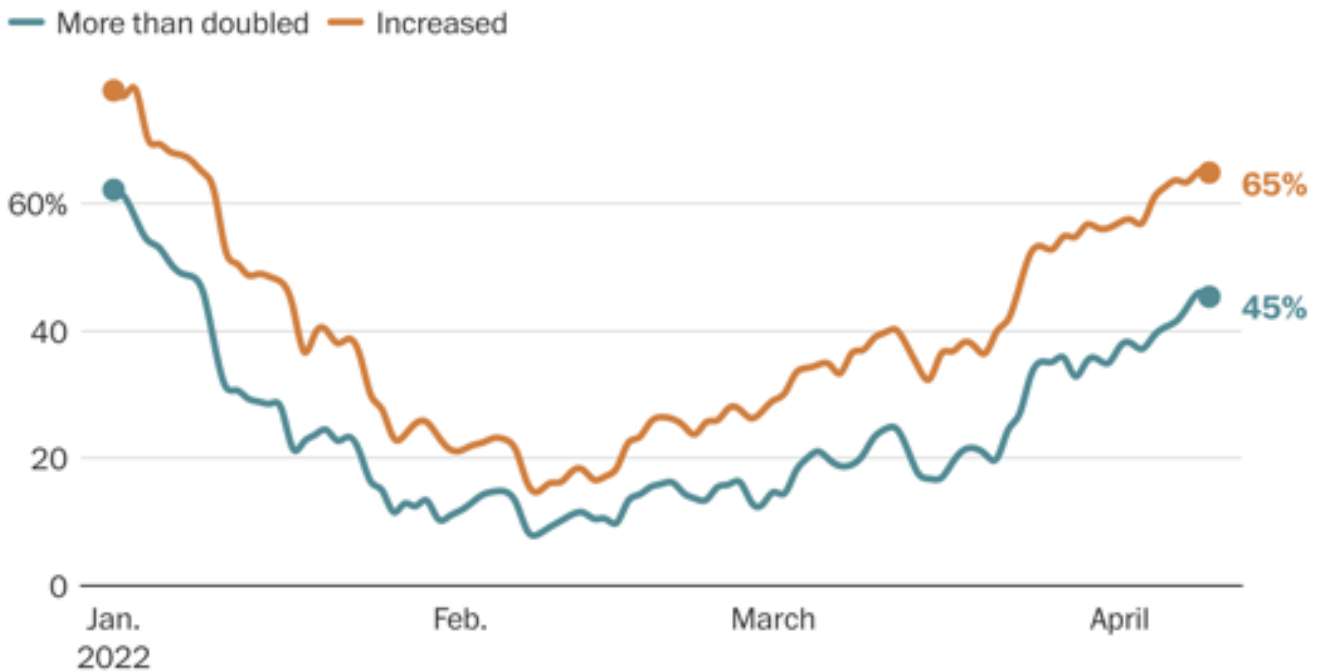
Each day reflects the trend for the preceding 15 days.

Source: Centers for Disease Control and Prevention

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Perhaps the biggest advantage: "It's fast. We can have data in hand five to seven days after that toilet is flushed," Kirby said. "That means that wastewater data is often the first indication that cases are going up in a community."

The surveillance system is also coming fully online at just the right time, Kirby said. Even though hospitalizations are falling, a large number of cases can still be a huge health-care burden, not to mention the potentially devastating consequences of long covid.

Maine has been reporting uniform increases in wastewater levels statewide, a big difference from previous episodic spikes, said Nirav Shah, director of the Maine Center for Disease Control and Prevention. He alerted hospitals recently to prepare for a rise in cases. If beds start filling up, Northern Light Health, a Brewer-based system with 10 hospitals, says it will limit elective surgeries, as it has done in previous surges.

Whether another wave happens remains to be seen. But James Jarvis, who heads the health system's pandemic response, wants to be ready.

"We fear that it is coming," said Jarvis, highlighting the potential exposures from travel related to spring break and Easter, Passover and Ramadan that could lead to hospitalizations by the end of April or early May. "We're preparing for that to be what we will see as we get further on into spring."

Rhode Island officials are watching to see if hospital beds fill up; hospitalizations are about half of what they were a month ago, said state health department spokesman Joseph Wendelken.

In Houston, virus levels have increased "in a pretty straight line," but hospitalizations are still falling "ever so gently," said David Persse, the city's chief medical officer. "This is the first time wastewater is going in one direction and hospitalization is going in another," Persse said. His hope is that vaccinations, coupled with previous infections, may be preventing severe illness.

In the past two weeks, Ohio has sent alerts to about a dozen city and county health departments informing them of short-term virus level increases. The state also shares what variants have been detected.

"There's no question that our vaccination rates bumped up significantly after we shared information about the arrival of those variants," state health director Bruce Vanderhoff said.

But even as wastewater monitoring takes on greater importance in some parts of the country, using it as a national surveillance system faces obstacles.

The CDC system is only partially in place, with fewer than half of states regularly reporting data to the agency. In some states, only one or two sites are included.

Setting up a monitoring system "is not a simple process where you flip a switch and the data is there," said Heather Bischel, an assistant professor in the Department of Civil and Environmental Engineering at the University of California at Davis. Bischel and Davis city officials are tracking virus levels for the city and the university campus.

Even with funding from the CDC, the monitoring programs take time, labor, equipment and coordination with wastewater treatment plants.

For some communities, the early warning in sewers has helped target hotspots. In Tempe, Ariz., city officials were already using wastewater to track opioid overdoses. Then, the pandemic struck.

"We didn't have any way to identify asymptomatic people," said Rosa Inchausti, Tempe's deputy city manager. That's where wastewater monitoring came in. Virus levels shot up in one neighborhood where many generations live in large apartment

buildings. Officials rushed to build ad hoc coronavirus testing sites. They posted fliers in laundromats to explain how to quarantine in small spaces.

"Wastewater was our leading indicator," Inchausti said.

In mid-February, a drop in those levels was one reason the city lifted its indoor mask mandate, Inchausti said.

© Cheney Orr/Bloomberg A University of Arizona researcher looking for evidence of the coronavirus processes wastewater samples from dormitory sewage lines in August 2020. (Cheney Orr/Bloomberg)

But others say it is too early to know how useful wastewater monitoring will prove.

"We really struggled over how much time and effort that we [want to] put into wastewater testing versus what will be the long-term benefits. I don't think we quite know yet," said Anne Zink, chief medical officer for Alaska's health department. A handful of sites are doing wastewater monitoring, but the state, with its many rural areas, relies heavily on septic tanks.

As a physician, Zink can test dozens of people and know from PCR results who might qualify for treatment and prescribe antivirals, she said. But if wastewater levels are increasing, "how do I action that information?" she asked.

To be sure, Zink and others say sewer monitoring can be a useful tool at this stage in the pandemic.

"The pandemic picture is best when it has a lot of pixels," Zink said. Now, pixels are missing because of a lack of testing data, she said. "So, it's perfect to think about wastewater as an additional piece to that so you don't lose visibility of the [big] picture."

Maine's Shah said more states are likely to change their approach with time.

"It's important to view wastewater screening as an additional tool in our pandemic response, not a replacement for something we've been using," Shah said.

Sewage samples are typically collected a few times a week and sent to a laboratory where scientists concentrate the virus from the wastewater.

"It doesn't really smell that bad," said Jen Mou, a molecular biologist at Kent State University who heads a lab that tests samples. The liquid — the color varies from yellow to black — is poured into tiny test tubes and spun in a centrifuge to separate liquid from solids. Genetic material is extracted from the solids for analysis. A separate review takes place to identify variants.

It typically takes a few days from collection to results. LuminUltra, which was awarded a contract by the CDC to help states and localities set up wastewater surveillance systems, is reporting results to the agency three to four days after sample collection.

The process allows scientists to see increases in virus levels, but if sewer water tests positive for the pathogen, the data can't tell you "if it's one, 10 or 100 cases," the CDC's Kirby said. But if there is a doubling in wastewater levels of virus, "then there's roughly a doubling of cases in that community."

Temperature, rainfall, a big influx of tourists, even the time and distance waste spends traveling through sewer pipes can affect outcome.

"Every wastewater treatment plant is its own animal," said Mike Abbott, environmental health director at Maine's CDC. In smaller towns, "it may only take a handful of cases to change the concentration."

Some experts are discovering that sewer data can be surprisingly useful in building trust among the vaccine-hesitant.

Graduate program students Emma Lancaster, right, Emily Lu, center, and Fan He, left, extract fragments of the coronavirus March 23 in an Ohio State University laboratory. (Patrick Orsagos /AP)

After the CDC changed its guidance on pandemic measures in late February, many people no longer had to wear masks. That's because the agency's formula for assessing the threat posed by the virus focused on hospitalizations. Previously, cases were the paramount metric. Overnight, that turned the map of the United States from mostly red (high risk) to almost all green (low risk).

"People think that everything is fine, but the map is green because hospitalizations have gone down," said Jarvis, of Northern Light Health. "The map is not green because there is no disease out there. ... Wastewater data, that can be a helpful tool in saying, 'Look, this is showing there is still virus out in your community.'"

In Chautauqua County in western New York, which relies heavily on tourism, the health department recently posted on its website that "it is difficult for our department to monitor COVID-19 levels in the general community," but wastewater surveillance showed low levels for three weeks.

Sharing good news builds trust, said David Larsen, associate professor of public health at Syracuse University and a member of the state's wastewater monitoring team. At the

dawn of the pandemic, Chautauqua and other rural New York counties shut down before recording a single covid-19 case, Larsen said.

"If we had this system in place back then, they could have stayed open for at least a little while longer," Larsen said.

Albert Hsu, an obstetrician-gynecologist in Columbia, Mo., said the Missouri health department's wastewater monitoring has helped persuade some pregnant patients to get vaccinated.

"For my more hesitant patients, I sometimes say, 'Hey, I don't want you to get the next variant,' and sometimes I present … quite a few surveillance images," Hsu said.

At least 64 other countries are monitoring wastewater virus levels, according to COVIDPoops19, a dashboard operated by Colleen Naughton and colleagues at the University of California at Merced. The Netherlands has used sewage monitoring for decades.

A microbiologist who used to study norovirus, Kirby has long wanted the CDC to put in place a broader monitoring system to detect outbreaks.

"But it's hard to build this capacity across the country," Kirby said. "The return on investment for any pathogen was never high enough to warrant that. Covid changed that calculus."

Eventually, the CDC plans to use wastewater surveillance to gather data on other pathogens, such as antibiotic-resistant bacteria, norovirus, influenza, a deadly fungal pathogen called Candida auris and food-borne infections caused by E. coli and salmonella.

Tempe has approved money for tracking at least a dozen pathogens or biomarkers in addition to SARS-CoV-2. One of them is the asthma rescue medication albuterol — which people shed in their waste — to pinpoint where more trees can be planted to improve air quality.

The Arizona city has hired an arborist to expand the tree canopy to help improve air quality and diminish asthma.

"I never thought I would be sitting down with an arborist to talk about wastewater," Inchausti said. "This is how local government should be thinking about public health … not just responding to emergency calls on your worst day."