COVID-19 Surveillance Through Wastewater in New York State

Katie Greening

Received October 11, 2023
Accepted February 04, 2024
Electronic access February 15, 2024

Wastewater surveillance is a developing method for monitoring the transmission of COVID-19 within communities, providing rapid and cost-effective insights into case trends by detecting asymptomatic cases and offering early outbreak warnings. The current study explores the effectiveness of wastewater surveillance and its potential for widespread implementation in New York State. Although wastewater surveillance is effective, with the ability to test thousands of people in a single sample, challenges arise in scaling up infrastructure, particularly in areas reliant on septic tank systems rather than sewage systems. The study highlights the advantages of wastewater surveillance over traditional clinical testing, emphasizing its ability to cover large populations, provide advanced notice of outbreaks, and ensure privacy. Comparisons between wastewater surveillance and clinical testing underscore the former's safety, cost-effectiveness, and ability to detect trends at a nationwide scale. While over 75% of New York State's population is being surveyed for COVID-19 trends, challenges persist in areas with little coverage, such as Suffolk County, where only 23% of residents are under surveillance. Semi-structured interviews with key public health officials shed light on the onboarding of treatment plants, public health actions taken based on surveillance data, and the challenges in achieving comprehensive population coverage. Findings from this study emphasize the need for collaboration between wastewater surveillance programs and public health departments for more accurate and meaningful COVID-19 trend monitoring. The effectiveness of wastewater surveillance is acknowledged; however, the expansion of such programs, particularly in regions such as Suffolk County, faces challenges due to the limitations of current waste collection infrastructures and the extensive measures required for New York State to establish sewage systems statewide. Further investigation into alternative wastewater sources for COVID-19 surveillance is recommended.

Introduction

Wastewater Surveillance

Since its emergence in December 2019, COVID-19 has swiftly evolved into a global health crisis. COVID-19's rapid transmission affected every corner of the world, disrupting economies and straining healthcare systems[1,2]. Economies around the world fell into recessions, as a result of decreased spending among consumers[3]. Hospitals, unprepared for the dramatic increase of patients, resorted to placing beds in hallways. Resources such as protective equipment for staff and ventilators for patients were depleted, leaving many unprotected or untreated[1].As governments, healthcare professionals, and researchers rushed to understand and contain this pandemic, it became crucial to explore methods for monitoring the transmission of the virus within communities. Alongside conventional measures, such as clinical testing and contact tracing, emerging research has explored alternative approaches to track transmission– one such method being wastewater surveillance.

Wastewater surveillance has been in use prior to COVID-19, such as for poliovirus in Cuba in 2003, where wastewater surveillance was shown to be as sensitive as stool sampling– testing positive even with the smallest populations shedding the virus. Poliovirus was detected in wastewater when as little as 6% of the population sampled shed the virus in their stool[4]. A highly sensitive surveillance system ensures that a greater number of cases, including milder or asymptomatic ones, are captured and reported. This helps in identifying the true extent of infections, understanding transmission dynamics, and accurately estimating the prevalence of the disease. Wastewater-based epidemiology was also used to monitor illicit drug use in Italy in 2005[5] and antimicrobial resistance, a serious threat to global public health, across 60 countries using untreated sewage[6].

The process of wastewater surveillance includes various methods for collection and testing. Collecting samples from wastewater treatment facilities, an example of a "downstream site," covers a larger population, possibly thousands of people, compared to individual testing. However, collecting samples from manholes next to residential buildings, an example of an "upstream site," would cover a smaller population– the residents of the building adjacent to the manhole[7]. College campuses, for example, can obtain accurate information regarding COVID-19 trends among the residents of their dorm buildings. Although wastewater surveillance is not generally sensitive enough to detect single cases in these residential buildings, they are still able to monitor the ongoing case trends[8].

Samples are commonly taken using Moore swabs– cotton gauze tied with a fishing line. Swabs are lowered into wastewater and removed 24-72 hours later. This Moore swab method has already been used to detect pathogens such as poliovirus, human norovirus, Escherichia coli, Vibrio cholerae, and S. Typhi[7]. Samples are also taken by collecting wastewater in a container to be taken back for testing. However, the Moore swab method has been shown to be more sensitive for detecting COVID-19 in wastewater[8].

Wastewater Surveillance vs. Clinical Testing

By searching for the presence of SARS-CoV2 in wastewater, wastewater surveillance holds the potential to provide rapid and cost-effective insights into the trends of the virus within a community or population. While asymptomatic patients are less likely to go in for clinical testing, their cases will still present themselves in wastewater surveillance, alongside the cases of symptomatic patients[9,10]. Additionally, COVID-19 can present itself in wastewater before the onset of symptoms, which allows for early warning of an outbreak[11]. Quicker turnaround times allow for earlier visibility of COVID-19 trends. While PCR tests may take a similar amount of time to show results, the results from wastewater testing can be on a nationwide scale[12]. Epidemiologists can proactively prepare the tested population for an outbreak, rather than waiting for patients to get PCR tests individually. Better foresight can give public health officials more time to set up surge testing, prepare hospitals for the incoming surge of patients, or evaluate school system closings or reopenings.

Not only is wastewater surveillance safer due to its quicker turnaround of results, but it also exposes less people to COVID-19. To get clinically tested, patients would often have to go out for testing, potentially infecting others or themselves if they were not originally infected. Wastewater surveillance does not require patients to leave their residences, thereby slowing the spread of COVID-19.

Wastewater surveillance is low-cost relative to polymerase chain reaction (PCR) and antigen tests, which range from $1.29-$5 per test. Wastewater collection using the Moore swab method can cost as little as $1.20 per swab[6]. While this may seem similar to the cost of PCR and antigen tests, wastewater testing can test hundreds to even ten thousand people through a single sample, testing an entire community or population[13,14]. Wastewater surveillance also allows for more privacy for those who are included in the sample being tested. Due to the fact that thousands of patients can be included in a single sample of wastewater, healthcare officials are able to track COVID-19 trends without the risk of breaching people's privacy.

The rise of at-home test kits for COVID-19 makes it more difficult than ever to monitor the true trend of COVID-19 cases. These testing kits do not require individuals to travel to clinics to get tested, only requiring a nasal swab or saliva sample. These samples can then be tested by the patients themselves, with the results being shown in minutes. Although these may be affordable, quick, and convenient, these cases may not be reported to public health officials, making the reported COVID-19 trends less accurate. If wastewater surveillance becomes more widespread, the visible trend in cases will be more accurate, allowing public health officials to take appropriate action to slow the spread.

Wastewater Surveillance in New York State

In New York, wastewater surveillance for COVID-19 covers over 75% of the total state population. However, in areas such as Suffolk County, only a small part of the county is covered by the wastewater treatment plants testing for COVID-19. Therefore, only about 23% of the population is accounted for by wastewater surveillance[15].

In order for wastewater surveillance to become more reliable, it must cover a larger percentage of the population. While some wastewater treatment plants are not participating with the New York State Department of Health, there must be adequate infrastructure to support frequent testing of large populations.

Potential Limitations of Wastewater Surveillance

While using wastewater surveillance to track COVID-19 trends has the potential to provide valuable insight into the spread of the virus within communities, it's important to acknowledge the limitations and challenge that comes with it.

Wastewater surveillance can detect the presence of SARS-CoV-2 in a community, but it cannot differentiate between individuals who are actively shedding the virus and those who have recovered from the infection. This lack of specificity makes it difficult to identify individual cases, limiting the usefulness of wastewater surveillance as a standalone diagnostic tool. Therefore, wastewater surveillance should not be the sole method of monitoring COVID-19 cases. It should instead be used as a method of monitoring overall trends alongside the use of clinical testing to monitor individual cases.

Although wastewater surveillance is generally considered cost-effective compared to clinical testing, it still requires infrastructure and equipment for regular sampling and analysis. Implementing and maintaining these surveillance systems can be a significant financial burden, particularly for communities with limited resources.

Results

Selected excerpts from interviews shown below reflect the most common themes and topics brought up across these interviews.

On-boarding of Treatment Plants

When asked about bringing new treatment plants into the program, all responded by stating that wastewater surveillance programs try to overload treatment plants with responsibilities.

Author: "When a treatment plant joins your program in testing their water, what changes on their end– what is added to their usual processes?"

Individual #1: "They just receive the sampling kits, and from our side, we do that whole process– shipping the sampling kits, doing the analyses."

According to Individual #3, many larger treatment plants (flow rates being at least 5 million gallons per day) are required by the New York State Department of Environmental Conservation (DEC) to send in samples twice every week. Treatment plants are only asked to send in samples to one additional lab- a lab running tests for these wastewater surveillance programs– instead of being asked to conduct additional sample collecting.

"But we provide the shipping, and we send the UPS trucks to pick it up," says individual #4 when asked about what's added to treatment plants' usual operations. "We try to minimize the additional effort."

While larger treatment plants are required by the DEC to sample twice per week, other smaller plants may only sample weekly, or even monthly. Although larger treatment plants would be better due to the larger population they serve, getting as many people covered is what's important in order to have a larger sample size. "We'll take what we can do, and try not to be too pushy," says individual #3.

Public Health Actions

After testing and data analysis, wastewater surveillance programs send data to the CDC and to local health departments. The data is also posted to various dashboards, run by the programs, the CDC, or local health departments. However, public health actions are not taken by the programs themselves.

Author: "And when we get the data and when it's all analyzed, what public health actions could we take due to better foresight of these COVID-19 trends?"

Individual #3: "Something that we try to be conscious of when we send the memos out, we're really just sharing data. We don't want to offer public health guidance when we send the memos out. We usually try to leave that up to local health departments and local communities, and let them decide what is best for them and their community. If that means they want to push for boosters, or if they want to send out any kind of messaging, then that's up to them. We really want to leave it in their hands, to control what kind of public health messaging, if any, that they would like to do. We just share what we're seeing."

According to individual #1, results can be shown in wastewater up to 10 days before they would show up anywhere else. Public health actions taken due to better foresight from wastewater surveillance include hospitalization forecasting and vaccination campaigns, which can help communities and hospitals prepare for upcoming peaks in COVID-19 cases. The advanced notice of these peaks gives hospitals more time to acquire personal protection equipment, hospital beds, and proper personal protection equipment. Back in 2020, at the beginning of the pandemic, this advanced notice could have prevented personal protection equipment shortages that occurred around the world[16]. Individual #4 brings up the past holiday season in Wales:

"They were nervous because the hospitals were getting overwhelmed, and they were considering asking people to stay home and reduce their movement, but the wastewater showed that transmission was already declining. So they didn't ask people to stay home during the holidays, because the transmission was already going down. They only knew that from the wastewater. If they had relied on hospitalizations, it would have been a very different holiday season for many people."

Population Coverage and Expansions

According to the New York State Department of Health COVID-19 Wastewater Surveillance Dashboard, 76.86% of New York State's population is covered by wastewater surveillance. However, when we look at individual counties, such as Suffolk County, only about 23% of the population is being surveyed by wastewater. To make wastewater surveillance more reliable for detecting COVID-19 trends, it should be able to monitor the majority of New York residents to make data as accurate as possible. But even if surveillance programs were able to get every treatment plant in New York onboard, would most of New York State's population be covered?

According to Individual #4, the 200 treatment plants that are currently participating in the wastewater surveillance program in New York State already survey 95% of the population that uses sewage systems. Since these surveillance programs prioritize the onboarding of larger treatment plants, the remaining 5% come from, according to this individual, 400 smaller collection sites, resulting in a diminishing return as more treatment plants join the program. If the surveillance programs in New York State were to attempt to expand further into these treatment plants, each plant will only contribute, on average, .0125% of the population in New York that uses sewage systems. For those that do not use sewage systems, and instead use septic tanks, wastewater surveillance would not be able to reach them directly from housing. Programs may instead rely on "public source systems," which can include schools or hospitals.

Discussion

The findings from the semi-structured interviews shed light on several important aspects of wastewater surveillance for COVID-

19 in New York State. The streamlined testing processes at wastewater treatment plants suggest they are not burdened with additional effort. The focus is on providing sampling kits and conducting the analyses.

The interviews also revealed that the data collected through wastewater surveillance is shared with the CDC and local health departments, who are responsible for taking public health actions based on the data. The programs themselves do not directly take action but provide the necessary information for public health officials to make informed decisions. This emphasizes the importance of collaboration between wastewater surveillance programs and public health departments for effective response to COVID-19 outbreaks.

Population coverage was identified as a key factor in the success of wastewater surveillance in New York State. While the overall population coverage is high, certain areas, such as Suffolk County, have relatively low coverage. This highlights the need for expanding the program to include more treatment plants and improve the infrastructure to support frequent testing of large populations. The discussion also mentioned the challenge of reaching populations that do not use sewage systems, such as those relying on septic tanks. Alternative approaches, such as testing public source systems like schools and hospitals, may be necessary in these cases.

Overall, the results suggest that wastewater surveillance for COVID-19 in New York State has been effective in providing valuable data and insights for public health officials.

Methodology

Interviewee Selection

To research New York's wastewater surveillance, I interviewed public health officials and researchers who work for or with New York institutions. Individuals from Syracuse University and the Centers for Disease Control and Prevention (CDC) Foundation were able to put me in contact with one more individual from the New York State Department of Health. The fourth individual in this study was identified through a professor at Stony Brook University.

Semi-Structured Interviews

Interview questions were prepared based on the literature review. Papers were chosen for the literature review based on its relevance to wastewater surveillance and its uses around the world. Topics included funding, septic tanks, and public health initiatives. Specific questions included the following:

- Where are you from, and what is your role in wastewater surveillance for COVID-19?
- Do we have the necessary infrastructure to survey a larger percentage of the population?
- How does New York's wastewater surveillance program compare to those of other states?

Interviews were then scheduled over email, spread across three separate days. Interviews were conducted via Zoom. Prior to the beginning of the interview, permission to record the interview was requested, with each of the interviewees approving. Each interview lasted about 20 minutes, and recordings of the interviews were saved.

Data Analysis

The recordings were then played back and transcribed into a Google Doc. The transcriptions that resulted were then coded and analyzed for recurring topics and answers.

Conclusions

These results support the bigger issue of the lack of wastewater surveillance infrastructure. Since about 95% of New York's population that is on sewer systems is already covered by wastewater surveillance, the remaining population on septic tanks will not be able to be monitored directly using wastewater testing. In order to increase population coverage, New York would have to uproot the majority of its suburban residents' neighborhoods to implement sewage systems, which is not feasible. Otherwise, surveillance programs still have to rely on public source systems. Therefore, New York does not have the infrastructure necessary to increase population coverage for COVID-19 monitoring through wastewater surveillance.

To continue monitoring COVID-19 trends, wastewater surveillance programs may have to focus on expanding their "public source systems," which may be able to provide samples from individuals that would otherwise remain unnoted due to their use of septic tanks.

Future Recommendations

To expand on wastewater surveillance research, more research should be done regarding "public source systems" that were often referenced in the interviews. The sources, populations covered, their reliability, and approaches to expanding these public source systems should be investigated. Alternative infrastructure solutions that may be more cost-effective and less disruptive than the complete renovation of wastewater collection systems, especially for areas using septic tanks, should be examined as well. Policymakers may consider allocating funds for infrastructure improvement, possibly through targeted investments, grants, or partnerships with private entities. Incentives or subsidies could be provided to encourage municipalities to upgrade wastewater collection systems.

Acknowledgements

Thank you for the guidance of Crystal Harrell MS MPH from Yale University in the development of this research paper.

References

1 A. Burdorf, F. Porru and R. Rugulies, *Scandinavian Journal of Work, Environment Health*, **46**, 229–30.

2 V. Haldane, C. Foo, S. Abdalla, A. Jung, M. Tan, S. Wu, A. Chua, M. Verma, P. Shrestha, S. Singh, T. Perez, S. Tan, M. Bartos, S. Mabuchi, M. Bonk, C. McNab, G. Werner, R. Panjabi, A. Nordström and H. Legido-Quigley, *Nat Med*, **27**, 964–980.

3 M. Balcılar, *On Eurasian Economies*, **1**, year.

4 P. Lago, H. Gary, Jr., J. Pérez, V. Cáceres, J. Olivera, R. Puentes, M. Corredor, P. Jímenez, M. Pallansch and R. Cruz, *International journal of epidemiology*, **32**, 772–777.

5 E. Zuccato, C. Chiabrando, S. Castiglioni, D. Calamari, R. Bagnati, S. Schiarea and R. Fanelli, *Environmental Health*, **4**, 1–7.

6 R. Hendriksen, P. Munk, P. Njage, B. Bunnik, L. McNally, O. Lukjancenko, T. Röder, D. Nieuwenhuijse, S. Pedersen, J. Kjeldgaard and R. Kaas, *Nature communications*, **10**, year.

7 P. Liu, M. Ibaraki, J. VanTassell, K. Geith, M. Cavallo, R. Kann, L. Guo and C. Moe, *Science of the Total Environment*, **807**, 151047.

8 Y. Wang, P. Liu, H. Zhang, M. Ibaraki, J. VanTussell, K. Geith, M. Cavallo, R. Kann, L. Saber, C. Kraft and M. Lane, *Science of The Total Environment*, **821, 153291**, year.

9 W. Ahmed, N. Angel, J. Edson, K. Bibby, A. Bivins, J. O'Brien, P. Choi, M. Kitajima, S. Simpson, J. Li and B. Tscharke, *Science of the Total Environment*, **728**, 138764.

10 A. Jiehao, X. Jin, L. Daojiong, Y. Zhi, X. Lei, Q. Zhenghai, Z. Yuehua, Z. Hua, J. Ran, L. Pengcheng and W. Xiangshi, *Clinical Infectious Diseases*, **71**, 1547–1551.

11 M. Hellmér, N. Paxéus, L. Magnius, L. Enache, B. Arnholm, A. Johansson, T. Bergström and H. Norder, *Applied and environmental microbiology*, **80**, 6771–6781.

12 B. Duvallet, F. Wu, K. McElroy, M. Imakaev, N. Endo, A. Xiao, J. Zhang, R. Floyd-O'Sullivan, M. Powell, S. Mendola and S. Wilson, *ACS Est Water*, **2**, 1899–1909.

13 S. Shrestha, E. Yoshinaga, S. Chapagain, G. Mohan, A. Gasparatos and K. Fukushi, *Water*, **13**, 2897.

14 M.-B. Polo, A. Corbishley, D. Jones, A. Singer, D. Graham and J. Romalde, *Water research*, **186**, 116404.

15 *The New York State Wastewater Surveillance Network*, `https://coronavirus.health.ny.gov/covid-19-wastewater-surveillance`.

16 J. Cohen and Y. Meulen Rodgers, *Preventive medicine*, **141 106263**, year.