The success of the coronavirus disease 2019 (COVID-19) vaccination effort may be limited by the ability to equitably and expediently reach the general public in the final deployment phase. Prior experience has shown that significant cultural, economic, racial, and communication barriers prevent widespread participation in public health initiatives, such as COVID-19 testing and, now, vaccination. Public health agencies would benefit from tools that identify recalcitrant refugia of infection in discrete geographic hot spots and enable targeted vaccine messaging and deployment to expand coverage. Measuring the concentration of virus in municipal sewers could help. After initial waves of mass vaccination, public health officials, along with health care delivery partners, could deploy this approach to identify locations where viral fecal and urinary shedding into wastewater is not declining—thus revealing pockets of concentrated community infection and opportunities for increased vaccination focus. These areas could be described as vaccination deserts.

Rapid Evolution of a Public Health Tool

The World Health Organization uses wastewater surveillance to uncover polio outbreaks and to assess immunization coverage in resource-limited countries. Because of the urgent need to monitor community-wide spread of infection, the COVID-19 pandemic has inspired key conceptual advancements in the evaluation, assessment, and interpretation of wastewater surveillance data. The approach has been extensively deployed to monitor the spread of infection in cities, neighborhoods, and congregate living settings, including long-term care homes, dormitories, and correctional facilities.

Wastewater surveillance infrastructure, fueled in part by the Coronavirus Aid, Relief, and Economic Security (CARES) Act, is in place in hundreds of communities in the US. High-profile consortia, including the National Science Foundation wastewater Research Coordination Network, Oak Ridge Associated Universities-MITRE Corporation, and the Water Research Foundation formed partnerships with university researchers to evaluate methods for extracting severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) genetic material from wastewater. Additionally, private laboratories, such as Biobot Analytics, began offering testing services by mail early in the pandemic, and now other laboratories and laboratory kit manufacturers support this specialized polymerase chain reaction analysis. Finally, the US Centers for Disease Control and Prevention has established a National Wastewater Surveillance System to facilitate data sharing.

Sewershed Epidemiology

Prior to the pandemic, we at the University of Louisville, in collaboration with Arizona State University, were sampling wastewater to look for urinary metabolites of air pollutants in wastewater for their association with cardiovascular disease risk in urban neighborhoods. When the pandemic was declared, the Louisville Health Department tasked us with COVID-19 prevalence assessment, conducting stratified random screening of residents every 8 weeks. We designed sewershed catchment zones to determine how levels of virus in wastewater compared with infection estimates from the random testing of individuals living in those areas. Through this endeavor, we have developed protocols for establishing sewersheds, which can vary from neighborhoods of 8000
residents to suburbs of more than 60,000 residents, so that we can detect more precisely where COVID-19 hotspots may be developing.

Louisville is not alone. Many other cities, including Houston, Texas; Tempe, Arizona; and Portland, Oregon, have established ongoing COVID-19 wastewater surveillance efforts with defined monitoring zones. Nationally, the US Health and Human Services Office of the Assistant Secretary awarded contracts to surveille SARS-CoV-2 virus from sanitary sewer systems covering one-third of the US population across 42 states.

Wastewater surveillance can yield data—with appropriate privacy protections—to identify infection outbreaks. Privacy concerns have been few to date, but continued adoption of this surveillance method for pathogens and toxins will require proactivity. For research purposes, this is considered public health surveillance and does not involve any individually identifiable information and associated consent. However, such surveillance benefits from extensive community engagement and communication to maintain trust and integrity. Communities like Tempe have developed model practices for doing this well. In general, the scale of the catchment areas is important, with concern decreasing as the number of residents aggregated increases. While some highly visible headlines were made using this method in dormitories, a more in-depth national dialogue is needed to establish long-term guidelines in settings with smaller numbers of residents.

**Pivoting From Testing Deserts to Vaccinations Deserts**

Wastewater surveillance frameworks developed for estimating COVID-19 prevalence could be readily adapted to help to identify areas where vaccination is lacking. Uncovering such vaccination deserts within the US will be crucial in ensuring the goal of herd immunity is expeditiously achieved. A wide range of barriers to COVID-19 vaccination have been reported. Wastewater surveillance may reveal the human geography of unvaccinated communities, which could facilitate interventions, such as tailored public health messaging, or suggest more convenient access via pop-up vaccination sites.

**Refreshing the Public Health Mission of Wastewater Infrastructure**

The treatment of drinking water and wastewater are pillars of good public health. This pandemic is a wake-up call and an opportunity. Approximately 76% of the US population is connected to a sanitary sewer system, which leaves many rural and exurban populations off the grid. Those living in older cities may be connected to sewers dating back to the 19th century, and we do not yet know the full extent of any additional limitations those older sewers may pose.

Beyond vaccination support, this approach can become part of the fabric of public health for cost-effective, near–real-time surveillance of general population health. Longer term, it could become a source of place-based population health data, illuminating patterns of prescription medication use, pollutant exposure, and biomarkers of population health status. These passively measured biomarkers could inform the geography of health and hold promise for environmental medicine in fields such as cardiology, oncology, and behavioral health. Considering the importance of an effective, equitable, and efficient approach, we urge federal, state, and local governments to embrace and redeem the promise of wastewater surveillance as a critical tool in coordinating national efforts to complete mass vaccination.

**ARTICLE INFORMATION**

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