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COMMENTARY

Testing wastewater to detect severe acute respiratory syndrome coronavirus 2 in communities

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Research groups around the world are starting to analyse whether wastewater surveillance is a useful tool to monitor the presence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in communities. Reported studies from the Netherlands, USA, Australia and France have demonstrated that SARS-CoV-2 can be detected and quantified in wastewater, allowing the total number of community infections to be estimated as well as monitoring whether the virus has returned to a community after elimination. Further work is required to improve the quantification of virus, to better detect the virus at low levels and to ensure wastewater samples are representative of the community under surveillance.

Keywords: COVID-19, SARS-CoV-2, sewerage, surveillance, wastewater

As countries around the world begin the perilous journey of gradually unlocking from tight government restrictions aimed at limiting the transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), strong emphasis has been placed on a strategy of testing, tracing and isolation of index patients and their close and casual contacts. With the need to test tens of thousands of people with suspected coronavirus disease 2019 (COVID-19) and track their possible contacts every day, coupled with the logistic challenges of procuring, supplying, distributing reverse transcription polymerase chain reaction (RT-PCR) tests, administering the tests and returning results promptly, the task ahead is daunting.

A new approach that may complement this testing strategy is being assessed by several research groups in countries such as the Netherlands, USA, Australia and France.[1–4] SARS-CoV-2 can be found in the stools of about 60% of patients with COVID-19 and RT-PCR tests can remain positive in faeces for a median of 4–11 d after nasopharyngeal swabs become negative.[5] Research groups have therefore started to analyse wastewater—i.e. sewage that goes through the drainage system to a treatment facility—for SARS-CoV-2 as a way of identifying the virus and estimating the total number of infections in a community.

In the Netherlands, composite samples from wastewater treatment plants serving six large and medium-sized cities and the airport were tested for SARS-CoV-2 and showed no evidence of infection up to 3 weeks before the first national case of COVID-19 was reported on 27 February 2020.[1] However, on 5 March, with 82 COVID-19 cases reported through the health surveillance system, wastewater samples from four treatment plants showed positive signals, and 10 d later, positive signals were obtained from six of the treatment plants. In Massachusetts, USA, high titres of SARS-CoV-2 were found in wastewater between 18 and 25 March 2020, which were much higher than expected based on clinically confirmed cases, perhaps pointing to much greater transmission than was realised.[2]

In Australia, SARS-CoV-2 RNA copy numbers observed in wastewater using quantitative RT-PCR were used to estimate the number of infected individuals in two urban catchments in southeast Queensland through a Monte Carlo simulation model, indicating the great potential of this approach to provide early warning signs about how broadly SARS-CoV-2 is circulating in the community.[3] In Paris, France, a time-course quantitative analysis of SARS-CoV-2 by quantitative RT-PCR was conducted on raw wastewater samples collected from several large wastewater treatment plants between 5 March and 23 April 2020.[4] Viral genomes were detected before the start of the exponential growth of the epidemic, there was an increase in genome units that accurately followed the increase in COVID-19 cases in the area and there was a decrease in genome units coinciding with a reduction in COVID-19 cases as a result of lockdown.

The feasibility and benefits of monitoring pathogens in wastewater have been recognised for >50 y.[6] This was shown first with polio, where there was a good relationship between the occurrence of poliovirus in wastewater and clinical incidence of disease in the community. In the years that followed, surveillance of poliovirus in wastewater was used by several countries to assess the success of vaccination programmes and as an early warning system to identify and prevent outbreaks.[6] Several other enteric and respiratory pathogens can be usefully monitored in this way due to large concentrations of pathogens in stools and urine and the long duration of release from the host during infection. This is especially helpful for detecting pathogens in the community when a large proportion of individuals have asymptomatic infection. In a recent example, daily untreated wastewater samples were collected during every second week over a 5-month period from a large treatment plant in Gothenburg, Sweden.[7] Samples were pooled and analysed to detect enteric viruses. Seven different viruses were found, with large amounts of norovirus being detected 2–3 weeks before most patients were clinically diagnosed with the infection. The advent of molecular diagnostic technology has considerably enhanced this screening approach, as survival of pathogens in their viable form is not necessary for detection.

A wastewater treatment plant can capture waste from a million or more people.[8] Wastewater surveillance could therefore be used to detect SARS-CoV-2 in the community and provide an estimate of the total number of infections. The added value is that this approach accounts for those who have not been tested, as they have no or mild symptoms. If lockdown measures have worked and a community is declared coronavirus free, routine wastewater surveillance could be used as an early warning alert that new infections are present. In such a scenario, persons with COVID-19 could also be tracked down by systematically testing samples from the manholes along the wastewater pipe network and identifying the dwellings that feed to the manhole that shows positive wastewater testing results. If this approach was feasible and was found to work, the ethical implications would need careful consideration. New Zealand, which has a declared strategy of eliminating SARS-CoV-2 and has reported no new COVID-19 cases in recent days, is considering just this approach to monitor control and elimination.[9]

It has been estimated that if one person in a population of 10,000 is infected with SARS-CoV-2, the viral RNA can be detected in the wastewater.[10] The amount of virus in wastewater, however, can change depending on temperature, acidic pH, particulate solids and pollutants, the amount of rainwater entering the sewage system and the methods of purification at the wastewater treatment plant. More work is needed on improving wastewater testing, such as better quantification of the amount of viral RNA in stool specimens, developing better tests to detect the virus at low levels and ensuring that samples of wastewater tested are representative of the community under surveillance. Care in this line of work must be also taken. The finding of viral RNA in faeces and wastewater does not imply that the virus is viable and infectious, and to date there are no clusters of cases linked to wastewater management.[11] Nevertheless, there is the possibility that the virus can become aerosolised during the pumping of wastewater through sewerage systems, at the wastewater treatment works and through its discharge and subsequent transport through the catchment drainage network.[12] Technicians researching this area of work need to be prudent and consider appropriate personal protective equipment.

At a time when the world is focused on the spread of SARS-CoV-2 through droplet and aerosol transmission, a better understanding of how the virus can spread, and therefore be detected by the faecal–oral route, must not be neglected. The scale and rapid spread of COVID-19 is forcing medical scientists to think outside the box and the researchers engaged in wastewater testing of SARS-CoV-2 deserve funding and our full support.

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