Wastewater surveillance of SARS-CoV-2

Questions and answers (Q&A)
Background

Understanding the full extent of the COVID-19 pandemic is an ongoing challenge for public health authorities and outbreak managers.

Since discovering that RNA fragments of severe acute respiratory syndrome coronavirus type 2 (SARS-CoV-2) – the virus that causes COVID-19 – are shed in faeces, the number of wastewater surveillance programmes targeting the virus and its known variants worldwide has grown considerably. Many countries have started using wastewater data as a complementary surveillance method for population-level screening. Wastewater is the product of any water use, including from domestic sewage, industrial, commercial or agricultural activities but also other sources like storm water (1). Information gained from wastewater containing human excreta and respiratory secreta can help public health authorities to identify outbreak hotspots, monitor for emergence and circulation of variants, and anticipate surges and trends in a municipality, province or region, thereby informing public health response measures, including where to target clinical testing (2).

The COVID-19 pandemic has shown that wastewater surveillance for a new pathogen can be set up relatively quickly. While it is a dynamic and growing field of work, wastewater surveillance is not new and already exists for other pathogens and hazards, such as poliovirus and other enteroviruses, antimicrobial resistance (AMR) and drugs of abuse. While wastewater surveillance can provide very cost-effective data to augment clinical surveillance when implemented at scale, the approach requires an initial investment, including in building human and laboratory capacities, if there are no similar programmes already in place.

These Q&As draw on the WHO interim guidance Environmental surveillance for SARS-CoV-2 to complement public health surveillance (3), as well as evidence and experiences discussed during WHO expert consultations organized by the WHO Regional Office for Europe (4,5). The Q&As are also informed by key information from the literature, and resources from national authorities currently implementing wastewater surveillance programmes for SARS-CoV-2.

These Q&A aim to provide a first point of access to knowledge and information around wastewater surveillance of SARS-CoV-2 for health and environment professionals. Further details and specialized information on applications of the concept, considerations for planning and coordination, and issues relating to data collection, analysis and interpretation can be found in the WHO interim guidance Environmental surveillance for SARS-CoV-2 to complement public health surveillance (3).

These Q&As will be updated as new information becomes available.
1. **What is wastewater surveillance for COVID-19?**

Wastewater surveillance involves the systematic sampling and testing of untreated wastewater and sewer sludge for fragments of non-infective RNA of SARS-CoV-2, its so-called genetic fingerprint. These RNA fragments are present in the faeces of individuals infected with the virus regardless of health status (symptomatic, asymptomatic, pre-symptomatic, convalescent) and are detectable in wastewater. Wastewater surveillance uses domestic wastewater present in sewerage systems and open drains, which contain the faecal matter and respiratory secretions of humans, to provide information about the circulation of SARS-CoV-2 in a population (6). By analysing wastewater for RNA fragments that are present, health authorities can identify trends at the population level and detect where SARS-CoV-2 is circulating to inform the public health response. Wastewater surveillance does not monitor for live virus and is a non-invasive way of monitoring the circulation of SARS-CoV-2 in a community.

2. **Is SARS-CoV-2 found in wastewater contagious?**

No. SARS-CoV-2 is a coronavirus, and this group of viruses is not known to have a waterborne transmission route (7). Although fragments of SARS-CoV-2 are found in wastewater, this says nothing about the infectiousness of the waste (8). There are two main routes of transmission of SARS-CoV-2: airborne droplets and aerosol particles, and physical contact (9). While people infected with SARS-CoV-2 shed fragments of the virus in their bodily wastes (such as faeces, urine, saliva and sputum), there have been no reports of faecal–oral transmission of the virus, and based on the available evidence, there is no indication that SARS-CoV-2 is transmittable in wastewater. SARS-CoV-2 is rapidly inactivated in the gastrointestinal-tract fluid and is primarily excreted in a non-infective state (10). Moreover, SARS-CoV-2 loses infectivity when exposed to environmental conditions, making it less viable in wastewater (11).
3. Are people who work with wastewater at risk of getting infected?

Workers whose activities bring them into contact with raw sewage and human waste are generally at risk of contracting a work-related infection. This is because sewage contains numerous potentially dangerous pathogens and hazards. Working with wastewater in the context of COVID-19 is not expected to cause any additional infection risk to workers (8,12). Coronaviruses do not have a waterborne transmission route and following standard safety procedures when working with wastewater is recommended to protect against a range of infectious agents. Staff should protect themselves from occupational health risks by means of personal protective equipment (goggles, face-shields or masks, water-repellent overalls, waterproof gloves), practicing good hygiene (washing hands often with soap and water, coughing and sneezing into the inside of the elbow or into disposable tissues, not shaking hands), and adhering to standard safety procedures (13).

4. What is the role of wastewater surveillance in relation to clinical surveillance?

Wastewater surveillance is not a standalone surveillance approach and it is critical to partner with epidemiologists, environmental engineers and other public health partners to best understand and make use of wastewater data in public health decision-making and response alongside other surveillance indicators (14). Such surveillance represents a complementary adjunct to clinical testing for assessing infection trends in the wider community. In addition, wastewater surveillance may help overcome known limitations of clinical surveillance, such as low population coverage, high costs, testing and reporting delays, and the uncertain likelihood of an individual to seek health care (15). It is a sensitive tool for monitoring SARS-CoV-2 and known variant circulation; however, data gathered from examining wastewater are not a replacement for existing SARS-CoV-2 surveillance approaches. When combined with clinical testing, sentinel surveillance, hospitalization rates and epidemiology data, wastewater surveillance for SARS-CoV-2 can track and identify at an early stage where the virus is present, it’s geographic spread and the intensity of transmission.
5. What is the added value of wastewater surveillance for SARS-CoV-2?

Wastewater surveillance for SARS-CoV-2 provides added value in a number of ways:

- It can establish the presence of SARS-CoV-2 across an entire community. As wastewater contains waste from many sources, samples that are examined for the presence of SARS-CoV-2 represent the combined collective signature of communities regardless of health status (symptomatic, asymptomatic, pre-symptomatic or recovered) or access to and use of clinical testing (5).

- People who are infected may shed virus fragments in faeces before they show symptoms, seek health care or get tested. Wastewater surveillance is a cost-effective tool to survey outbreak dynamics – tracking increasing and decreasing trends at community level – and in combination with other indicators can help target COVID-19 responses and interventions by providing an early indication (4–7 days) of changes in incidence and levels of virus circulation (5,16,17).

- Detecting outbreaks in places thought to be COVID-19-free provides early warning of its emergence and enables public health authorities to prioritize outbreak control actions or perform further epidemiological and virological investigations.

- Cost-effective targeting of public health surveillance enables deployment of scarce diagnostic testing resources in hotspot areas with higher SARS-CoV-2 RNA loads in wastewater.

- Surveillance for early warning of circulation can be targeted in specific settings, such as settings with vulnerable or high-risk groups (e.g. managed isolation facilities, elder care facilities, schools, prisons, informal settlements, facilities for refugees and displaced people) and isolated communities (e.g. remote and indigenous communities; industrial, mining and research facilities; student residences; ships and aircraft arriving at borders).

- Wastewater surveillance can identify existing, known variants of interest or variants of concern where proportions of variants in circulation are uncertain, and detect emergence of novel variants (albeit challenging in sewage samples).

- Risk communications can be augmented to help promote good behaviours by publicizing data on detection in wastewater in a way that reminds the community that the virus is circulating, encourages people to seek diagnostic testing and reduces complacency about control interventions (e.g. mask wearing, physical distancing).

- Retrospective analysis can provide intelligence on the timing of introduction, evolution and dissemination of the virus, to inform future pandemics.
6. What actions can public health authorities take based on wastewater surveillance signals?

When combined with clinical surveillance data, information from wastewater can facilitate public health measures before community transmission reaches exponential growth, helping governments mitigate the health and socioeconomic consequences of outbreaks. If wastewater results trend upward over time in a particular area, additional observations in clinical data and hospitalization rates for that area would be critical to the appropriate interpretation and use of wastewater data. Relevant data should be promptly provided to competent health authorities and, depending on assessments, possible public health actions should be discussed. Such actions could include (16):

- stepping up communication about a potential increase in cases;
- increasing health awareness and outreach efforts in communities where increased virus shedding has been found;
- increasing human clinical and/or wastewater testing in affected communities;
- implementing and scaling up clinical testing in specific locations;
- continuing to evaluate and monitor clinical case data and hospitalization rates;
- recommending additional public health restrictions or infection control measures, such as the use of face masks, hand hygiene campaigns etc.

7. What are the limitations of the wastewater surveillance approach?

Prior to the implementation of wastewater surveillance, it is important to consider the challenges and limitations of the approach:

- Decentralized sanitation systems are often difficult to include in a wastewater surveillance programme and are typically not representative of the community in which such systems are located.
- Collaboration between health and environmental agencies is essential for wastewater surveillance to work effectively, but it is not always a given. It is therefore vital for authorities in charge of wastewater management to work together with the authorities in charge of public health and vice versa.
- It may be difficult for wastewater surveillance to detect low levels of infection in a community as the lower limits of detection of current testing methods are not well understood. The absence of SARS-CoV-2 in wastewater does not indicate a lack of the virus in the community.
There is no unified standard method for sampling or testing of wastewater. The data generated must be interpreted within the context of the sites and sources being sampled, the testing methods adopted, the laboratories performing analysis and the epidemiological characteristics of the area being sampled.

Establishing a validated and reliable sampling strategy, laboratory analyses and data interpretation is necessary for wastewater surveillance to inform public health action. This may be difficult in insecure and limited-resource settings, where wastewater systems can be fragmented and laboratories face challenges in acquiring the equipment needed to establish a wastewater surveillance programme.

There remains limited experience and understanding of both the interpretation of data and subsequent actions that public health authorities may take based on wastewater surveillance alone.

8. Is wastewater surveillance feasible in my setting?

The conditions and resources present in national settings vary greatly and should be investigated to understand the feasibility and appropriateness of wastewater surveillance. There is a spectrum of wastewater surveillance programmes, ranging from sampling a few locations for a limited period of time to comprehensive national surveillance programmes that include multiple disease agents and gene sequencing. While cost effective at scale, setting up a surveillance programme does require initial investment if no similar surveillance network infrastructure and expertise are present. Existing wastewater surveillance networks have been used successfully as a starting point for investigating the presence of SARS-CoV-2 with commercially available test kits. Testing environmental samples representing a large number of pooled individuals could optimize the use of limited clinical testing resources and infrastructure, if conditions allow (17). In these settings, information generated from wastewater surveillance may provide relevant data points to support the public health response. Public health authorities should investigate whether wastewater surveillance is feasible and appropriate in their local context and adds value in public health decision-making. Programmes may start small through pilot projects and scale up over time, if feasibility and usefulness has been confirmed. However, wastewater surveillance should not be used as a replacement for clinical surveillance.
9. Is the wastewater surveillance approach able to track the spread of known SARS-CoV-2 variants and identify the introduction of future variants?

Yes. The systematic collection of wastewater surveillance data can be used to provide information on the emergence or re-emergence of SARS-CoV-2, including known variants, and confirm absence of virus circulation in the community (18). Integration of sequencing methods in a wastewater surveillance programme can detect the introduction of novel variants in a community (19). Ultimately, generating frequent information from wastewater can support public health officials to make decisions with the most up-to-date data available.

10. What are the key steps needed to develop a wastewater surveillance programme for SARS-CoV-2?

The key steps in the development of a continuous wastewater surveillance programme are (3):

- identify the relevant stakeholders at local and national level, in particular those professionals and policy-makers who are the end-users of the information from wastewater surveillance, and gain an understanding of their needs and expectations;
- develop and define coordination mechanisms and identify a lead agency or collective that will be responsible for the wastewater surveillance programme;
- develop understanding of the technical, organizational and financial capacity of the participating stakeholders;
- define and communicate the objectives, scope and scale of the wastewater surveillance programme;
- define the roles and responsibilities of all stakeholders involved in the wastewater surveillance programme and identify opportunities to build on existing capacities (e.g. environmental surveillance for poliovirus) to ensure time and cost efficiencies;
- develop a sustainable sampling strategy that considers all relevant logistical factors (such as location, frequency, transport, testing method, normalization methods, data processing and reporting);
- procure equipment and consumables and train personnel;
• develop an analytic framework with a minimum dataset (including sewershed characteristics, and sampling, testing and analytical methods), as well as modelling or statistical capacity to interpret data (e.g. calculating relevant trends);

• clarify the coordination, data-sharing and data-interpretation arrangements for end use of the data by public health authorities;

• set up a database to collate and communicate relevant data and information;

• develop means to communicate about the findings of wastewater surveillance to stakeholders and the general public (e.g. through public dashboards, paired with public health advice/messages);

• ensure ongoing sustainability and reliability of the wastewater surveillance programme.

11. How can the environment and health sectors come together to programme and coordinate wastewater surveillance?

Successfully setting up a national wastewater surveillance system requires collaboration and coordination between and within sectors. Establishing cooperation mechanisms between the environmental and health sectors, and setting up dialogue between wastewater utilities and health authorities is essential to successfully supporting the introduction and expansion of wastewater surveillance. Establishing wastewater surveillance at scale will often exceed the capability of any one sector, and partnerships provide a way to pool necessary resources and skills. Experts from these sectors, such as public health staff, wastewater utility staff and scientists, among others (5) can come together through joint programming, interconnecting data and partnerships that are of mutual benefit. Such partnerships can be further strengthened through the use of legal and financing frameworks.

The health sector as the end-user of wastewater signals supporting the public health response to COVID-19, should have a leading and coordinating role in the design of the surveillance programme, convening relevant environment departments, wastewater system operators, testing laboratories, and other relevant partners and stakeholders. When planning for wastewater surveillance, relevant environment and health experts should be identified for sample collection, testing, interpretation and response, and encouraged to work together. Pilot studies can serve as an effective way to bring together these sectors and establish workable protocols and systems in the local and regional context.
12. How can wastewater surveillance data be communicated and shared between authorities and to the public?

Authorities planning to implement wastewater surveillance should identify all potential stakeholders and their communication needs early on. Ideally, communication structures and agreements with and between relevant stakeholders will be put in place before samples are collected and results produced. It should be ensured that communication strategies are driven by public health needs and that information from wastewater surveillance is integrated with other sources where applicable.

An effective way of sharing findings from wastewater surveillance with the general public is the use of online information dashboards. The added value of dashboards lies in the ability to present data in conjunction with information from clinical testing or hospitalization rates and/or public health advice for the general public. Dashboards are also able to present data at various governance levels including at the local level, where most community-level decisions need to be taken. The surveillance team should make conscious decisions on the types of information that can be publicly shared and how and when. Seeking ethical approval can be beneficial as it allows authorities to understand the critical and sensitive points that require attention. Data shared with the public should be understandable, focusing on impacts and solutions. Information should be suitable for the audience, and measures adopted to reduce misunderstanding such as expressing results and information in a clear way, while implementing risk communication strategies.

13. What investments in systems and capacity are needed to scale up wastewater surveillance for SARS-CoV-2?

In several countries, existing wastewater surveillance programmes have been expanded and new programmes initiated for COVID-19. While they can be cost effective when at scale, wastewater surveillance requires an initial investment, including in human and laboratory capacities, if similar or existing programmes are not yet in place. In developing a wastewater surveillance programme at any level of sophistication, from basic to advanced, it is necessary to improve capacity and investments in: the development of analytical methods, particularly for settings with low coverage of laboratories that can process wastewater samples; modelling and interpretation of wastewater data; and the use of such data to inform decision-making. Importantly,
such investments in wastewater surveillance should not draw resources away from essential health responses, particularly in limited-resource settings (4).

Wastewater surveillance is not new and is already used to detect pathogens such as poliovirus (20). Harmonizing wastewater surveillance under a multi-hazard approach, that includes SARS-CoV-2, can lead to less administrative and sampling burden, greater cost efficiency and increased cross-research and public health synergies. To facilitate the sustaining of current efforts in wastewater surveillance for the future, consideration of a multi-hazard approach is encouraged.

14. Can wastewater surveillance be used to support preparedness for future pandemics?

Wastewater analysis can be used to detect other disease agents, as well as pharmaceutical residues, hormones and illicit drugs, which can offer insight into the health of communities (8). Wastewater surveillance has already been used for many decades to identify polio outbreaks and inform immunization programmes, and can serve as a basis for multi-pathogen approaches, to monitor hazards such as AMR and future pandemics. A unique strength of wastewater testing is the efficiency with which it can measure multiple health biomarkers and other pathogens. For future public health threats, wastewater surveillance represents a unique and valuable source of health data, independent of a person’s likelihood to seek health care. Using it to inform a passive surveillance system can signal the introduction of hazards that are harmful to population health (e.g. novel pathogens, substance abuse, and environmental and food contaminants) (21). The information gained from wastewater may help public health authorities to better understand community health risks and inform relevant interventions in a timely manner.
References


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