

Ethics Framework for Wastewater and Environmental Surveillance



World Health
Organization

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Abbreviations

SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
WES	Wastewater and environmental surveillance
WHO	World Health Organization

Glossary

Distributive justice: This term refers to a set of principles that provide “moral guidance for political processes and structures that affect the distribution of economic benefits and burdens within societies” (1, 2). It is generally thought to be difficult, if not impossible, to distribute health. However, there are a number of factors that may be relevant to the just distribution of health, including income, wealth and utility; the number of possible persons involved – that is, individuals or groups; and differences in how the distribution should be made, such as for equality or maximization. Egalitarianism is one example of a distributive justice principle (2).

Equity: Equity is the absence of unfair, avoidable or remediable differences among groups of people, whether those groups are defined socially, economically, demographically or geographically, or by other dimensions of inequality (e.g. sex, gender, ethnicity, disability or sexual orientation) (3). Health is a fundamental human right. Health equity is achieved when everyone can attain their full potential for health and well-being.

Illicit drugs: This term describes psychoactive substances that are under international control and are produced, trafficked or consumed illegally. These substances are referred to as either narcotic drugs or psychotropic substances, depending on the international drug control convention under which they are described. The term does not include alcohol or tobacco (4).

Informed consent: This refers to agreement given by a competent individual without coercion to follow a certain course of action, such as treatment or participation in research, after receiving complete and relevant information (2).

Justice: As used in this document, justice encompasses two different concepts (5). The first is equity, which refers to fairness in the distribution of resources, opportunities and outcomes. Key elements of equity include treating people with similar needs fairly, avoiding discrimination and exploitation, and being sensitive to persons who are especially vulnerable to harm or injustice. The second aspect of justice is procedural justice, which refers to using a fair process for making important decisions. Elements of procedural justice include due process (e.g. providing notice to interested persons and an opportunity for them to be heard), transparency (e.g. providing clear and accurate information about the basis for decisions and the process by which they are made), inclusiveness and community engagement (e.g. ensuring that all relevant stakeholders are able to participate in decisions), accountability (e.g. allocating and enforcing responsibility for decisions) and oversight (e.g. ensuring appropriate mechanisms for monitoring and review).

Proportionality: This refers to balancing the positive features and benefits of a particular intervention, policy or research study against their negative features and effects when deciding whether to implement it (2).

Public health surveillance: Public health surveillance is the continual and systematic collection, orderly consolidation and evaluation of pertinent data, with prompt dissemination of results to those who need to know, particularly those who are in a position to take action (6).

Reciprocity: Reciprocity consists of providing a fitting and proportional return for contributions that people have made. Enacting policies that encourage reciprocity can be an important means for promoting the principle of justice, as they can correct disparities in the distribution of the benefits and burdens of efforts to respond to an epidemic (5).

Respect for persons: This refers to treating individuals in ways that are informed by a recognition of common humanity, dignity and inherent rights (5). A central aspect of respect for persons is a respect for autonomy, which requires letting individuals make their own choices based on their values and preferences. Ensuring that an individual provides informed consent – a process in which a competent individual authorizes a course

of action based on sufficient relevant information without coercion or undue inducement – is one way to operationalize this concept. If individuals lack decision-making capacity, it may be necessary for others to be responsible for protecting their interests. Respect for persons also includes paying attention to values, such as privacy and confidentiality, as well as social, religious and cultural beliefs, and important relationships, including family bonds. Finally, respect for persons requires transparency and truth-telling in the context of carrying out public health and research activities.

Stigma: Stigma refers to shame, disgrace or disapproval that results in an individual being rejected, discriminated against or excluded from participating in different areas of society (7).

Wastewater and environmental surveillance (WES): WES is a passive, community-level public health surveillance tool that consists of the ethical and systematic collection and analysis of wastewater and environmental samples. WES is used to assess the presence or quantity of biological or nonbiological targets and translate those data into a format that supports decision-making. WES complements existing surveillance systems to gain information about various aspects of public health and to improve the decision-making process.

Wastewater and environmental samples: A wastewater and environmental sample is untreated sewage, faecal sludge or other human-impacted water collected from sewers or the environment, such as drains, rivers or ponds. Samples are taken from defined locations where human waste enters water systems. They are collected using different sampling techniques and frequencies and in defined geographical locations to ensure representativeness. These samples are processed to support wastewater surveillance and detect targets circulating in the population.

References¹

1. Lamont J, Favor C. Distributive justice. In: Zalta EN, editor. The Stanford encyclopedia of philosophy [online database]. Stanford (CA): Stanford University; 2017 (<https://plato.stanford.edu/entries/justice-distributive/>).
2. Global health ethics: key issues. Global Network of WHO Collaborating Centres for Bioethics. Geneva: World Health Organization; 2015 (<https://iris.who.int/handle/10665/164576>). License: CC BY-NC-SA 3.0 IGO.
3. Health equity [website]. Geneva: World Health Organization; 2025 (https://www.who.int/health-topics/health-equity#tab=tab_1).
4. WHO's role, mandate and activities to counter the world drug problem: a public health perspective. Geneva: World Health Organization; 2015 (<https://www.who.int/publications/m/item/who-s-role-mandate-and-activities-to-counter-the-world-drug-problem>). Licence: CC BY-NC-SA 3.0 IGO.
5. Guidance for managing ethical issues in infectious disease outbreaks. Geneva: World Health Organization; 2016 (<https://www.who.int/publications/i/item/9789241549837>). Licence: CC BY-NC-SA 3.0 IGO.
6. Public health surveillance [website]. WHO Regional Office for the Eastern Mediterranean; 2025 (<https://www.emro.who.int/health-topics/public-health-surveillance/index.html>).
7. The World Health Report 2001. Mental health: new understanding, new hope. Geneva: World Health Organization; 2001 (<https://iris.who.int/handle/10665/42390>). Licence: CC BY-NC-SA 3.0 IGO.

¹ All references were accessed on 29 May 2025.

Executive summary

Wastewater and environmental surveillance (WES) is a public health tool that has long been used to monitor polio eradication efforts and other health problems, such as antimicrobial resistance. WES was widely implemented during the COVID-19 pandemic, and this approach is now being considered, implemented or reviewed worldwide for use in detecting multiple pathogens. WES may also be expanded to health issues related to illicit drug use or toxin exposure. Simultaneously, there have been rapid developments in laboratory testing and data technologies that are used in public health surveillance. Therefore, there is an increasing need for guidance on designing ethical WES programmes, as well as developing appropriate governance frameworks. As this surveillance tool evolves, maintaining public trust through ethical implementation will be essential for realizing its public health potential while respecting the rights and interests of populations monitored by WES.

This Ethics Framework for Wastewater and Environmental Surveillance is informed by the *WHO* guidelines on ethical issues in public health surveillance (1). This document addresses seven sets of ethical considerations related to designing and implementing WES programmes. First, WES programmes must have clearly defined aims regarding the health issues to be monitored and the target populations, and they must have appropriate public health goals. Second, programmes should demonstrate realistic potential benefits by establishing clear links to public health actions and integration with existing surveillance systems, if any. Third, potential harms must be assessed and relevant risks minimized, including stigmatization, economic impacts and harms related to infringements on privacy or liberty. Fourth, the proportionality of WES programmes should be evaluated by weighing benefits against harms and other negative effects. Fifth, programmes should promote health equity by ensuring fair representation of populations and an equitable distribution of benefits and burdens. Sixth, respect for persons should be promoted by ensuring appropriate community engagement, procedural fairness and minimization of restrictive measures. Seventh, programmes should use ethically appropriate data- and sample-sharing policies that aim to maximize public health benefits while protecting privacy and preventing misuse. Annex 1 presents a checklist to guide WES practitioners in ethical assessments of a programme's activities.

This document was developed in consultation with experts in WES and public health ethics. It is intended to aid policy-makers and practitioners involved in WES in identifying relevant ethical considerations and developing ethically appropriate policies for such surveillance.

References²

1. WHO guidelines on ethical issues in public health surveillance. Geneva: World Health Organization; 2017 (<https://www.who.int/publications/i/item/9789241512657>). Licence: CC BY-NC-SA 3.0 IGO.

² The reference was accessed on 29 May 2025.

Introduction



Background

Wastewater and environmental surveillance (WES) involves testing wastewater and other environmental water affected by human actions to monitor infectious diseases and other targets, such as drugs or toxins, as part of public health surveillance (1–4). Surveillance is defined as the “continuous, systematic collection, analysis and interpretation of health-related data needed for planning, implementation and evaluation of public health practice”(5).

For more than 20 years, WHO has issued a series of guidance documents relating to WES for poliovirus (6–9). During the COVID-19 pandemic, wastewater surveillance demonstrated its value in a range of settings and provided an important additional source of data for monitoring trends in the incidence of infection, as well as for informing the appropriate use of risk reduction measures in the community. In 2022, WHO issued its first guidance on environmental surveillance for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) to complement public health surveillance (10), which was subsequently updated in 2023 (11). In 2024, WHO published comprehensive technical guidance on WES (12), as well as summaries of specific considerations for mpox, poliovirus and respiratory and enteric pathogens (13–18).

The experience of using WES for poliovirus and SARS-CoV-2 has ignited widespread interest in expanding its implementation in parallel with research on its application to a variety of other pathogens, although additional work is needed to validate and assess the cost effectiveness of more novel approaches (3, 19–23). WES can also be used for public health surveillance of health issues not related to infectious diseases, including testing for the presence of drugs, whether prescribed or illicit, or exposure to environmental toxins, such as pesticides (4, 24). While the methods and use cases for WES are evolving, countries, regions, public health practitioners, sanitation system managers and researchers are increasingly seeking advice about implementing WES to promote public health while respecting other ethical values, such as equity or justice, and respect for persons. The field of public health ethics has developed key principles to guide ethical decisions, especially when there may be tensions between competing considerations (25–27). These ethical values and principles have informed this Ethics Framework for Wastewater and Environmental Surveillance. The principles highlighted by this Framework include proportionality, least infringement, distributive justice, reciprocity and transparency (Box 1).

Method used to develop the framework

This Ethics Framework for Wastewater and Environmental Surveillance was developed through a collaborative, multi-stage consultation process involving experts in both the technical and ethical aspects of wastewater surveillance.

The Framework was drafted by a core writing team co-ordinated by WHO headquarters. It draws upon existing WHO guidance, particularly the 2017 WHO Guidelines on Ethical Issues in Public Health Surveillance, and both foundational and recent academic literature in public health ethics, including reference to ethical analyses of wastewater surveillance during the COVID19 pandemic.

Framework development involved multiple rounds of consultation and peer review with (i) internal WHO experts including technical staff from WHO's Health Emergencies Programme and relevant departments at headquarters; (ii) the WHO Expert Group on Ethics & Governance of Infectious Disease Outbreaks and Other Emergencies, including members with expertise in bioethics and public health; and (iii) external experts.

The World Health Organization conducted a thorough assessment of the declarations of interest and determined that no conflicts of interest exist.

Public health surveillance and public health ethics

It is widely recognized that surveillance data are ethically and practically important for promoting public health because “what doesn’t get counted doesn’t count” (5): health agencies cannot respond appropriately to public health problems without information about their presence and distribution in relevant communities (28). The 2017 WHO guidelines on ethical issues in public health surveillance (5) provides important foundational principles that are relevant to WES, drawing on recent work in public health ethics (27, 29, 30). Similar to other forms of public health surveillance, WES must balance the ethical obligation to collect data to inform public health action with concerns about privacy, equity and potential harms to individuals and communities. The Guidelines emphasize ethical considerations that align with those needed for WES, including duties to (i) conduct surveillance for legitimate public health purposes, (ii) ensure data quality and security, (iii) develop appropriate programmes for community engagement, (iv) share data appropriately while protecting confidentiality and (v) establish governance mechanisms for ethical oversight (5).

Box 1. Selected general principles of public health ethics

Principle	Example
Proportionality	The burdens or harms involved in an intervention should be outweighed by the public health benefits achieved.
Least infringement	When two policies are expected to be equally effective, the policy that involves the least invasion of privacy or encroachment on liberty should be selected.
Distributive justice	The benefits and burdens of public health surveillance and linked public health interventions should be equitably distributed across relevant populations.
Reciprocity	Those who benefit from public health policies or interventions have a duty to assist or compensate, or both, those on whom burdens are imposed.
Transparency	Public health policy-making should be clear and open, with the justification for the policy made available to the public.

Ethics of wastewater and environmental surveillance

The ethical aspects of WES arise in part due to several features that are unique to this type of surveillance (Box 2). Features of WES that require ethical consideration include (i) the collective nature of pooled samples gathered from a population or geographically defined area, or both (e.g. sewer network catchments); (ii) the potential to monitor multiple targets within a single sample (e.g. pathogens, antimicrobial resistance, toxins, illicit substances or human DNA); (iii) the potential to monitor travellers and mobile populations, including through surveillance of transport hubs and vessels at international borders; (iv) the likelihood that individuals will be unaware that sampling is occurring; and (v) the involvement of non-public-health agencies in the surveillance, including other government agencies or private companies, for example (31).

As a result of its collective nature, WES can be used to monitor a large population with few samples and, therefore, can be relatively cost effective (32). WES is also relatively noninvasive in that it does not involve collecting bodily samples, such as nasal swabs, and it is unaffected by health care access or health care-seeking behaviours. Therefore, it can be used to collect data from groups that might be underrepresented in other forms of surveillance, including situations in which stigma prevents individuals from accessing testing or treatment. WES can be used to detect both asymptomatic and symptomatic infections, and it does not require access to clinical samples, thus it could provide a general picture of the incidence of infection, for example, at a population level. However, where feasible, WES can be used in a more focused way to provide highly localized data, for example at the building level.

The ethical acceptability of WES depends in part on the extent to which the data collected can be correctly interpreted and used to inform appropriate public health actions that promote health. Such actions may include sharing data with communities to promote their understanding and developing independent responses to local health issues. Health agencies may also use data from WES to inform public health messaging or priority-setting for resource allocation, for example by preparing hospitals or other health care facilities for seasonal waves of respiratory viruses (33). Further, relevant actions may include implementing targeted interventions, such as enhanced vaccination programmes or control measures during outbreaks (19, 21, 34). In addition to translating WES data into beneficial public health action, ethically acceptable programmes should be proportionate: the public health benefits arising from surveillance must outweigh any associated burdens or harms. If harms occur, there should be support for those affected. WES programmes should also aim to ensure an equitable distribution of benefits and harms in relevant populations and subpopulations. The assurance of high ethical standards is particularly important for WES, given its potential to generate data about populations without their awareness or consent, and the multiple ways such data might be used or misused. Therefore, WES programmes should be transparent and accountable to the relevant communities.

Some recent technical developments are applicable to WES and they raise their own issues, such as the use of metagenomics, which can simultaneously identify genomic sequences from multiple pathogens, including novel diseases, and human genetic material. Ethical guidance for WES may need to be updated regularly or be accompanied by case studies and implementation materials to be able to respond to relevant emerging applications or technical developments.

Wastewater and environmental surveillance during public health emergencies

It is likely that WES will be considered or implemented, or both, during future public health emergencies. Under public health emergency legal powers, it may be lawful for appropriately authorized public health agents to compel the release of data for emergency response purposes.

There is a strong ethical rationale for sharing data rapidly to inform emergency responses (5). However, the misuse of WES during an emergency may undermine future trust in public health. For example, emergencies increase the potential for the excessive use of public health powers or the misuse of public health data by law enforcement or other agencies for purposes unrelated to public health (26, 35). Further, there will often be increased public scrutiny during an emergency. Therefore, public health agencies should remain transparent about their activities and accountable for their policies, including those for the use of surveillance data even – perhaps especially – during an emergency (36).

Restrictive public health measures, which are often used during emergencies, require strong ethical justification (26, 27). Restrictive measures, such as building-level quarantine and mandated testing, have been implemented based on WES and sometimes when data from WES has been used in combination with other surveillance data (34, 37, 38). More generally, responses to surveillance data can trigger mass quarantine or the closure of local, national or international borders. Such restrictive interventions may sometimes be justified by large potential public health benefits – that is, they may be proportionate, with benefits expected to outweigh harms. However, stringently enforced restrictive measures will often be ethically and politically controversial.

Excessively restrictive measures may generate unacceptable harm and increase mistrust, thereby undermining community participation in future public health surveillance and response activities (26). For example, if a positive wastewater sample leads to the mass quarantine of people in a building or mandated testing of all residents, many of whom may not be infected or have had any high-risk contact, the measure may be perceived as excessive or inequitable, or both, especially if the disease is simultaneously spreading elsewhere in the community without resulting in similar restrictions.

Target audience and scope

This Framework is intended to support policy-makers and practitioners in addressing ethical considerations throughout the processes of design, implementation and maintenance of WES by providing guidance for practical decision-making. Its target audience may include staff of public health agencies, as well as staff of other government bodies, and public or private institutions involved in WES in high- or low-resource settings.

The ethical considerations discussed may be relevant to various activities related to WES programmes including the (i) identification of sampling sites, (ii) collection and transportation of samples, (iii) laboratory processes and testing, (iv) analysis and reporting of WES data or (v) use of such data for public health actions, or some combination of these. The document is intended to improve the design and implementation of WES by providing practitioners with a structured approach to identify, evaluate and address relevant ethical issues. It applies to both public health emergency and non-emergency contexts.

For the purposes of this Framework, the sources of samples collected for WES may include sewage and other wastewater or environmental water affected by human actions from defined catchment areas, with known input from human sanitation and hygiene activities (e.g. water from open drains or pit latrines). The types of

samples excluded from this Framework include drinking-water and other types of environmental samples (e.g. from the soil or air, swabs collected from surfaces or objects).

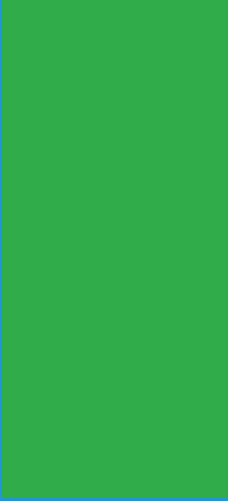
The scope of this Framework includes the use of samples and surveillance data derived from wastewater and environmental water affected by human activity to promote public health. This scope includes instances in which data are primarily collected for surveillance but are then shared for secondary use in research. Such sharing may require appropriate oversight mechanisms within public health or other government agencies involved in surveillance, in part because standard research ethics requirements (e.g. for academic publication) are often waived for surveillance data (39). The Framework also includes limits on sharing surveillance data for purposes unrelated to public health.

Activities that are not in the scope include the collection and use of wastewater samples or data for the primary purpose of health research; such activities are covered by standard research ethics oversight mechanisms. Also, this Framework is not intended to cover the testing of wastewater for any purpose outside of formal public health surveillance (e.g. by law enforcement agencies) (39).

Box 2. Features of wastewater and environmental surveillance

Features	Explanation
Target health problems • Infectious diseases • Antimicrobial resistance • Illicit drug use • Exposure to environmental toxins	Recently, there has been interest in expanding WES to include additional infectious diseases. WES can also be used to monitor patterns of drug use or toxin exposure for public health purposes and future research will expand further the potential uses for WES.
Sampling approach • Collective sampling	WES typically involves collective sampling of populations rather than sampling of individuals. However, it may be possible for data from WES to be used to identify individuals, for example if it is combined with other data.
Target populations • Members of the population with access to collective wastewater treatment or whose wastewater is untreated but sampled for WES (e.g. from open drains or pit latrines)	WES has primarily been used in populations with access to piped wastewater collection systems (e.g. sewers), but those without access may be included via appropriate sampling (e.g. by collecting from other sources of water that are affected by human activities).
Case detection • Asymptomatic and symptomatic	Unlike some other forms of surveillance, WES routinely detects asymptomatic as well as symptomatic infections.
Inclusion of mobile populations • Can be applied to travellers and mobile populations, including at international borders, mass gatherings or refugee camps	WES can be used to identify pathogens, toxins or drugs in travellers, for example via sampling of wastewater from transport hubs or vessels, including at international borders and entry points.
Links to public health action • Data can inform decisions to implement public health measures	Despite the limitations in interpreting WES results, they can be used to justify the initiation or relaxation of restrictive interventions, such as quarantine of specific buildings or geographical areas, including border closures, and may inform other public health measures.
Potential secondary uses of data • Research • Law enforcement • Military or espionage	Similar to other forms of public health surveillance, it can be ethically appropriate to use data from WES for research. However, sharing data from WES for purposes unrelated to public health should be strictly limited.

WES: wastewater and environmental surveillance.



Key ethical questions



The ethical issues highlighted by this Framework are organized under seven questions (Box 3). These questions address the ethical aspects of the (i) aims of WES, (ii) potential benefits, (iii) potential harms, (iv) assessments of proportionality, (v) equity and justice, (vi) respect for persons and (vii) data-sharing.

Box 3. Key ethical questions associated with wastewater and environmental surveillance

1. Aim: What is the aim of adding WES to existing public health surveillance?

- Which health issues will be monitored?
- Who is the target population?
- What is the public health goal?

2. Potential benefits: What are the potential benefits of WES?

- How will WES be linked to public health actions?
- How will WES be integrated into existing public health surveillance systems, if any and if necessary?

3. Potential harms: What are the potential harms related to WES, and how will risks be mitigated?

- What are the potential harms?
- How will risks be mitigated?
- How will support be provided for any harms that occur?

4. Proportionality: Do the benefits of WES outweigh the harms and any other negative effects?

5. Equity and justice: How will WES be designed to promote health equity or the fair distribution of benefits or harms, or both?

- Representativeness: What is the justification for including and excluding geographical areas or populations?
- Distributive justice: How will the benefits and burdens be distributed?

6. Respect for persons: How will WES be designed to promote respect for communities and individuals?

- What form of public engagement will accompany WES?
- How will privacy infringements related to WES be minimized?
- How will the WES programme be transparent about its activities and accountable to the public?
- Will WES be linked with restrictive public health measures?

7. Data and sample stewardship: How should data and samples from WES be shared to promote benefits and minimize harms?

- Who owns the samples and data generated by WES?
- How will data be shared for public health purposes?
- How will data be shared for emergency preparedness and response?
- Will data or samples be shared for public health research?
- Will data or samples be shared for purposes unrelated to public health?

WES: wastewater and environmental surveillance.

Question 1. Aim:

What is the aim of adding WES to existing public health surveillance?

Assessing the ethical acceptability of WES requires being clear about its aims. Key issues include identifying the (i) target health problem (or problems) to be monitored, (ii) target populations and (iii) public health goals.

Which health issues will be monitored?

WES can be used to monitor infectious diseases and antimicrobial resistance, as well as public health issues that are not related to infectious diseases (e.g. illicit drug use, the use of medical abortifacients or toxin exposures) (4, 24, 40, 41). Examples of infectious agents or diseases for which WES has been used or proposed for use include poliovirus, arboviruses, mpox, SARS-CoV-2, respiratory viruses, foodborne enteric pathogens, and emerging or novel pathogens (13–21, 37, 42, 43).

Selecting a health issue for surveillance is ethically significant, in part because such public health data-collection activities are linked to public health actions that result in benefits and may result in negative effects (Questions 2 and 3). Further, the selection of a health issue has ethical implications because it may result in increased identifiability of the specific individuals or groups that are most at risk from the health issue. For example, diseases such as mpox or HIV infection may be concentrated among gay men and other men who have sex with men or female sex workers (44–46), and migrants may be at higher risk from certain other infectious diseases or detectable exposures (33, 47). Where WES data identify areas with higher concentrations of diseases and this results in public health action (e.g. enhanced testing and case-finding), individuals or groups may become easily identifiable. Such identifiability may be contentious in situations in which behaviours or activities associated with the risk of an infectious disease are illegal or it results in the stigmatization of groups, such as undocumented migrants.

Who is the target population?

Wastewater surveillance potentially targets all members of a population who have access to collective wastewater treatment or whose wastewater is untreated but sampled for WES (e.g. from open drains or pit latrines). In some countries, almost the entire population may have access to wastewater treatment, but in others it is only those in relatively wealthy subpopulations who have access (23, 43). Thus, other subpopulations would be excluded unless sampling approaches go beyond the wastewater treatment infrastructure. Surveillance of environmental water (i.e. testing of environmental water affected by human activities, such as drain water) potentially targets a wider population; however, it is more labour intensive to collect from these sources and, therefore, surveillance may be restricted to targeted geographical areas (23).

Identifying the target population is ethically significant because inclusion or exclusion from surveillance may promote or undermine health equity. Additional specifics of how data are collected and analysed to target specific subpopulations may also be ethically significant. For example, while wastewater surveillance can be used to provide collective data about large populations, it is also possible to focus testing on smaller wastewater subcatchment areas, which enables the collection of highly localized data, for example from one city block or one building (37). Although wastewater typically provides a collective sample in which individuals are anonymous, such techniques, especially if combined with other data from other sources, can result in the identification of and public health action targeted to specific individuals or groups of individuals (37).

What is the public health goal?

Determining ethically acceptable public health goals of surveillance is an essential part of designing and implementing WES systems. In general, surveillance can be used to provide overall population data (e.g. the prevalence or incidence of a health issue) or data focused on a subpopulation targeted for public health action, or both.

In the case of infectious diseases, goals might include (i) monitoring the elimination of an infectious disease (e.g. polio), (ii) monitoring endemic or frequently epidemic diseases (e.g. seasonal respiratory viruses, cholera or malaria) (18, 33, 48–50), (iii) ensuring emergency preparedness (e.g. monitoring epidemics of known pathogens or detecting novel pathogens) (19, 51), or (iv) shaping the emergency response (e.g. informing epidemic-containment measures) (34, 37, 52), or some combination of these.

These goals may have different ethical implications. For example, when monitoring a rare infection as part of an elimination programme, it is likely that active cases of infection will be few and thus infected individuals could be more easily identifiable (e.g. when combining data from WES with other data, such as from enhanced testing or case-finding). This may be more likely when rare, infected individuals are chronic carriers or chronically shed infection, including due to immunodeficiency. Although identifying individuals may sometimes be important for public health action, identifiable information must remain strictly confidential. Even de-identified metadata, such as age or postcode, if publicly available can make it possible to identify specific individuals, especially if cases of infection are rare.

However, it is often possible for WES to inform appropriate public health action without the need to identify or implement actions aimed at infected individuals. For example, detecting poliovirus through WES might trigger enhanced local vaccination programmes (14) or detecting Zika virus might inform communications about public health risks (21). In many cases, however, WES may be a first step in public health actions that lead to enhanced contact-tracing to identify infected individuals and prevent transmission (37, 38, 53).

Where the goal of WES is to detect novel pathogens likely to cause a public health emergency or to respond to an existing emergency, surveillance data will often be linked to highly restrictive public health interventions, such as quarantine or isolation, which may be targeted at geographical areas, groups or individuals (34, 37, 38, 54). Restrictive interventions may result in public health benefits (Question 2) but also significant harms (Question 3), making assessments of proportionality particularly important (Question 4). While such issues may arise with all forms of surveillance, WES is unique in its ability to detect both symptomatic and asymptomatic infections with novel pathogens in a geographical area or water catchment area without testing specific individuals.

In summary, the ethical acceptability of WES will partly depend on the aims of the programme, the health issues included in the surveillance, the programme's goals and the links to public health actions (Question 2). Most WES systems that provide population-level data without identifying individuals or groups may be ethically unproblematic. However, some uses may require more robust ethical assessment or public engagement, or both, such as surveillance that may make individuals more easily identifiable, or situations in which a disease or public health action is associated with significant stigma or other harms (Question 3), the people targeted by surveillance are disadvantaged (Questions 5) or restrictive interventions are used (Question 6).

Ideally, within public health agencies there should be a process for both **scientific and ethical review** of the aims and conduct of WES programmes. Many public health agencies do not have ethics support, and this has been identified as a significant gap for capacity-building (55). Such processes for review should be transparent and accountable to the public, with mechanisms for feedback from populations subject to WES (Question 6) (36).

Question 2. Potential benefits:

What are the potential benefits of WES?

How will WES be linked to public health actions?

Similar to other forms of surveillance, WES must be linked to actions aimed at producing public health benefits, although such linkage may occur by combining WES with other sources of data. For the purposes of this Framework, public health benefits encompass any improvement in health, broadly conceived, for relevant communities. Potential benefits of linked public health actions may include (i) communities becoming better informed about the incidence or prevalence of specific health issues; (ii) public health messaging that is better targeted; (iii) improvements in setting priorities for public health, such as efficiently allocating resources; (iv) reduced exposure to relevant hazards, for example through legislation, public health messaging or actions taken to minimize exposure to it; (v) improved access to care or prevention services, such as vaccination, for individuals affected by or at risk from a relevant health issue that is measured by surveillance; or (vi) improvements in controlling or preventing infectious disease epidemics through measures aimed at reducing transmission.

Some public health actions not only produce benefits but also involve potential harms (Question 3) or infringements of individual rights to privacy or liberty (Question 6). In such cases, it is especially important to define how public health actions are justified by data from WES and to determine whether the overall programme will be proportionate (Question 4) and thus ethically acceptable (26).

In summary, ethically acceptable WES programmes should strengthen overall surveillance to produce additional public health benefits. In general, more beneficial programmes are more ethically acceptable, but such benefits should be evaluated alongside any relevant potential harms or other negative effects (Questions 3–6).

How will WES be integrated into existing public health surveillance systems, if any and if necessary?

Similar to other forms of public health surveillance, WES should produce data of sufficiently high quality that it can be interpreted in a timely manner to inform relevant public health actions. It is easier to integrate data from WES to already well established surveillance systems. In other cases, a WES programme may become the only sustained form of surveillance. This may require significant capacity-building, including increased funding, the development of additional infrastructure and standards, training for a specialized workforce, improved coordination between different government or private agencies (e.g. those responsible for wastewater treatment), or reform of legal or governance frameworks.

WES programmes should be integrated into existing public health surveillance activities, if any exist. Before WES is implemented, there should be an informed assessment to determine whether adding such surveillance is likely to be complementary to existing systems and increase the public health benefits of surveillance. For example, WES may enable the detection of infectious diseases at a large scale, and it may detect asymptomatic infections, regardless of variations in access to testing.

As for any other public health policy, there should be an assessment of the most cost-effective combination of approaches. Such assessments should include judgements regarding whether WES is likely to be necessary

and sustainable for local public health surveillance overall and its likely effects on the equity of surveillance (Question 5). Programmes that are not cost effective may be unethical insofar as they divert resources from interventions that would be more cost effective and thus provide more overall health benefits to the relevant population. In principle, WES could be implemented in low-resource settings lacking other well established public health systems. This may be ethically acceptable if it produces cost-effective public health benefits without undermining capacity-building for other valuable types of public health surveillance; however, significant capacity-building would likely be required to ensure the success of WES in many low-resource settings (56).

Question 3. Potential harms:

What are the potential harms related to WES, and how will risks be mitigated?

Public health surveillance can produce harms as well as benefits. Assessments of benefits and harms may be prospective, retrospective or ongoing. Prospective evaluations involve assessments of potential benefits and risks (i.e. potential harms). Any risks from WES implementation and use should be carefully assessed and minimized. The proportionality of WES programmes should also be re-evaluated over time (Question 4), especially if any harms occur as a result of the programme. The existence of potential harms makes it especially important to ensure that data from WES meet high quality standards because harms arising from public health actions taken based on false-positive results, or inaccurate data or interpretation are likely to undermine public trust.

What are the potential harms?

The potential harms (i.e. the risks) of WES should be evaluated prior to implementing the programme. This evaluation should involve considering the types of harms likely to occur, as well as their probability and magnitude, and the potential for an inequitable distribution of harms (Question 5). Harms may include, first, stigma, for example because individuals or groups may be identified as being more likely to be affected by a health problem that is associated with a moral judgement or considered a negative attribute (57, 58). Stigma may result from infringements of privacy (Question 6) and can result in prejudice, discrimination or other harms (58). Second, there may be economic harms for individuals or groups because of the effects of stigma or public health actions that reduce access to employment or affect business activities (e.g. due to public awareness of the prevalence of infection in a particular area, mass quarantine during an epidemic or regulation of the use of wastewater in agriculture) (59, 60). Third, there may be mental health harms due to stigma or situations in which WES is linked to public health actions targeting individuals, such as isolation or quarantine. Fourth, harms may arise due to decreased trust in public health activities as a result of concerns about WES, other surveillance activities or related public health actions. Such mistrust may result in avoidance of health care or non-compliance with testing and other public health interventions. Fifth, there may be potential harms for personnel involved in collecting or analysing samples from WES due to exposure to pathogens or other hazards.

How will risks be mitigated?

The risks of public health programmes should be minimized. However, it will often be impossible to eliminate potential harms, especially when harms stem from actions aimed at producing public health benefits, such as controlling an epidemic. Strategies to minimize risks from WES may include delivering positive public health messaging, for example by countering rumours and incorrect information regarding a health problem or marginalized population (61). It may also include reducing the use of restrictive public health measures, such as mass quarantine of residents of a building or location from where there have been positive samples. However, some restrictive measures may be ethically justifiable during epidemics if there are significant potential benefits from controlling the spread of infection that could not be achieved with less restrictive policies. Where implemented, such measures should be designed to produce as little harm as possible, and this should include by reducing negative or stigmatizing language in public health messaging (58). Risks to

personnel who handle samples from WES should be mitigated through the use of appropriate biosafety and infection control policies.

How will support be provided for any harms that occur?

If harms occur due to WES, there is a strong ethical case for supporting or compensating individuals or groups who experience harm (62). One justification for support or compensation policies is the ethical principle of reciprocity (Box 1) (27). If some individuals are harmed as part of a programme aimed at producing benefits to the overall population (i.e. the programme benefits not only those who are harmed), the population arguably owes a duty of reciprocity to provide support or compensation, or both (27, 62). Further, when equity and justice are considered, there is an especially strong ethical case for minimizing risks and providing reciprocal support for harm when it is likely to be concentrated among disadvantaged subpopulations (Question 5).

In summary, there should be careful assessment of any potential or actual harms associated with WES programmes. There should be mechanisms to minimize risks, as well as to compensate and provide reciprocal support for harms that occur despite risk minimization. While many settings may not have existing mechanisms to support or compensate those harmed by public health interventions, there is arguably a strong ethical rationale to develop such mechanisms over the long term.

Question 4. Proportionality:

Do the benefits of WES outweigh the harms and any other negative effects?

Proportionality is a key principle of public health ethics (Box 1). It requires that the benefits of a public health intervention or policy, in this case WES, outweigh the harms and other negative effects (26).

Assessments of proportionality require data about benefits versus harms, burdens and costs, but these assessments cannot be based on data alone (26). This is because relevant benefits and harms are often incommensurable – that is, they cannot be measured in the same way. For example, the benefit of reducing the spread of an infectious disease is a different kind of outcome than the mental health harms of quarantine and isolation. Although measures such as quality-adjusted life years attempt to account for such differences, it is unlikely that such assessments alone are sufficient for decisions regarding whether benefits outweigh harms (63). Assessments of the proportionality of public health policy, including for WES, should, therefore, be transparent (Question 6), in part to promote respect for populations targeted by surveillance or other public health actions.

Other types of negative outcomes that can arise during the implementation of public health surveillance include infringements of privacy and liberty, which often produce harms but can be ethically wrong or problematic even if they do not result in harm (Question 6). A secondary negative outcome may be reduced trust in public health agencies and, consequently, a reduction in the effectiveness of public health messaging and other interventions. Such mistrust of public health activities may occur if surveillance and other actions are perceived to involve excessive infringement of privacy or other important values. These types of negative outcomes may be difficult to measure. However, assessments of proportionality should take such considerations into account, including by estimating their severity or degree and the number of people they will likely affect. For example, an intervention that produced large benefits, minimal harms and a small reduction in public trust might be judged to be proportionate, but one that produced small benefits, minimal harms and a large reduction in public trust might be disproportionate, and thus ethically unacceptable.

Further, benefits and harms are often unequally distributed throughout a population. Public health actions linked to WES can have a positive effect on equity by improving health among disadvantaged populations. However, in other cases, even when the benefits of an intervention outweigh its harms at the population level (i.e. it is proportionate), interventions may produce inequitable outcomes by providing greater benefits to relatively advantaged subpopulations or greater harms to relatively disadvantaged populations, or a combination of these (Question 5).

Assessments of proportionality, similar to other assessments of ethics, may need to be revised over time. For example, it might be considered proportionate to implement highly localized WES coupled with restrictive interventions at the start of a pandemic when a public health agency is aiming for major reductions in transmission and has widespread public support for these approaches. In contrast, highly localized surveillance or restrictive policies that infringe strongly on privacy may not be proportionate or ethically justifiable later in a pandemic when a pathogen has become endemic or has minimal health impacts due to population immunity, or if policy-related harms have increased.

In summary, public health agencies should make holistic assessments of the proportionality of WES based on the overall expected public health benefits and a wide range of potential harms or negative effects. Proportionality should be reassessed regularly, and policies should cease or be revised if they are no longer proportionate, for example if the benefits decrease or harms increase.

Question 5. Equity and justice:

How will WES be designed to promote health equity or the fair distribution of benefits or harms, or both?

Similar to other forms of surveillance, WES may promote equity or justice, but it may also create or exacerbate inequity or injustice. Key issues in equity assessments for WES should include evaluations of (i) the representativeness of data obtained through WES, (ii) distributive justice and (iii) the reciprocal support available or provided for any harms or negative effects, especially if these disproportionately affect disadvantaged subpopulations.

Representativeness: What is the justification for including and excluding geographical areas or populations?

Including a population in WES and other forms of surveillance can be beneficial for such groups if the surveillance data inform appropriate public health responses to the health issues affecting that population (5). One advantage of WES in terms of equity is that it can collect data about populations that may not have access to, or may avoid, testing for infectious diseases and, therefore, may be poorly represented in other types of surveillance data (35). Excluding a population or geographical area from WES, for example due to lack of access to wastewater treatment, can reduce the visibility of and responses to the health problems of those populations or areas. However, populations included in WES may sometimes experience privacy infringements or harms related to restrictive interventions linked to surveillance.

Therefore, WES should be designed to ensure fair representation and equitable public health responses across the relevant populations. Efforts should be made to include populations for whom the surveillance would produce net benefits or improve health equity, or both. Further, there may be strong ethical and scientific cases for focusing WES and linked public health actions on specific populations where the disease burden is high. However, WES programmes should be designed to avoid excessive privacy infringements among disadvantaged groups and the inequitable use of restrictive interventions (54).

Distributive justice: How will the benefits and burdens be distributed?

Although it is important to determine whether the overall population-level benefits of WES outweigh any negative effects, public health agencies should also evaluate how these outcomes are distributed in the population. WES should aim to achieve equitable improvements in population health, for example by collecting data about and providing public health benefits to disadvantaged groups while avoiding excessive burdens on these groups.

Although WES typically has minimal direct burdens, it may involve infringements of privacy when individuals or groups are identifiable (e.g. residents in a single building) or there are other burdens related to restrictive public health interventions resulting from surveillance. For example, WES has been used as the primary justification for highly localized restrictive measures, such as mandated testing and mass quarantine (37, 38). When infringements on privacy or restrictive actions disproportionately occur among disadvantaged populations, they can increase inequities (54).

Many of the benefits of surveillance will be focused on those at highest risk from the relevant health issue. Since ill health is often concentrated among disadvantaged subpopulations, measuring and addressing health problems can improve health equity by improving their health. Therefore, some populations may actively request surveillance as part of efforts to address inequitable health burdens (5).

In the case of infectious diseases, however, it will often be that the public health benefits of epidemic control are widespread – that is, they will affect both advantaged and disadvantaged subpopulations. Yet the burdens and negative effects of surveillance and policy actions based on surveillance data will be concentrated among those for whom the risks of infection are highest, which is often strongly correlated with other forms of disadvantage (54). This supports a reciprocity-based case for support because one subpopulation is experiencing burdens for the benefits of others. As discussed in Question 3, which focuses on potential harms, the ethical case for providing reciprocal support for any harms associated with WES is especially strong when such harms are concentrated among disadvantaged groups.

In summary, WES should aim to achieve equitable improvements in population health. Since health problems, including infectious diseases, are often concentrated among disadvantaged subpopulations, WES should aim to produce health benefits and avoid excessive negative effects for these subpopulations, and reciprocal support should be provided for any burdens or harms that occur as part of the interventions implemented to promote population health.

Question 6. Respect for persons:

How will WES be designed to promote respect for communities and individuals?

As with all public health programmes, the design of WES should involve appropriate consideration and respect for the individuals and populations who will be affected. Respect for persons can be promoted by (i) ensuring appropriate community engagement, (ii) using fair procedures to make decisions about policies and evaluations, and (iii) minimizing the use of restrictive or harmful public health measures.

What form of public engagement will accompany WES?

Ensuring appropriate public engagement can be a way to promote respect for communities affected by WES (5). Such engagement is justified because WES, similar to other forms of surveillance, typically requires government resources, involves collecting data about citizens and residents, and is often linked to other public health actions for the affected communities (5). The aims of public engagement may include (i) co-designing WES with community members, (ii) informing communities about the programme, (iii) assessing public awareness and acceptance of current programmes, or (iv) seeking feedback on existing or planned WES programmes.

The strength of the ethical rationale for engaging about WES, as well as the appropriate forms of engagement, depend on how a programme is designed. Programmes that involve collecting anonymized data from large populations without identifying individuals or using restrictive public health measures require minimal engagement, for example the public can simply be informed that such data are being collected. Programmes that involve highly localized data collection, identification of individuals, including by combining data from WES with other data, or the use of restrictive measures should include more rigorous engagement, comprising assessments of public acceptability and implementation of fair procedures for receiving feedback from relevant communities. Such feedback should inform any evaluations of or revisions to WES policies, as appropriate.

One of the challenges of ensuring engagement with WES is that the relevant communities from whom data are collected may include international travellers (e.g. if wastewater from arriving airplanes is sampled) or other mobile populations (e.g. migrants on temporary visas). While such groups may not have the same political rights as local citizens, minimal engagement for public health surveillance could include informing individuals that wastewater may be collected and analysed. Surveillance and the linked public health actions should also be equitable (Question 5), by avoiding the disproportionate collection of data or use of restrictive measures among disadvantaged groups, including migrants and temporary residents, or inequitable border closures targeting specific countries.

How will privacy infringements related to WES be minimized?

Privacy is ethically important in terms of respect for persons because there is a presumption that individuals have a right to decide whether to share their personal information with others (64). Public health surveillance often involves infringing individual privacy but with the goal of promoting health (5). This breach of privacy may include collecting and sharing data about individuals, groups or populations.

Many WES programmes collect only population-level data and thus will involve minimal or no infringement of individual privacy. However, for more than 50 years, identifying individuals has been a goal of some forms of WES, for example to track individuals carrying typhoid (65). When data from WES that is carried out in a highly localized wastewater catchment area is combined with other data or public health measures (e.g. case-finding and mandated testing), or both, it may be possible to identify individuals, such as those with a specific infectious disease (37, 38). Procedures for sharing data from WES (Question 7) should be designed to minimize privacy infringement by ensuring identifiable data are shared only when necessary for public health action. In most cases, data from WES can be shared in aggregate, which may reduce infringements of individual privacy, but may still involve risks of stigma for population groups (Question 3).

How will the WES programme be transparent about its activities and accountable to the public?

The ethical values of fairness and justice apply not only to the equitable distribution of benefits and harms from public health programmes but also to the procedures for developing, evaluating and revising policies. Procedural fairness requires transparency, for example by ensuring that a programme's policies and the justifications for them are publicly available (66). It also requires accountability, for example by ensuring that summary data from WES and the uses of the data to justify public health actions are reported to the public (5, 36).

Accountability also requires being responsive to relevant communities. At a minimum, this should include informing communities about the rationales for a WES programme (Questions 1 and 2) and how the proportionality of any proposed programme has been assessed (Question 4), as well as sharing data from WES with local communities (Question 7). More robust forms of accountability would include co-designing a WES programme with the communities where it will be implemented and providing mechanisms for feedback (e.g. via public engagement), with revision of policies based on such feedback (5, 36).

Will WES be linked with restrictive public health measures?

Restrictive public health measures, such as isolation and quarantine, can be justifiable and proportionate components of public health responses in cases in which they will produce greater net benefits than less restrictive alternative policies (Question 4). The principle of least infringement is a key principle of public health ethics (Box 1) (27). It applies to WES as well as to other public health surveillance and responses to disease. This principle requires that if two policies would achieve similar public health benefits and one involves more restriction than the other, the less restrictive option should be selected (25, 26). This principle maintains respect for individual autonomy and liberty by minimizing the degree to which these rights are restricted by public health policy.

Many WES programmes involve only minimal or no restriction of individual liberty, for example where these programmes collect only population-level data to inform public health messaging and resource allocation. However, in instances in which WES is linked to restrictive public health measures, including when used in combination with other surveillance data, these measures should involve the minimum restriction compatible with producing the relevant benefits (25). All restrictive measures require strong justification, and this should be transparently communicated to the public. If restrictive interventions will be implemented, the potential negative effects of such interventions should be considered as part of the overall assessment of proportionality (Questions 3 and 4).

In summary, promoting respect for persons in the context of WES requires an approach that balances public health benefits with individual and community rights and interests. This includes implementing appropriate

mechanisms for public engagement, protecting privacy through careful data-handling practices (Question 7), ensuring procedural fairness through transparency and accountability, and adhering to the principle of using the least restrictive means to achieve public health goals.

The degree of engagement and privacy protection required should be proportional to the level of detail in the surveillance data and the restrictiveness of linked public health measures. Disadvantaged populations must be appropriately protected (Question 5). Policies for using WES at national borders must be balanced, and these may include models of international collaboration and data-sharing (Question 7). Maintaining public trust through the respectful implementation of WES will be essential for its long-term sustainability as a public health tool.

Question 7. Data and sample stewardship: How should data and samples from WES be shared to promote benefits and minimize harms?

Data and samples from WES should be owned and shared according to policies that aim to promote public health benefits while limiting infringements of privacy or the misuse of data for purposes unrelated to public health (28). The development of appropriate policies should include consideration of appropriate (i) data ownership and storage practices; (ii) mechanisms for sharing data for public health purposes, including for public health actions; (iii) policies for the secondary use of surveillance data for public health research; (iv) restrictions on the sharing of data for purposes unrelated to public health; and (v) biosafety policies for samples from WES. Additional legal and governance frameworks may exist that address the sharing of samples beyond those that apply to sharing data.

Who owns the samples and data generated by WES?

A public health agency, a community organization or another entity may collect, analyse or use data from WES. Community ownership of data from WES may be one option, if feasible, although in many jurisdictions health-related data will often be held by a public health agency or relevant government agencies. In some jurisdictions, wastewater may be the responsibility of, for example, an environmental agency of the government or a private company responsible for wastewater treatment (31). Since WES may involve collaboration across multiple sectors, including health and the environment, and other infrastructures, it reflects a Health in All Policies approach, in which health and non-health sectors work together to support public health goals (67). Such cross-sectoral collaboration will often be essential to implement WES effectively and ethically.

Data used for public health surveillance purposes should be analysed and stored according to appropriate standards that protect individual privacy, promote respect for persons and minimize harm (Questions 3 and 6). While wastewater and other samples may be owned by different entities, WES as a public health activity should be conducted by health agencies, rather than other actors, ideally in partnership with relevant stakeholders and participating communities. One reason for this is to set appropriate limits on the sharing of health-related data and thereby promote trust in public health agencies.

How will data be shared for public health purposes?

The ethical justification for WES requires that data are used to promote public health (5). The goal of promoting public health can involve sharing data for the purposes of (i) informing the local or national community about a health issue; (ii) informing local or national public health action, including emergency preparedness and responses; and (iii) informing international communities or international public health actions.

There should be transparent communication about which data are being collected and shared, and appropriate policies clarifying how such data will be shared for public health purposes. Although WES typically involves collecting aggregated data so that individuals may be anonymous, care should be taken to ensure that individuals are not re-identifiable (e.g. in the case of rare diseases in which only one infected individual is present in a water catchment area). Further, aggregate data may still result in stigmatization of identifiable population groups (e.g. those living in a geographical location targeted for WES).

Data from WES should be shared to inform appropriate public health actions. Such actions may include priority setting, optimizing vaccination or using restrictive public health measures. Any data-sharing should involve the least infringement of privacy compatible with achieving the relevant public health objective. Among other things, this should involve restricting who has access to detailed or identifiable WES data as part of a public health action: such access should be limited to the smallest number of public health agency staff that requires access for this purpose.

How will data be shared for emergency preparedness and response?

Data from WES may be shared according to appropriate policies for managing public health emergency preparedness and response. The International Health Regulations (2005) require data to be shared internationally about health hazards that have the potential to cross borders, and this may include hazards identified through WES (68). Such data may include details of novel pathogens, such as their genomic sequences, if appropriate.

WES may include analysing wastewater from international air or sea vessels in their arrival country (69), and thus also the collection of data from international populations. If WES is used for such purposes, its use should be guided by clear aims (Question 1) and policies regarding how data will be shared with other nations or international agencies, or both. However, this is an area for capacity-building because there are few established mechanisms for sharing data collected at international borders (69).

At the national level, data from WES should also be shared as part of local emergency preparedness and response activities. There should be mechanisms to ensure that such data sharing balances respect for persons with the need to promote public health benefits (Question 2). Although legal states of emergency may involve exceptions to normal rules of law, there remains a strong ethical rationale to ensure that an individual's privacy is protected and to minimize the restriction of individual liberty that may be caused by public health actions linked to the use of data from WES.

Will data or samples be shared for public health research?

The primary purpose of collecting data from WES is to inform public health actions. Appropriate secondary uses of such data may include research activities that have the goal of promoting long-term public health. Unlike standard research, surveillance data are typically collected without consent, and the plan for data collection and analysis is not subject to ethics review (5).

The appropriate governance framework for such secondary use of surveillance data for research is an unresolved area in policy development. On the one hand, public health surveillance and public health research using the same data are often similar activities, and members of the public may not perceive a significant difference between them. On the other hand, research is strictly controlled by well established ethics frameworks, including those that require informed consent from individuals, which is not necessarily appropriate to surveillance (70).

If surveillance data are used for research, health agencies should determine whether this use will be (i) governed by standard research ethics requirements or (ii) such research may be conducted and published under a public health waiver of such requirements. If research ethics requirements are waived, it is even more important that surveillance data are collected and handled according to stringent ethical standards. The development of an internal mechanism for ethics review for WES and other forms of surveillance is an important area for capacity-building within public health agencies (39, 55).

Will data or samples be shared for purposes unrelated to public health?

Data from WES could be used for purposes other than public health, for example by agencies involved in law enforcement, border control, and military or espionage activities (35). For the same reasons that wastewater may be useful for surveillance, it could also be used for non-health-related monitoring of specific groups, such as migrants or people living in a certain geographical area. For example, data from WES could be combined with other data to identify or locate groups in whom an infectious disease is more prevalent (e.g. migrants, gay men and other men who have sex with men, or sex workers) or to monitor the use of illicit drugs or medical abortion, including in jurisdictions where such activities are illegal (35, 45, 46). It may also be possible to identify groups such as families or, potentially, individuals, in highly localized wastewater catchment areas by testing for human DNA in wastewater to identify relevant genetic markers (71–73). While such activities might be legally authorized in some jurisdictions, they should be kept separate from collecting data for public health surveillance. The use of public health surveillance data for purposes unrelated to public health is arguably unethical, and it may undermine trust in health agencies (5).

Data from WES may also be used by private companies for their own profit, including through contracts with public health agencies or by using the data to develop intellectual property, such as testing modalities or analytical approaches (31, 74). Public health agencies should develop appropriate policies for sharing sensitive samples or data with the private sector, including by limiting access to them.

The 2017 WHO Guidelines on ethical issues in public health surveillance specifies that personally identifiable surveillance data should not be shared for purposes unrelated to public health (5). Although WES typically involves collective samples, individuals and groups may be identifiable. This can occur in the context of (i) rare infections or exposures to rare toxins; (ii) geographically focused WES, for example if a signal in a larger sample is gradually traced to a smaller sample; or (iii) a situation in which data or results from WES are combined with other data or public health actions, for example if there is mandated testing of residents in a building where wastewater was positive for an infectious disease (37).

One ethical reason why data from WES should not be shared for non-health-related purposes is that any infringement on privacy arising from public health surveillance should be minimized. A second reason is that sharing data may undermine trust in public health agencies and thus result in a decline in long-term health outcomes, for example through decreased participation in vaccination programmes (5, 75). The 2017 Guidelines require that only under exceptional conditions should identifiable data be shared, and these conditions should be prespecified and transparently available; the Guidelines also strongly recommend sanctions for inappropriate use.

In summary, data from WES should be stored and shared according to transparent policies that prioritize public health benefits while protecting privacy and preventing misuse. These considerations include establishing clear data ownership and storage protocols, implementing appropriate mechanisms for sharing data to support public health actions and research, and placing strict limitations on sharing data for non-public-health purposes. Sharing data from WES is essential for effective public health surveillance and emergency responses, but health agencies must develop governance frameworks that balance the promotion of public health benefits against privacy concerns and potential harms in order to maintain public trust through transparency in and accountability for data-handling practices.

Conclusions



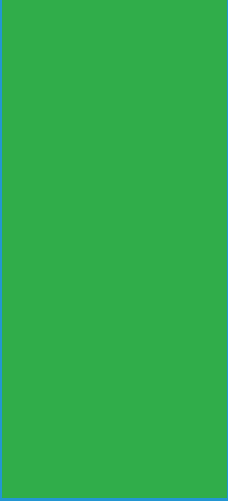
Conclusions

WES is an emerging public health tool that raises distinct ethical considerations. The implementation of WES often requires a collaborative, multisectoral approach and will benefit from governance frameworks that include mechanisms for ensuring ethical oversight and collecting feedback through community engagement. The implementation of WES should be guided by ethical principles, including respect for persons, justice and equity, and proportionality. Proportionate WES programmes are expected to have benefits that outweigh any related harms or negative effects.

The ethical acceptability of WES programmes and the public health actions linked to data from them depends on clearly articulated aims and a realistic assessment of the benefits versus the potential harms. Potential privacy infringements and harms, such as stigmatization, should be evaluated and minimized, especially when WES is used alone or in combination with other public health actions for highly localized surveillance, or when it is linked to restrictive public health measures. Assessments of the benefits and harms of WES should also evaluate equity, for example in terms of the distribution of benefits and harms across relevant populations. Reciprocal support should be provided to communities that experience harms or other burdens related to the surveillance.

Well designed WES can promote health equity, provided that it is linked to public health actions that benefit disadvantaged groups. While WES may provide valuable population-level health data with only a minimal direct burden on individuals, in certain instances the surveillance may also provide highly sensitive data about subpopulations, or when combined with other data or case-finding activities, result in the identification of specific individuals. To promote privacy and respect for individuals, data-sharing policies should be developed that permit the use of data from WES to produce public health benefits while limiting excessive infringements of privacy or restrictions on liberty.

Ethically acceptable WES programmes require the development of transparent policies for data collection and data-sharing, as well as mechanisms to encourage meaningful public engagement and ensure accountability. As WES continues to evolve, it will be essential to ensure it is ethically implemented to maintain public trust and realize its public health potential, while respecting the interests of the populations subject to surveillance.



References



References³

1. Wastewater-based disease surveillance for public health action. Washington (DC): National Academies Press; 2023 (<https://doi.org/10.17226/26767>).
2. Increasing the utility of wastewater-based disease surveillance for public health action: a phase 2 report. Washington (DC): National Academies Press; 2024 (<https://doi.org/10.17226/27516>).
3. Parkins MD, Lee BE, Acosta N, Bautista M, Hubert CR, Hrudey SE et al. Wastewater-based surveillance as a tool for public health action: SARS-CoV-2 and beyond. Clin Microbiol Rev. 2024;37(1):e0010322 (<https://doi.org/10.1128/cmr.00103-22>).
4. Castiglioni S, Thomas KV, Kasprzyk-Hordern B, Vandam L, Griffiths P. Testing wastewater to detect illicit drugs: state of the art, potential and research needs. Sci Total Environ. 2014;487:613–20 (<https://doi.org/10.1016/j.scitotenv.2013.10.034>).
5. WHO guidelines on ethical issues in public health surveillance. Geneva: World Health Organization; 2017 (<https://www.who.int/publications/i/item/9789241512657>). Licence: CC BY-NC-SA 3.0 IGO.
6. Viral disease surveillance: monitoring of circulation of poliovirus in waste water. Wkly Epidemiol Rec. 1981;56(14):105 (<https://iris.who.int/handle/10665/223441>).
7. Guidelines for environmental surveillance of poliovirus circulation. Geneva: World Health Organization; 2003 (<https://iris.who.int/handle/10665/67854>).
8. Global polio surveillance action plan 2022–2024. Geneva: World Health Organization; 2022 (<https://iris.who.int/handle/10665/354479>). Licence: CC BY-NC-SA 3.0 IGO.
9. World Health Organization, Global Polio Eradication Initiative. Field guidance for the implementation of environmental surveillance for poliovirus. Geneva: World Health Organization; 2023 (<https://iris.who.int/handle/10665/368833>). Licence: CC BY-NC-SA 3.0 IGO.
10. Environmental surveillance for SARS-CoV-2 to complement public health surveillance: interim guidance, 14 April 2022. Geneva: World Health Organization; 2022 (WHO/HEP/ECH/WSH/2022.1; <https://iris.who.int/handle/10665/353158>). Licence: CC BY-NC-SA 3.0 IGO.
11. Environmental surveillance for SARS-CoV-2 to complement other public health surveillance. Geneva: World Health Organization; 2023 (<https://iris.who.int/handle/10665/372995>). Licence: CC BY-NC-SA 3.0 IGO.
12. Wastewater and environmental surveillance for one or more pathogens: guidance on prioritization, implementation and integration. Pilot version. Geneva: World Health Organization; 2024 (<https://www.who.int/publications/m/item/wastewater-and-environmental-surveillance-for-one-or-more-pathogens--guidance-on-prioritization--implementation-and-integration>).
13. Considerations for wastewater and environmental surveillance for monkeypox virus: interim guidance, 25 November 2024. Geneva: World Health Organization; 2024 (<https://iris.who.int/handle/10665/379619>). Licence: CC BY-NC-SA 3.0 IGO.
14. Wastewater and environmental surveillance: summary for poliovirus, pilot version, 6 December 2024. Geneva: World Health Organization; 2024 (https://cdn.who.int/media/docs/default-source/wash-documents/wash-related-diseases/wes-summary-for-poliovirus---pilot-version-6dec2024.pdf?sfvrsn=893e67a8_3).

³ All references were accessed on 30 May 2025.

15. Wastewater and environmental surveillance: summary for SARS-CoV-2, pilot version, 6 December 2024. Geneva: World Health Organization; 2024 (<https://www.who.int/publications/m/item/wastewater-and-environmental-surveillance--summary-for-sars-cov-2>).
16. Wastewater and environmental surveillance: summary for typhoid and paratyphoid, pilot version, 6 December 2024. Geneva: World Health Organization; 2024 (<https://www.who.int/publications/m/item/wastewater-and-environmental-surveillance--summary-for-typhoid-and-paratyphoid>).
17. Wastewater and environmental surveillance: summary for influenza, pilot version, 6 December 2024. Geneva: World Health Organization; 2024 (<https://www.who.int/publications/m/item/wastewater-and-environmental-surveillance---summary-for-influenza>).
18. Wastewater and environmental surveillance: summary for cholera, pilot version, 6 December 2024. Geneva: World Health Organization; 2024(<https://www.who.int/publications/m/item/wastewater-and-environmental-surveillance--summary-for-cholera>).
19. Grassly NC, Shaw AG, Owusu M. Global wastewater surveillance for pathogens with pandemic potential: opportunities and challenges. *Lancet Microbe*. 2025;6(1):100939 (<https://doi.org/10.1016/j.lanmic.2024.07.002>).
20. Kilaru P, Hill D, Anderson K, Collins MB, Green H, Kmush BL et al. Wastewater surveillance for infectious disease: a systematic review. *Am J Epidemiol*. 2023;192(2):305–22 (<https://doi.org/10.1093/aje/kwac175>).
21. Wong JCC, Tay M, Hapuarachchi HC, Lee B, Yeo G, Maliki D et al. Case report: Zika surveillance complemented with wastewater and mosquito testing. *EBioMedicine*. 2024;101:105020 (<https://doi.org/10.1016/j.ebiom.2024.105020>).
22. Adams C, Kirby AE, Bias M, Riser A, Wong KK, Mercante JW et al. Detecting Mpox cases through wastewater surveillance – United States, August 2022–May 2023. *MMWR Morb Mortal Wkly Rep*. 2024;73(2):37–43 (<https://doi.org/10.15585/mmwr.mm7302a3>).
23. Keshaviah A, Diamond MB, Wade MJ, Scarpino SV, Ahmed W, Amman F, et al. Wastewater monitoring can anchor global disease surveillance systems. *Lancet Glob Health*. 2023;11(6):e976–e81 ([https://doi.org/10.1016/s2214-109x\(23\)00170-5](https://doi.org/10.1016/s2214-109x(23)00170-5)).
24. Venkatesan AK, Halden RU. Wastewater treatment plants as chemical observatories to forecast ecological and human health risks of manmade chemicals. *Sci Rep*. 2014;4(1):3731 (<https://doi.org/10.1038/srep03731>).
25. Allen T, Selgelid MJ. Necessity and least infringement conditions in public health ethics. *Med Health Care Philos*. 2017;20:525–35 (<https://doi.org/10.1007/s11019-017-9775-0>).
26. Jamrozik E. Public health ethics: critiques of the “new normal”. *Monash Bioeth Rev*. 2022;40(1):1–16 (<https://doi.org/10.1007/s40592-022-00163-7>).
27. Upshur RE. Principles for the justification of public health intervention. *Can J Public Health*. 2002;93:101–3 (<https://link.springer.com/article/10.1007/BF03404547>).
28. WHO data principles [website]. Geneva: World Health Organization; 2025 (<https://www.who.int/data/principles/>).
29. Childress JF, Faden RR, Gaare RD, Gostin LO, Kahn J, Bonnie RJ, et al. Public health ethics: mapping the terrain. *J Law Med Ethics*. 2002;30(2):170–8 (<https://doi.org/10.1111/j.1748-720x.2002.tb00384.x>).
30. Kass NE. Public health ethics: from foundations and frameworks to justice and global public health. *J Law Med Ethics*. 2004;32(2):232–42 (<https://doi.org/10.1111/j.1748-720x.2004.tb00470.x>).

31. Ram JL, Shuster W, Gable L, Turner CL, Hartrick J, Vasquez AA, et al. Wastewater monitoring for infectious disease: intentional relationships between academia, the private sector, and local health departments for public health preparedness. *Int J Environ Res Public Health*. 2023;20(17):6651 (<https://doi.org/10.3390/ijerph20176651>).
32. Nascimento de Lima P, Karr S, Lim JZ, Vardavas R, Roberts D, Kessler A, et al. The value of environmental surveillance for pandemic response. *Sci Rep*. 2024;14(1):28935 (<https://doi.org/10.1038/s41598-024-79952-5>).
33. Mercier E, Pisharody L, Guy F, Wan S, Hegazy N, D'Aoust PM, et al. Wastewater-based surveillance identifies start to the pediatric respiratory syncytial virus season in two cities in Ontario, Canada. *Front Public Health*. 2023;11:1261165 (<https://doi.org/10.3389/fpubh.2023.1261165>).
34. NEA leads scientific team in wastewater surveillance trials for assessment of COVID-19 transmission [website]. Singapore: National Environment Agency; 2020 (<https://www.nea.gov.sg/media/news/news/index/nea-leads-scientific-team-in-wastewater-surveillance-trials-for-assessment-of-covid-19-transmission>).
35. Molldrem S, Hussain MI, McClelland A. Alternatives to sharing COVID-19 data with law enforcement: recommendations for stakeholders. *Health Policy*. 2021;125(2):135–40 (<https://doi.org/10.1016/j.healthpol.2020.10.015>).
36. Decision-making for pandemics: an ethics framework. Canberra: National Health and Medical Research Council; 2021 (<https://www.nhmrc.gov.au/file/17452/download?token=a363M PE>).
37. Betancourt WQ, Schmitz BW, Innes GK, Prasek SM, Brown KMP, Stark ER, et al. COVID-19 containment on a college campus via wastewater-based epidemiology, targeted clinical testing and an intervention. *Sci Total Environ*. 2021;779:146408 (<https://doi.org/10.1016/j.scitotenv.2021.146408>).
38. Harris-Lovett S, Nelson KL, Beamer P, Bischel HN, Bivins A, Bruder A, et al. Wastewater surveillance for SARS-CoV-2 on college campuses: initial efforts, lessons learned, and research needs. *Int J Environ Res Public Health*. 2021;18(9):4455 (<https://doi.org/10.3390/ijerph18094455>).
39. Willison DJ, Ondrusek N, Dawson A, Emerson C, Ferris LE, Saginur R, et al. What makes public health studies ethical? Dissolving the boundary between research and practice. *BMC Med Ethics*. 2014;15:61 (<https://doi.org/10.1186/1472-6939-15-61>).
40. National wastewater drug monitoring program: report 22. Canberra: Australian Criminal Intelligence Commission; 2024 (<https://www.acic.gov.au/publications/national-wastewater-drug-monitoring-program-reports/report-22-national-wastewater-drug-monitoring-program>).
41. Olstein AM. The next abortion fight could be over wastewater regulation [online news source]. Politico. 23 November 2022 (<https://www.politico.com/news/2022/11/23/abortion-pills-opponents-environmental-laws-00070603>).
42. Atoui A, Jourdain F, Mouly D, Cordevant C, Chesnot T, Gassilloud B. A review on mpox (monkeypox) virus shedding in wastewater and its persistence evaluation in environmental samples. *Case Stud Chem Envir Eng*. 2023;7:100315 (<https://doi.org/10.1016/j.cscee.2023.100315>).
43. Mello MM, Meschke JS, Palmer GH. Mainstreaming wastewater surveillance for infectious disease. *N Engl J Med*. 2023;388(16):1441–4 (<https://doi.org/10.1056/nejmp2301042>).
44. Shen M, Zhang L. The third generation modified vaccinia Ankara vaccine is effective in preventing the transmission of mpox. *Lancet Reg Health Eur*. 2024;45:101052 (<https://doi.org/10.1016/j.lanepe.2024.101052>).

45. Lee JH, Sim G, Park HJ, Lee M, Yi H, Chung Y-S. Monkeypox virus detection using wastewater surveillance during the Mpox outbreak in the Republic of Korea. *J Environ Chem Eng*. 2024;12(6):114775 (<https://doi.org/10.1016/j.jece.2024.114775>).
46. Wolfe MK, Varkila MR, Zulli A, Parsonnet J, Boehm AB. Detection and quantification of human immunodeficiency virus-1 (HIV-1) total nucleic acids in wastewater settled solids from two California communities. *Appl Environ Microbiol*. 2024;90(12):e0147724 (<https://doi.org/10.1128/aem.01477-24>).
47. Update: wastewater poliovirus detections in the EU: a call for continued surveillance and maintaining high vaccination coverage rates [website]. European Centre for Disease Prevention and Control; 2024 (<https://www.ecdc.europa.eu/en/news-events/update-wastewater-poliovirus-detections-eu-call-continued-surveillance-and-maintaining>).
48. Diamond MB, Yee E, Bhinge M, Scarpino SV. Wastewater surveillance facilitates climate change-resilient pathogen monitoring. *Sci Transl Med*. 2023;15(718):eadi7831 (<https://doi.org/10.1126/scitranslmed.adi7831>).
49. Boehm AB, Hughes B, Duong D, Chan-Herur V, Buchman A, Wolfe MK, et al. Wastewater concentrations of human influenza, metapneumovirus, parainfluenza, respiratory syncytial virus, rhinovirus, and seasonal coronavirus nucleic-acids during the COVID-19 pandemic: a surveillance study. *Lancet Microbe*. 2023;4(5):e340–8 ([https://doi.org/10.1016/s2666-5247\(22\)00386-x](https://doi.org/10.1016/s2666-5247(22)00386-x)).
50. Ishtiaq F. Wastewater-based surveillance of vector-borne pathogens: a cautionary note. *Trends Parasitol*. 2024;40(2):93–5 (<https://doi.org/10.1016/j.pt.2023.12.005>).
51. Gahlot P, Alley KD, Arora S, Das S, Nag A, Tyagi VK. Wastewater surveillance could serve as a pandemic early warning system for COVID-19 and beyond. *WIREs Water*. 2023;10(4):e1650 (<https://doi.org/10.1002/wat2.1650>).
52. Murni IK, Oktaria V, Handley A, McCarthy DT, Donato CM, Nuryastuti T, et al. The feasibility of SARS-CoV-2 surveillance using wastewater and environmental sampling in Indonesia. *PLoS One*. 2022;17(10):e0274793 (<https://doi.org/10.1371/journal.pone.0274793>).
53. WHO guideline on contact tracing. Geneva: World Health Organization; 2024 (<https://iris.who.int/handle/10665/380060>).
54. Parker M. Ethical hotspots in infectious disease surveillance for global health security: social justice and pandemic preparedness. In: Wilkinson D, Savulescu J, editors. *Pandemic ethics: from COVID-19 to disease X*. Oxford: Oxford Academic; 2023:277–94 (<https://doi.org/10.1093/oso/9780192871688.003.0014>).
55. Parasidis E, Fairchild AL. Closing the public health ethics gap. *N Engl J Med*. 2022;387(11):961–3 (<https://doi.org/10.1056/nejmp2207543>).
56. Holm RH, Chigwechokha P, Kinnear C, Winters A, Street R. Promoting surveillance in sub-Saharan Africa: moving to wastewater and environmental genomic surveillance requires more attention. *ACS EST Water*. 2023;3(8):1994–6 (<https://doi.org/10.1021/acsestwater.3c00314>).
57. Corrigan PW, editor. *The stigma of disease and disability: understanding causes and overcoming injustices*. Washington (DC): American Psychological Association; 2014 (<https://psycnet.apa.org/doiLanding?doi=10.1037%2F14297-000>).
58. Paterson A, Olliaro PL, Rojek A. Addressing stigma in infectious disease outbreaks: a crucial step in pandemic preparedness. *Front Public Health*. 2023;11:1303679 (<https://doi.org/10.3389/fpubh.2023.1303679>).
59. WHO guidelines for the safe use of wastewater, excreta and greywater. Volume 4: excreta in greywater use in agriculture. Geneva: World Health Organization; 2006 (<https://iris.who.int/handle/10665/78265>).

60. Jiménez B. Irrigation in developing countries using wastewater. *Int Rev Environ Strategies*. 2006;6(2):229–50 (<https://www.iges.or.jp/en/pub/irrigation-developing-countries-using/en>).
61. Paterson A, Cheyne A, Tulunay H, Orkin C, Nutland W, Dunning J, et al. Mpox stigma in the UK and implications for future outbreak control [preprint]. *Research Square*; 2025 (<https://doi.org/10.21203/rs.3.rs-5704043/v1>).
62. Holm S. A general approach to compensation for losses incurred due to public health interventions in the infectious disease context. *Monash Bioeth Rev*. 2020;38(Suppl. 1):32–46 (<https://doi.org/10.1007/s40592-020-00104-2>).
63. Eyal N, Hurst SA, Murray CJL, Schroeder SA, Wikler D, editors. *Measuring the global burden of disease: philosophical dimensions*. Oxford: Oxford Academic; 2020 (<https://doi.org/10.1093/med/9780190082543.001.0001>).
64. Solove DJ. Conceptualizing privacy. *Calif Law Rev*. 2002;90:1087–1155 (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=313103).
65. Moore B. The detection of enteric carriers in towns by means of sewage examination. *J R Sanit Inst*. 1951;71(1):57–60 (<https://doi.org/10.1177/146642405107100109>).
66. Macuga M. Transparency as a double-edged sword: public health ethics perspective. *Diametros*. 2025;22(82):28–36 (<https://doi.org/10.33392/diam.2001>).
67. Health in all policies: Helsinki statement. Framework for country action. Geneva: World Health Organization; 2014 (<https://www.who.int/publications/i/item/9789241506908>). Licence: CC BY-NC-SA 3.0 IGO.
68. International Health Regulations (2005), third edition. Geneva: World Health Organization; 2016 (<https://iris.who.int/handle/10665/246107>). Licence: CC BY-NC-SA 3.0 IGO.
69. Li J, Hosegood I, Powell D, Tschärke B, Lawler J, Thomas KV, et al. A global aircraft-based wastewater genomic surveillance network for early warning of future pandemics. *Lancet Glob Health*. 2023;11(5):e791–5 ([https://doi.org/10.1016/S2214-109X\(23\)00129-8](https://doi.org/10.1016/S2214-109X(23)00129-8)).
70. Ontario Agency for Health Protection and Promotion. A framework for the ethical conduct of public health initiatives. Toronto: Queen's Printer for Ontario; 2012 (<https://jcb.utoronto.ca/wp-content/uploads/2021/03/framework-ethical-conduct.pdf>).
71. Pipek OA, Medgyes-Horváth A, Dobos L, Stéger J, Szalai-Gindl J, Visontai D, et al. Worldwide human mitochondrial haplogroup distribution from urban sewage. *Sci Rep*. 2019;9(1):11624 (<https://doi.org/10.1038/s41598-019-48093-5>).
72. Jacobs D, McDaniel T, Varsani A, Halden RU, Forrest S, Lee H. Wastewater monitoring raises privacy and ethical considerations. *IEEE Trans Technol Soc*. 2021;2(3):116–21 (<https://doi.org/10.1109/TTS.2021.3073886>).
73. Boger N, Ozer M. Monitoring sewer systems to detect the eDNA of missing persons and persons of interest. *Forensic Sci Int*. 2023;349:111744 (<https://doi.org/10.1016/j.forsciint.2023.111744>).
74. Sharara N, Endo N, Duvallet C, Ghaeli N, Matus M, Heussner J, et al. Wastewater network infrastructure in public health: applications and learnings from the COVID-19 pandemic. *PLOS Glob Public Health*. 2021;1(12):e0000061 (<https://doi.org/10.1371/journal.pgph.0000061>).
75. Polio eradication: the CIA and their unintended victims. *Lancet*. 2014;383:1862 ([https://doi.org/10.1016/S0140-6736\(14\)60900-4](https://doi.org/10.1016/S0140-6736(14)60900-4)).

Annex 1



Annex 1.

The checklist in this Annex presents a standardized approach to guide wastewater and environmental surveillance (WES) practitioners in ethical assessments of such programmes (Table A1.1).

Table A1.1. Checklist for ethical assessments of wastewater and environmental surveillance programmes

Ethical questions	Response		
	Yes	No	NA
1. Aims of WES			
Have the health issues to be monitored by WES been defined (e.g. the infectious diseases, drugs or toxins)?			
Has the target population been defined?			
Has the public health goal of WES been defined (e.g. monitoring, disease reduction, disease elimination)?			
Has a process for scientific and ethical review of WES been implemented?			
2. Potential benefits of WES			
Have links between WES and public health actions been defined? (Actions include, for example, developing public health messaging, allocating resources, devising vaccine strategies, or implementing epidemic control measures or emergency preparedness activities.)			
Is there a process for integrating WES into existing surveillance systems, if any and if necessary?			
3. Potential harms of WES and risk mitigation			
Have the potential harms (i.e. risks) been assessed (e.g. stigmatization, economic harms, mental health harms, mistrust in health agencies)?			
Is there a plan for risk minimization?			
Is there a plan to provide reciprocal support to individuals or communities that experience harms?			
4. Proportionality			
Has there been an assessment that the expected benefits of WES outweigh the expected harms and any other negative effects?			

Ethical questions	Response		
	Yes	No	NA
5. Equity and justice			
Have the reasons for including or excluding relevant populations been assessed?			
Has the distribution of benefits and burdens across relevant populations been assessed?			
Has an assessment been conducted to determine whether benefits or harms will be concentrated among disadvantaged groups?			
6. Respect for persons			
Is there a plan for public engagement (e.g. for informing the public about WES, to assess public acceptability, to provide mechanisms for feedback)?			
Have potential privacy infringements been assessed?			
Are there appropriate policies for accountability and transparency?			
Will WES be linked with restrictive public health measures (e.g. building-level quarantine orders)?			
Will individuals be identifiable (e.g. if data from WES are combined with other data or case-finding)?			
7. Data and sample stewardship			
Is the ownership of data and samples clearly defined?			
Will data or samples be shared for public health research?			
If the data will be shared with other nations or international agencies, is there a clear and defined aim?			
If data will be shared for research, is there a plan for ethical oversight of data-sharing?			
Will data or samples from WES be shared for purposes unrelated to public health?			

NA: not applicable; WES: wastewater and environmental surveillance.

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