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2021

Ethics Guidance for Environmental Scientists Engaged in Surveillance of Wastewater for SARS- CoV-2

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Cite This: *Environ. Sci. Technol.* 2021, 55, 8484–8491



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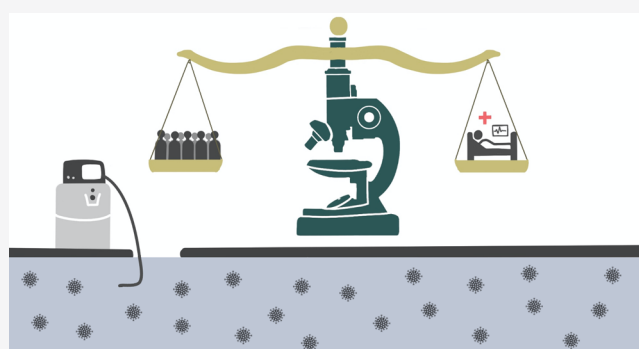
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ABSTRACT: The COVID-19 pandemic has given rise to rapid and widespread international pursuit of wastewater surveillance for genetic signals of SARS-CoV-2, the virus causing the pandemic. Environmental scientists and engineers familiar with the techniques required for this endeavor have responded. Many of the environmental scientists engaged in these investigations have not necessarily had experience with the ethical obligations associated with generating and handling human health data. The Canadian Water Network facilitated adoption of these surveillance methods by creating a national coalition, which included a public health advisory group that recognized a need for ethics guidance for the wastewater approach to public health surveillance. This Policy Analysis addresses that need and is based on a review of relevant ethics literature tightly focused on ethics applicable to public health surveillance. That review revealed that classical health bioethics governing clinical practice and general public health ethics guidance did not adequately address key issues in wastewater surveillance. The 2017 World Health Organization guidelines, directly based on a systematic literature review, specifically addressed ethical issues in public health surveillance. The application of relevant ethical guidance to wastewater surveillance is analyzed and summarized for environmental scientists.

KEYWORDS: COVID-19, virus, sewage, public health, bioethics



INTRODUCTION

The COVID-19 pandemic has become the most pervasive public health crisis in higher income nations since the 1918 influenza pandemic over a century ago. An unprecedented international research effort directed at all aspects of SARS-CoV-2, the virus responsible, has followed.

Environmental scientists have appropriately had a direct role in exploring routes of SARS-CoV-2 exposure.^{1–6} The COVID-19 pandemic has also brought a rapidly accelerating focus (www.covid19wbec.org/covidpops19) on what was previously a specialty research area: monitoring of pathogenic agents in municipal wastewater (sewage). This field has come to be termed wastewater-based epidemiology.⁷ While the mobilization of environmental science talent and expertise toward the current public health crisis is impressive and valuable, the role of environmental scientists in supplying environmental monitoring evidence to directly inform epidemic management by public health agencies is likely new territory for many. In particular, one of the elements that this work involves, the ethical requirements associated with the collection and dissemination of data related to human health outcomes, has to be well understood by

researchers in the health sciences, but specific concerns may not be recognized or understood by all environmental scientists.

The Canadian Water Network (CWN), a not-for-profit knowledge broker, responded to the pandemic challenge by launching the Canadian COVID-19 Wastewater Coalition (<https://cwn-rce.ca/covid-19-wastewater-coalition/>). This coalition facilitated collaboration among researchers, wastewater utilities, and public health authorities to evaluate and implement wastewater-based epidemiology, where feasible. From the outset, it was clear that the majority of laboratory personnel who would generate data measuring the genetic signals of SARS-CoV-2 in wastewater were analytical chemists/molecular biologists and environmental engineers, our key target group for knowledge transfer about public health surveillance ethics.

Received: January 15, 2021

Revised: May 13, 2021

Accepted: May 14, 2021

Published: June 8, 2021



■ POLICY ANALYSIS

The need to consider ethics was adopted by CWN with its first-principles to guide pilot projects in wastewater-based epidemiology that were established as part of the initial framing of the COVID-19 Wastewater Coalition. This need was stated as follows:⁸

“Consider ultimate use and ethics of data use in public health decision-making. The ultimate objective of informing public health decision-making demands that decision makers are actively engaged in study planning and implementation. Full consideration must be given from the outset to how the wastewater monitoring data is likely to be disseminated and used. This will inevitably invoke ethical considerations in data collection, availability and use. Ethical concerns will likely become greater when the number of contributing individuals in a community or institution is smaller.”

The University of Arizona^{9–11} and others have monitored sewers on campus to detect COVID outbreaks in student residences. The public health benefits of achieving early detection of COVID outbreaks is self-evident, but the ethical considerations for management of such surveillance data for an identifiable contributing population needs attention and was not explicitly addressed in the literature.

As media interest and coverage of the results of SARS-CoV-2 wastewater work grew, with speculations about what the analytical results meant for community risk and action, the need for more explicit guidance, directly focused on the nature of wastewater-based epidemiology for surveillance of SARS-CoV-2 in wastewater was needed. A public health advisory group of experts, including 3 public health physicians, 2 health ethicists, a medical microbiologist, a public health practice academic, and an environmental health scientist was appointed by CWN to review the issues and develop ethics guidance specifically on this topic.⁸

A review of the public health ethics literature, tightly focused on public health surveillance, was performed to establish the relevant knowledge-base discussed in this paper. Specifically, wastewater-based epidemiology is logically viewed as a contributing element of public health surveillance, so we chose to focus on ethics applicable to public health surveillance within the broader context of public health and bioethics. Although much of what has been written in various jurisdictions focuses on legal requirements, our attention has been guided by our concern that the ultimate goal of wastewater-based epidemiology should be to inform public health decision-making to respond more effectively to a pandemic. Public trust and confidence in such measures are critical to achieving widespread societal acceptance and adoption of scientifically determined measures; however, as experience with public health measures in response to the current pandemic has unfortunately demonstrated, such public trust may be lacking.¹² For example, mixed messages about the merits of widespread use of face masks to reduce the spread of COVID-19 has apparently contributed to inconsistent adoption of this practical measure to limit community spread. In parallel, public trust in public health decision-makers delivering appropriate information is critical. From a pragmatic perspective, risk exists that actions by public health authorities or by their environmental science collaborators that may be perceived as unethical could ultimately undermine public trust and, thereby, the effectiveness of essential public health measures.

The foundations of modern bioethics have developed and evolved in large measure from moral principles¹³ as first articulated most notably by Beauchamp and Childress in the 1970s, often used as a primary reference text on bioethics.¹⁴ These articulated moral principles are autonomy (respect for self-determination to make decisions about an individual's own life), nonmaleficence (inflicting the least harm possible to reach a beneficial outcome), beneficence (seeking the overall welfare of the affected population), and justice (nondiscrimination and fair adjudication of benefits and burdens). Despite the pervasive impact of these foundations on the bioethics of clinical practice and research, the limits of the moral principles framework when faced with the realities of public health practice become apparent when practical considerations for implementation present themselves.^{13,15–17} The conflicts between public and individual interests are likely associated with the principle of autonomy and its obligations for obtaining individual informed consent when implementing general population-wide measures. Other distinctions follow from the specificity of measures involved with individual medical interventions (surgery, drug therapy, etc.) versus population level public health interventions that involve law and public policy. The current pandemic conditions reveal the practical limitations of medical interventions and the challenges of achieving public cooperation for implementing effective public health interventions, even comparatively nondemanding measures like wearing masks in public spaces. A review of public health ethics experience¹⁸ in responding to the first SARS epidemic in 2003 reveals that even a commitment that is shared with clinical practice, to base decisions on evidence, will encounter severe challenges in responding effectively to an emerging epidemic because of inherent uncertainty about key evidence and the manner in which individual values influence personal decision-making. For individual interventions, such uncertainty can be addressed by allowing individuals to provide their consent to undergo uncertain experimental treatments, consent that cannot be practically obtained for general population interventions.

Public health ethics overall and more specific applications to a wide range of public health activities are addressed by the recently updated Code of Ethics for the American Public Health Association.¹⁹ This Code includes many ethical domains that are informative for the pursuit of wastewater-based epidemiology, some of which will appear in specific guidance following. Four important components are outlined for the ethical analysis of any proposed public health action:¹⁹

- “Determination of the public health goals of the proposed action
- Identification of the ethically relevant facts and uncertainties
- Analysis of the meaning and implications of the action for the health and rights of affected individuals and communities
- Analysis of how the proposed action fits with core public health values.”

However, of the 12 domains provided, surveillance, as such, is explicitly mentioned only once in this otherwise comprehensive ethics guidance document, under the second domain:¹⁹

“Investigate health problems and environmental public health hazards to protect the community.”

Fairchild and Bayer²⁰ addressed public health surveillance but largely through the lens of whether or not surveillance could be considered to be research, given that ethics requirements for

health research were already institutionally embraced. They noted that various agencies had considered surveillance to be exempt from formal ethics requirements on a variety of pragmatic grounds, notably economics in the case of the World Bank. In contrast, they observe the reality that the ethics of public health surveillance will inevitably encounter tension between claims of individual rights versus the common good. Under these inevitable circumstances, simple rules will not suffice. Rather there is a need for an open dialogue that will encounter valid concerns for individual interests that are potentially in conflict with surveillance intended to serve the well-being of the population.

Desy et al.²¹ described a tool for preparing plans for public health surveillance that, under requirements of Quebec's Public Health Act, must be submitted to a provincial public health ethics committee. This proposed tool includes addressing the ethical dimensions of proportionality, usefulness, transparency, representativeness, equity, participation, independence, stigmatization, privacy, informed consent, and understandability.

Prichard et al.²² prepared ethical guidelines for wastewater-based epidemiology, which according to the title, should be directly applicable to the task we are addressing. However, their analysis is directed at a different concept of wastewater-based epidemiology which they described as being used for²²

"a wide variety of purposes that include estimating: rates of consumption of illicit drugs, alcohol, tobacco, elicit pharmaceuticals and foodstuffs; human exposure to pollutants"

This self-defined focus does not align with the ethical dimensions of public health surveillance that we recognize as being central to evaluating the presence of SARS-CoV-2 in wastewater.

Gable et al.²³ have considered legal and ethical implications of wastewater surveillance for SARS-CoV-2, but their analysis has primarily addressed constitutional and legal issues arising from this approach to public health surveillance rather than fundamental ethical issues that would provide guidance for environmental health scientists performing wastewater surveillance.

Klingler et al.²⁴ performed a systematic literature review of ethical issues in public health surveillance to provide a knowledge base for development of World Health Organization (WHO) guidelines on ethical issues in public health surveillance.²⁵ We judged the cited sources and the resulting WHO guidance to be the most directly relevant for determining ethics guidance applicable to surveillance for SARS-CoV-2 in wastewater.

RESULTS

The introduction to the WHO guidelines²⁵ confirms the relevance of applying them to ethics guidance for surveillance for SARS-CoV-2 in wastewater because this introduction addresses communicable diseases for early detection, trend and spatial analysis, and detection of risk by use of secondary data sources that we believe includes wastewater surveillance. This summary²⁵ also lists "*Estimation of incidence or prevalence*" under types of analyses. There would clearly be value if wastewater surveillance could achieve such estimation, but the reality is that there is considerable uncertainty in the underlying evidence that will need to be resolved in order to achieve reliable estimates, including comparative rates of faecal shedding of SARS-CoV-2 among infected individuals that would be functions of status of infection (pre-symptomatic vs sympto-

matic vs asymptomatic), time since infection, the distribution and stability of SARS-CoV-2 genetic signals in sewer networks, and the quantitative comparability of results obtained across surveillance networks.

We have chosen to focus upon four foundational premises from the WHO guidelines²⁵ and we have summarized these as follows:⁸

1. **"Common good:** Surveillance is acknowledged to be a common good²⁶ and its benefits are fundamentally shared and cannot be subdivided into individual private benefits.^{27,28}"
2. **"Equity:** This is ensuring the just distribution of socioeconomic benefits and burdens across a group or population, often in accordance with need and merit. Equity is a central concern for public health ethics, recognizing that social inequality has adverse effects on health.²⁹"
3. **"Respect for persons:** Sometimes referred to as "dignity," this is the recognition of the inherent worth of all persons by virtue of being a person. This consideration recognizes that the rights, liberties and other interests of individuals are important, in addition to overall population well-being. Individuals should be involved in decisions that affect them whenever possible."
4. **"Good governance:** Not specifically an ethical principle, good governance is a sound political aspiration that is subject to several ethical considerations. This includes accountability, transparency and community engagement."

WHO²⁵ proposed 17 guidelines that establish "*the duty to conduct surveillance, share data and engage communities transparently, while recognizing the limits of that mandate.*" Our analysis determined that 14 of these are directly applicable to our focus and these are discussed in terms of the specific nature of wastewater surveillance for SARS-CoV-2. The applicability of the WHO²⁵ guidelines to wastewater-based epidemiology, particularly in reference to how they inform the actions of individual investigators, is discussed for each of the identified WHO guidelines using their original guideline numbers and their²⁵ verbatim text descriptions for each guideline.

Guideline 1. Countries have an obligation to develop appropriate, feasible, sustainable public health surveillance systems. Surveillance systems should have a clear purpose and a plan for data collection, analysis, use, and dissemination based on relevant public health priorities. Clearly this guideline must be applied to wastewater-based epidemiology. Although there may be a case to be made for exploratory sampling to evaluate the feasibility and capability to reliably detect SARS-CoV-2 in wastewater, results from such preliminary work should not be prematurely presented as having meaning for public health interventions. For the specific case of SARS-CoV-2 being detected in wastewater derived from a source not known to have any clinical cases, such a finding may be important for public health authorities, but reliance should not be placed upon such data without replication and validation to be confident that the result is not a sampling or analytical anomaly.

Guideline 3. Surveillance data should be collected only for a legitimate public health purpose. International research findings^{7,30–32} about detecting genetic signals of SARS-CoV-2 before confirmation of infections from clinical testing could clearly be valuable to management of the pandemic satisfying

this requirement. We have observed⁸ that “much remains to be demonstrated before concluding that current investigations can provide reliable and effective early detection of COVID-19 outbreaks. A clear ethical obligation from this guideline is that rigorous and thorough validation of this approach by each and every investigative team is essential. Short cuts on method validation cannot be justified in the name of urgency.”³³ We propose that the scope of validation needed⁸ “will depend on the defined purposes of the study, including: prioritizing early detection of events, achieving accuracy and efficiency through reduction of false positives and harmonization of methods to improve data sharing arrangements.”²⁴

Guideline 4. Countries have an obligation to ensure that the data collected are of sufficient quality, including being timely, reliable, and valid, to achieve public health goals. Quality assurance and control need to be applied to the work of individual investigators and investigations, as well as being foundational ethical requirements for all research. Work toward part of this objective is being addressed by interlaboratory communications and performance studies.^{34–36} A review of these interlaboratory studies emphasizes that quality assurance and quality control protocols (including proper documentation and sample chain-of-custody) are critical to data integrity.

Guideline 7. The values and concerns of communities should be taken into account in planning, implementing, and using data from surveillance. We propose⁸ based on our experience that “Investigators capable of delivering valid surveillance of sewage for signals of SARS-CoV-2 are not normally equipped to assess and consider the values and concerns of communities about their activities. This guideline reinforces the imperative for such investigators to work closely with and be accountable to the responsible public health authorities and those who can best ensure their work engages with and is cognizant of community concerns and values. If investigators do recognize any such concerns and values to be addressed, including any perception of results unnecessarily being kept confidential, without justification, they should raise those concerns with public health authorities.”

Guideline 8. Those responsible for surveillance should identify, evaluate, minimize and disclose risks for harm before surveillance is conducted. Monitoring for harm should be continuous, and, when any identified, appropriate action should be taken to mitigate it. We propose⁸ based on our experience that “As with Guideline 7, investigators capable of delivering valid surveillance of sewage for signals of SARS-CoV-2 are not typically equipped with the skills and tools to enable them to identify, evaluate, minimize or disclose risks for harm from their surveillance activities. Consequently, this guideline also reinforces the imperative to work closely with and be accountable to the responsible public health authorities in identifying, evaluating, minimizing and disclosing risks” associated with generating and handling human health data. There is also a clear obligation on investigators to ensure that those involved in collecting and handling wastewater are fully informed about necessary risk management measures for protecting themselves from infection and workplace risks (e.g., confined space risks associated with sewer sampling)

Guideline 9. Surveillance of individuals or groups who are particularly susceptible to disease, harm, or injustice is critical and demands careful scrutiny to avoid the imposition of unnecessary additional burdens. There is evidence with COVID-19 that those susceptible to the disease, harm or injustice are already experiencing elevated rates of infection,

severe disease and higher mortality rates.³⁷ We note⁸ “that COVID-19 risks are higher for individuals with pre-existing health conditions that are also more prevalent in disadvantaged communities. Likewise, there are constraints on many individuals from such communities being able to limit their personal exposure to SARS-CoV-2 because of the nature of their living conditions, employment and access to preventive measures. These realities make it more likely that wastewater surveillance will detect signals of SARS-CoV-2 that has substantial contributions from disadvantaged communities. As noted in Guidelines 7 and 8, a close ongoing linkage to responsible public health authorities is imperative in these circumstances.”

A challenge to be aware of will be that not all local public health units will be fully capable to address all the ethical needs. Some may be prepared and ready to engage, having participated in past research initiatives and having adequate staff expertise and knowledge; others may have limited knowledge or understanding of the ethical implications—with little to no staff knowledge, expertise, and support. There are great differences in levels of experience and support found at local public health units. Investigators need to engage with public health units to identify and plan appropriate courses of action when dealing with these types of ethical issues. Both investigators and public health units must recognize the ethical importance of having a clear plan on how they intend to deal with the findings of the wastewater surveillance, particularly to avoid creating stigma or exacerbating existing stigma. Ultimately, the purpose of wastewater surveillance in response to the COVID pandemic is to improve the knowledge and understanding of public health agencies about the distribution of infection to better inform their ability to respond in a timely manner to reduce the transmission and adverse health consequences of the pandemic for the benefit of the community.

Guideline 10. Governments and others who hold surveillance data must ensure that identifiable data are appropriately secured. We propose⁸ based on our experience that “Investigators capable of competently pursuing surveillance of wastewater for signals of SARS-CoV-2 may not have direct experience with the management of human health information data and the high level of sensitivity that such data carries. Investigators pursuing this type of surveillance should recognize that the purpose of this work must be to assist public health decision-makers in managing the pandemic. Release of surveillance data to media personnel for coverage without the knowledge and approval of those public health decision-makers will, at a minimum, create an unwanted distraction from the challenging tasks of managing the pandemic. At worst, failing to maintain privacy might:

- (a) discriminate against and stigmatize those communities whose wastewater has been surveyed,
- (b) breach trust between marginalized communities and public health agencies, and/or
- (c) seriously undermine public confidence and jeopardize the effectiveness of measures that public health decision-makers are seeking to achieve to manage the pandemic.

In the face of such unfamiliarity a default position could be to treat such data with a similar level of security that individual health information data must be treated. Those requirements are regulated by privacy and specific health information security legislation in most jurisdictions.” Because aggregated public health data can offer an over-riding public benefit, a case can

generally be made for making such aggregated data more publicly available than the strong restrictions on any data that could be individually identifiable.^{38,39} We find⁸ that the balancing nature of “this obligation also reinforces the imperative of Guidelines 7, 8, and 9 requiring close linkage of investigators to responsible public health authorities.”

Guideline 11. Under certain circumstances, the collection of names or identifiable data is justified. On the basis of our experience, we believe⁸ that “Surveillance of wastewater for signals of SARS-CoV-2 should not require the collection of individual names. However, as the size of the population contributing to a sewer network being sampled decreases, the likelihood increases that surveillance results can be linked to small groups of individuals, creating a risk of personal identity being disclosed. This concern applies to surveillance of small communities, individual institutions or sampling within a sewer network draining from a small but geographically identifiable portion of a sewer network.” A small group of individuals could be identified as a source of infections based on sampling of a single building or a septic tank. Any of these circumstances must require higher levels of data security.

Guideline 12. Individuals have an obligation to contribute to surveillance when reliable, valid, complete data sets are required and relevant protection is in place. Under these circumstances, informed consent is not ethically required. We note⁸ that “Informed consent is a foundational element of public health and medical ethics. As outlined in the guidelines, the tension between individual rights to privacy and the common good can be resolved in favor of the latter when risks to the common good are compelling.” There is also an argument that a right to public health includes having a right to the benefits of public health measures like surveillance and, thereby, provides an aspect of autonomy.⁴⁰ Likewise, we find⁸ that although most circumstances “will not involve identification of individuals or groups of individuals, normal requirements for obtaining informed consent can be overridden by situations where the practicality of obtaining individual informed consent is not realistic for surveillance that does meet the common good threshold.²⁴”

Guideline 13. Results of surveillance must be effectively communicated to relevant target audiences. We note⁸ that “The preamble to the WHO guidelines emphasizes an imperative to engage communities transparently. There is no question that data from wastewater surveillance for SARS-CoV-2 must ultimately be communicated to the communities from which the data has been collected. However, a key phrase in this guideline is “effectively communicated”. These data cannot be effectively communicated until their meaning is first fully understood by those communicating the data” so that their meaning can be effectively conveyed.

We emphasize⁸ that “the kind of surveillance being implemented does not directly measure the presence of infective or even intact SARS-CoV-2; the monitoring methods measure genetic signals, as RNA fragments from the virus derived from its specific genetic code. The chance of false positives inherent to the monitoring methods being used is not high when competent, verifiable quality assurance/quality control (QA/QC) measures are followed. However, given the pervasive occurrence of SARS-CoV-2 in many locations across the globe, there is certainly a substantial risk of cross-contamination of samples during collection or processing unless rigorous QA/QC measures are followed and demonstrated. Because of the challenges of detecting small signals of SARS-CoV-2 in complex and variable

matrices like community sewage samples, the chance of false negatives is inherently higher than false positives.” False negatives (i.e., nondetect observations arising despite nonzero levels of SARS-CoV-2 in the wastewater source) are inevitable. Experimental design, sampling approach and imperfect analytical methods can collectively contribute to nondetect observations. Accordingly, the occurrence of nondetects do not necessarily indicate a community is void of SARS-CoV-2. Clearly, failure to detect signals of the virus in sewage samples does not ensure that there is no COVID-19 in the community.

We note⁸ that such caution equally applies to the absence of positive clinical tests, given the lack of universal and repetitive testing and the dynamics of SARS-CoV-2 occurrence in pre- and asymptomatic, as well as convalescent individuals. However, because public health officials are less likely to be familiar with the practical limitations of wastewater surveillance, investigators have a duty to fully inform and educate public health officials about the full implications of those limitations.

Whether such surveillance data (usually reported as a SARS-CoV-2 RNA concentration) is made available publicly via a dashboard or shared with data scientists and modelers for further analysis, there has been an overwhelming inclination to aggregate and interpret such data more broadly. However, the uniqueness of each community’s data set, which is subject to system/community specific biases that might preclude direct comparisons, ought to be recognized, acknowledged and communicated. Generators and holders of surveillance data have an obligation to work closely with public health data analysts to ensure that these secondary and tertiary uses of the data are appropriate and accurate. That obligation should also include honest efforts to ensure that affected communities are meaningfully engaged and consulted about how data about them is reported, recognizing available guidance on this task.^{41,42} Engaging the communities in a COVID wastewater surveillance project can empower citizens to identify and address needs in their communities. This activity poses clear challenges and will not be easy but is important to ensure thoughtful planning before starting a wastewater surveillance initiative.

Guideline 14. With appropriate safeguards and justification, those responsible for public health surveillance have an obligation to share data with other national and international public health agencies. We observe⁸ that “Because the pandemic is a global phenomenon and all nations are scrambling to understand as much as possible about the novel virus causing the COVID-19 pandemic, national and international sharing of knowledge is critical. In the case of wastewater surveillance for signals of SARS-CoV-2, European investigators initially led by an experienced team in the Netherlands have generated much of the international knowledge about this approach. The Netherlands, the European Union, France, Germany, Finland and England have implemented national wastewater surveillance programs. There are also numerous other programs underway, including in Australia, South Africa and across the United States. Canadian investigators are learning from and sharing with these international investigators who are extensively sharing information on their methodology and results. The obligation to reciprocate is compelling, subject to satisfaction of the constraints of all the other guidelines and interagency agreements. The details of how this would be done will be very context specific, but satisfying this guideline should not explicitly violate other guidelines.”

Guideline 15. During a public health emergency, it is imperative that all parties involved in surveillance share data

in a timely fashion. We note⁸ that “One of the strongest—if not the most compelling—reasons for pursuing wastewater surveillance for signals of SARS-CoV-2 is the potential to provide early warning of localized COVID-19 outbreaks in communities, institutions or parts of a community. That rationale cannot be effective unless fully validated results are rapidly communicated to public health authorities. This reality creates an inevitable tension between the time needed to validate surveillance results and the need for communication to public health decision-makers as rapidly as possible. Investigators working in medical and public health diagnostic testing are familiar with this explicit tension, but many investigators capable of pursuing wastewater surveillance have not had to deal with this previously. A fundamental understanding must be reached between investigators and public health decision-makers about how that tension will be managed to ensure that the latter receive fully validated results as soon as possible.”

As observed for other real-time, time-sensitive public health data generated throughout this pandemic, surveillance data initially reported to the public may also be subject to error. Efforts to disclose and communicate the implications of such errors to public health officials should also take place in a timely fashion, which is best facilitated by building honest and open channels of communication with public health officials.

Guideline 16. With appropriate justification and safeguards, public health agencies may use or share surveillance data for research purposes. We find⁸ that “Because so much is not known about COVID-19 and its cause, SARS-CoV-2, investigators are working to generate better understanding on all fronts. Wastewater surveillance for signals of SARS-CoV-2 has enormous potential to contribute to those knowledge needs. However, the full extent of knowledge that can be contributed in the long run is secondary to the immediate needs for early detection of COVID-19 outbreaks. Such secondary priorities include determining how well quantitative measures of SARS-CoV-2 signals in sewage can be correlated to estimate the prevalence of COVID-19 in the population source of the sewage versus the priority ability to detect trends (up or down) in prevalence” as an indicator of disease prevalence that is complementary to clinical monitoring.

Guideline 17. Personally identifiable surveillance data should not be shared with agencies that are likely to use them to take action against individuals or for uses unrelated to public health. We believe⁸ that “There is likely no ethically justifiable reason for investigators to ever share personally identifiable surveillance data with anyone other than the public health decision-makers to whom they need to be accountable for data handling.” Particular care will become necessary when reporting results for surveillance of sewage from a sewer network within a geographic area small enough to allow groups of individuals to be identified.

DISCUSSION

Wastewater surveillance for SARS-CoV-2 has emerged rapidly in response to the severity of the public health crisis created by the COVID-19 pandemic. The proliferation of these approaches has been driven by the potential for gathering insight and understanding about the distribution of COVID-19 infection in communities in a manner that is largely independent of clinical monitoring. The case for maximizing the potential of this approach is compelling, but the benefits of wastewater surveillance must clearly outweigh the ethical risks for the community. This need requires a commitment to generate

evidence that can be used for improved management of the pandemic by public health agencies.

The reality that wastewater surveillance for SARS-CoV-2 must be considered to be public health surveillance is surely self-evident. Our search for guidance on the ethics that investigators pursuing this research should consider has revealed that the foundational bioethics principles that largely govern the practice of medicine at the individual level have a limited utility for guiding wastewater surveillance that operates at a population level.

The best source for guiding ethical practice by environmental scientists and engineers was found to be provided by 2017 WHO guidelines²⁵ for public health surveillance that were based on a systematic review²⁴ commissioned for this purpose. Our review of these guidelines has found that 14 of the 17 guidelines provided by WHO are directly applicable to the issues raised by wastewater surveillance for SARS-CoV-2.

In summary, the ethical issues that should guide environmental scientists and engineers in performing wastewater surveillance for SARS-CoV-2 must address the general goals of considering the common good, equity, respect for persons and good governance. More specifically, plans for such surveillance should involve working in close cooperation with the responsible public health authorities to ensure inclusion of:

- careful planning of the surveillance program to meet a clear public health purpose
- plans for data collection that are justified as satisfying a legitimate public health purpose
- plans that are consistent with requirements for data being of sufficient quality, timely, reliable and valid to achieve public health goals
- plans that take into account the values and concerns of communities
- identification, evaluation, minimization and disclosure of risks for possible harm arising from wastewater surveillance including the possibility of community stigmatization
- consideration of surveillance providing coverage of individuals or groups who are particularly susceptible to disease, harm, or injustice
- security of surveillance data that can identify individuals or groups
- collection of names or identifiable data only in clearly justifiable circumstances
- careful consideration to deal with circumstances that require informed consent
- plans to effectively communicate results of surveillance to relevant target audiences
- plans, with appropriate safeguards and justification, to share data with other public health agencies
- plans to share surveillance data in a timely fashion with appropriate parties involved in the surveillance program
- plans to determine appropriate safeguards and justification to use or share surveillance data for research purposes
- plans to recognize any personally identifiable surveillance data to ensure that it is not shared with agencies that would use it for purposes unrelated to public health.

Because simple rules will not suffice, there is a need for an open dialogue that will reveal valid concerns for individual interests potentially in conflict with surveillance that is intended to serve the well-being of the population. Clearly, with so many ethical factors to consider, some guidance may seem to conflict

with other guidance. The point is to carefully consider the full range of issues raised and to make informed decisions that balance these issues in a rational manner.

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Author Contributions

All authors contributed to this manuscript.

Funding

The work of S.E.H. on this manuscript was supported by his Discovery Grant from the Natural Sciences and Engineering Research Council, Ottawa.

Notes

The authors declare no competing financial interest.

ACKNOWLEDGMENTS

This manuscript has been developed from an ethics guidance document prepared for the Canadian Water Network, which provided logistical support through the COVID-19 Wastewater Coalition. In addition to the coauthors of this manuscript, André Corriveau, Patrick Levallois, and James Talbot contributed to that guidance document; Dr. Levallois provided insightful comments on an early draft of this manuscript, and Elizabeth Hrudey provided editorial review.

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