WASTEWATER-BASED SURVEILLANCE FOR PUBLIC HEALTH:

KNOWLEDGE TO ACTION SERIES

WBS RESOURCES AND TOOLS

DASHBOARDS FOR COMMUNICATION AND DECISION-MAKING

In a recent international environmental scan of public health surveillance functions, the authors found that there is an international trend moving towards the use of dashboards for data sharing and publishing shorter, topic-focused reports rather than lengthy, all-encompassing surveillance reports (see Figures 1 and 2 for dashboard examples). Many countries are using public health surveillance dashboards for real-time data that is accessible to the government and the public (Snelling et. al., 2023).

The use of dashboards for wastewater-based surveillance (WBS)

From a WBS perspective, dashboards and websites have been proven to be effective modes of communication as they can be quickly updated to present the latest results. However, dashboards are only one tool in the communication toolbox (see Box 1).

Dashboards are decision support tools that can retrieve, analyze and integrate large amounts of data. This information can be used to deliver results based on monitoring priorities and can be oriented to internal (i.e., within the organization) or external (i.e., public-facing) use (Gotham et al., 2015; Rabiel et al., 2024).

Integration of information is a central characteristic, including in the context of "collaborative surveillance."

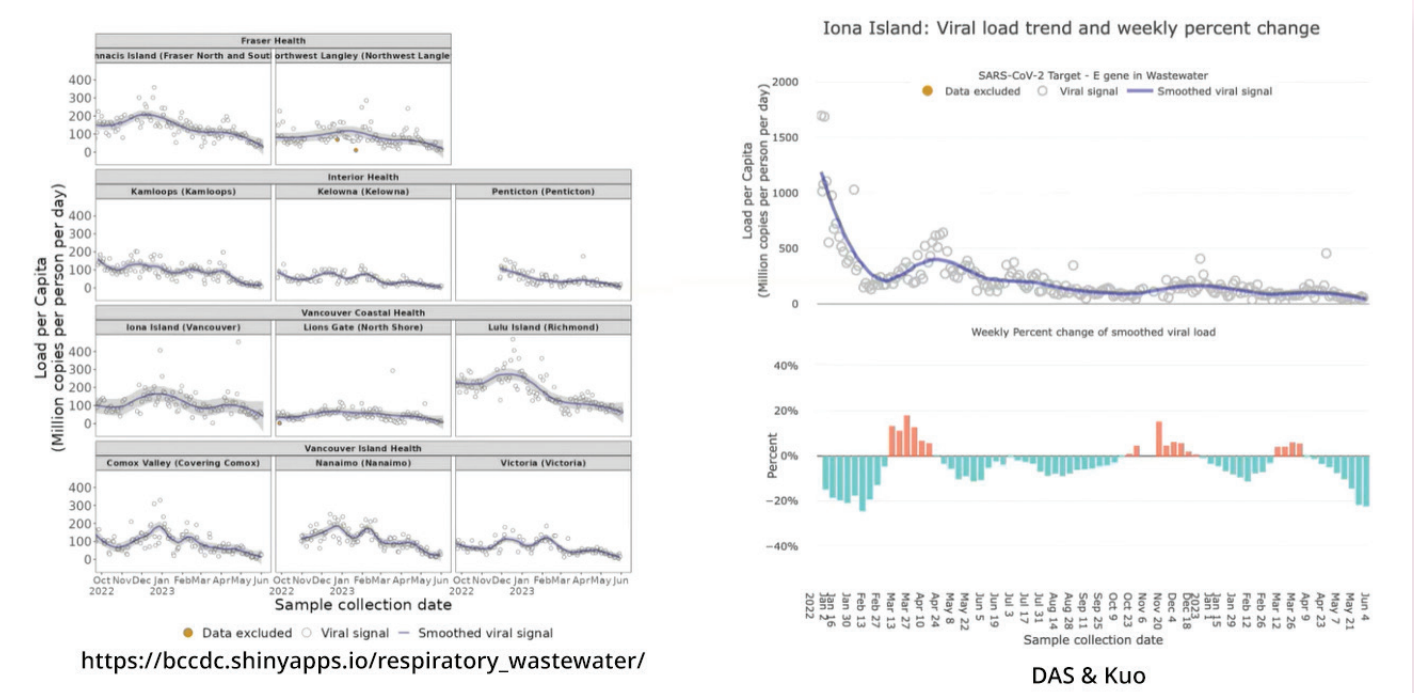


Figure 1: Example of the BC Centre for Disease Control's (BCCDC) Virus Dashboard.

Box 1: Modes of communication for WBS information to the community

- In-person events (e.g., community gatherings, health fairs, parent–teacher association meetings, etc.).
- Websites and dashboards.
- Email lists and direct reports to stakeholders.
- Electronic newsletters.
- Social media (e.g., Twitter, Instagram, TikTok, etc.)
- Radio and television.
- Podcasts.

(Shazneen et al., 2022, pg. 5).

"Collaborative surveillance is the systematic strengthening of capacity and collaboration among diverse stakeholders, both within and beyond the health sector, with the ultimate goal of enhancing public health intelligence and improving evidence for decision-making"

(WHO, 2023a, pg. vi).

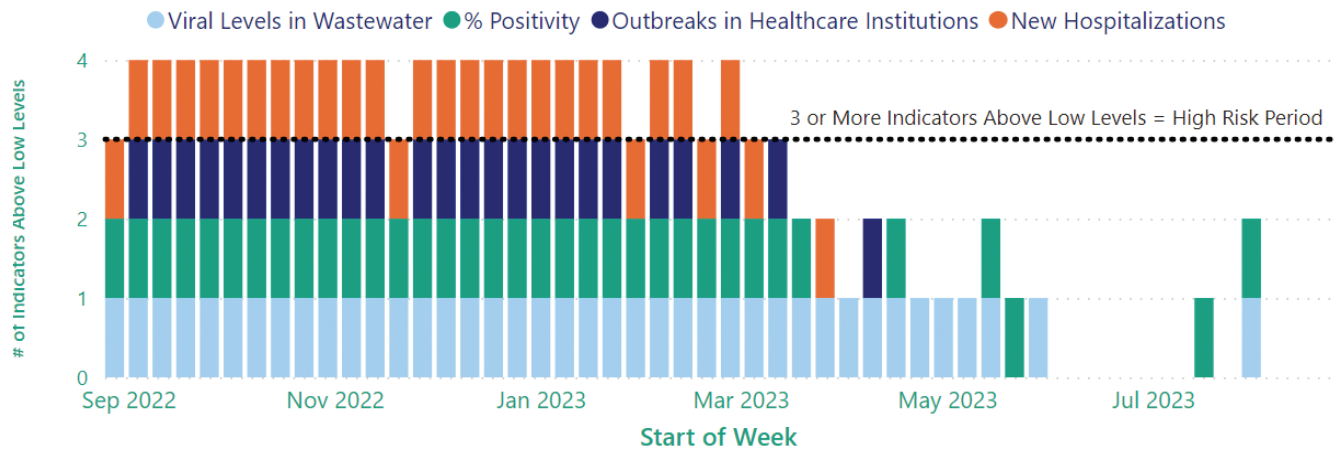


Figure 2: Example of Ottawa Public Health's Risk Assessment Dashboard.

This approach considers building intentional collaboration across diseases and threat surveillance systems, sectors, geographic levels and emergency cycles as a key capability (WHO, 2023a). There are four integration modalities that are part of collaborative surveillance (see Box 2) and are essential for vertical and horizontal integration systems that incorporate data sources not systematically captured in current models (WHO, 2023a).

Since the start of the COVID-19 pandemic, public-facing dashboards have been a common means of presenting WBS data in Canada, usually together with public health surveillance data for appropriate public access (Hrudey et al., 2022). Appendix 2 of the Royal Society of Canada Policy Briefing provides a list and links to jurisdictions with dashboards at the time (Hrudey et al., 2022).

Box 2: Modalities of integration for collaborative surveillance

- Consolidation of surveillance activities and establishing common, interoperable systems to address multiple hazards, where appropriate.
- Data and information sharing across systems that operate together to address the full range of surveillance objectives, linked to decision-making based on a comprehensive view and analysis.
- Sharing and integration of capacities, ensuring that resources (workforce, systems, infrastructure) and investments synergistically strengthen surveillance beyond individual disease objectives and can be effectively leveraged to address new and emerging threats.
- Open communication of surveillance findings at all levels where appropriate, with systems and feedback loops to enable the exchange of intelligence generated by others, driven by use cases aimed at informing decisions and driving action.

(WHO, 2023a, pg. 6)

The World Health Organization (2023b) recommended minimum criteria for information to be made available on WBS dashboards that were useful for the public and for public health agencies during the COVID-19 pandemic (see Box 3).

Hrudey and colleagues (2022) point out that the recommended elements have merit at a high level. For example, reporting on trends over time ensures that the information is comparable and can be relied on to guide future action. However, there is limited guidance for trying to define what levels and criteria should be used. For example, the meaning of an individual data point is dependent on the context. Reporting on data values rather than trends, without reference to criteria, makes it difficult to assess risk and recommend protective actions at a population level (Hrudey et al., 2022).

Box 3: Minimum Environmental Surveillance Data for SARS-C0V-2

The minimum information to make environmental surveillance (ES) data useful to public health agencies and the public includes:

- Results as trends over time (rising, falling or steady, expressed as concentrations of SARS-CoV-2 genome copies, or changes in the proportion of samples testing positive).
- Population monitored as represented by each sample with reference to its geographic catchment area (spatial and name labels).
- Filter function to view single catchment area or aggregate 'like' results to larger geographic areas at local, subnational, national and regional levels.
- Implications of results relative to a benchmark (e.g., using traffic light indicators to define the risk of SARS-CoV-2 exposure or COVID-19 health system burden).

Box 3 continued: Minimum Environmental Surveillance Data for SARS-C0V-2

- Additional specific information that is desirable, such as residential population monitored as represented by each catchment.
- Historical results from the same location.
- Current and historical results from nearby and comparable locations.
- Reported clinical information from the same location for the same period as sample collection, such as the number of clinical COVID-19 cases, the number of persons testing positive for SARS-CoV-2 infection (if case ascertainment is judged to be moderate to high), the percentage of persons tested for SARS-CoV-2 infection that return a positive result, and COVID-19 hospitalizations.

Additional useful information that is desirable to public health agencies and technical audiences includes:

- Sample type.
- Gene target.
- Assay detection limits.
- Population normalization marker.
- Units of measurement (e.g., ratio of SARS-CoV-2 to normalization marker).
- Quality assurance and quality control process and performance on method sensitivity and specificity.
- Variant analysis.

(WHO, 2023b, pg. 31)

How effective are dashboards for public health surveillance?

The broad health threats monitored by public health systems include three categories:

1. Health risks such as obesity, environmental pollution, food contamination or injuries.
2. Communicable/infectious diseases like Dengue Fever, reproductive tract infections, and/or non-communicable diseases like cancer or dementia.
3. Emergencies such as natural catastrophes or human-made disasters (Schulze, 2023).

In a recent systematic review of digital dashboards representing public health data, Schulze and colleagues note an important limitation of their review was the inconsistent differentiation of the term "dashboard." Some papers refer only to the visual representation of data, while others describe entire systems that include various functions of dashboards (Schulze et al., 2023). As a result, they settled on a comprehensive list of four different aspects that are important to consider in dashboard research:

1. How public health data is visualized.
2. The modes of communication used.
3. How the visualized data can be understood, is read and is filled with meaning by various subpopulations.
4. How effective different (communication) formats are (Schulze et al., 2023, pg. 02).

This systematic review reinforces the importance of dashboards as a valuable tool for communicating health risks through the visualization of data. The review describes how dashboards address at least one of four public health objectives: controlling threatening situations, improving information management, enhancing quality of life, and adjusting public health policies and measures. The authors conclude that the overall aim is to raise the situational awareness of health professionals, politicians and citizens in general (Schulze et. al., 2023).

However, the authors also note there are several challenges faced by public health in the development of dashboards. These include:

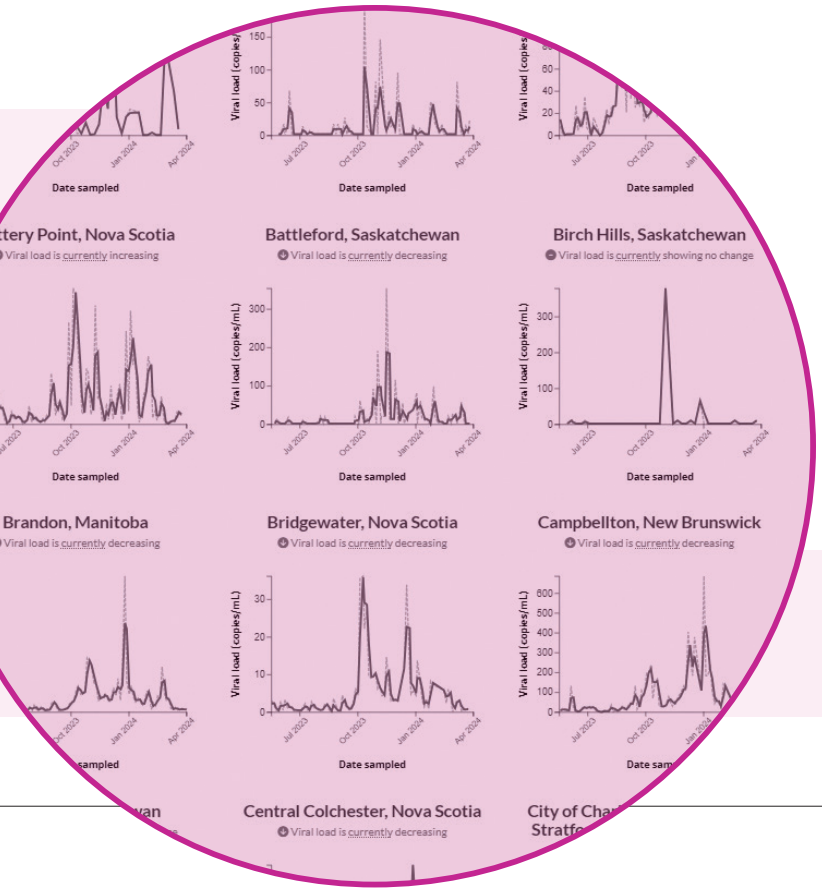
1. Integration and transmission of data from different and heterogeneous sources.
2. Alignment of data with legal requirements.
3. Data accuracy.
4. Appropriate and comparable surveillance methods.
5. Use of social media due to the challenge of misinformation. This was identified as a research gap.

The authors of the systematic review conclude that:

"The dashboards studied reflect the challenges identified in the field of public health in relation to technological progress. They enable faster data collection, sharing and analysis of data. However, one identified research gap seems to be very important with regard to the usefulness of this risk and crisis communication tool. If the needs of users in the context of health information behavior are not sufficiently empirically investigated, the benefits of dashboards for risk reduction or risk behavior change will remain without evidence" (Schulze et. al., 2023, pg. 13).

Principles of dashboard design

Despite there not being sufficient research evaluating the use of public health dashboards, there have been efforts to describe the main principles applied over the past 10-15 years in this area. A recently released scoping review on design principles for developing public health surveillance dashboards identified five groups of principles with related subsidiary principles and elements (Rabiel et. al., 2024) (see Table 1).



Rabiel and colleagues recommend investing in dashboard software tools and systems, processes and people who support public health dashboards as a tailored practice and intervention for public health policymakers. They suggest that developing an appropriate infrastructure for data exchange between parts of the health system is critical for more effective monitoring of epidemic diseases, especially the exchange of clinical and surveillance information in real-time at a national level. This would allow dashboards to be used effectively at the public health level for monitoring and managing epidemic diseases and taking timely actions (Rabiel et. al., 2024).

Table 1: Summary of principles for designing public health dashboard
(Adapted from: Rabiel et al., 2024, pg. 5-7)

Main principle & subsidiary principles	Sub-elements
1 Consider aim and target users	
	• Knowing the audience and their information needs. • Level (scale) of focus. • Responsible organization and type. • Multiple languages available. • Scope of web page information. • State the purpose of the dashboard.
2 Appropriate content	
Key performance indicators (KPIs)	• Macro, mezzo and micro level KPIs. • Timely and actionable indicators based on health system capacity. • Including relevant data disaggregation options (sex, SES). • Managing the type, volume, and flow of displayed information. • Disaggregating the information into relevant subgroups.
3 Interface	
Interaction techniques	• Provide an overview of KPIs, change the display size and location information. • Zoom in and zoom out, pop-up and control commands and warning, customizable and actionable dashboard. • Switching from a global to local view, drill down to the local regions of the map to explore datasets in greater detail, not used of scrolling.
Visualization techniques	• Choosing the right data visualization. • Visualization techniques include data tables, pie charts, bar charts, histograms, lines, areas, scatter plots, bubbles and a series of multiple and interactive maps equipped with geographic information system (GIS) software. • Using storytelling and visual cues. • Supporting correct data Interpretation (using coloured markers for clients to indicate their status, highlighting urgent/emergency alerts in red, and showing the data lines in the charts as blue (routine and exercise alerts) or red (urgent and emergency alerts). • Minimizing distractions, clichés and unnecessary embellishments (routine and exercise alerts) or red (urgent and emergency alerts).

Main principle & subsidiary principles	Sub-elements
4 Considering types of data analysis and presentation	
Trend Analysis, tracking, and forecasting	• Provide real-time analysis. • Linking time trends to policy decisions. • Geographic levels of analysis. • Global and local comparison. • Chart selection, mini-map, and global information display. • Techniques to analyze time trends and view past data. • Show trends and changes in data over time. • Key numbers relating to a region. • Assessing performance. • Support identification and evaluation of trends over time.
Applies machine intelligence	• Anticipate spread and assess patterns. • Allow users to select the time period over which performance indicators are displayed. • Support comparison against the national average.
Reporting format	• Reports in Word and PDF.
5 Infrastructure	
Data integration and warehousing	• Proper design of data warehouse and data collection. • Data integration with online analytical processing system and data. • Warehouse or other systems. • Data warehouse integrated with process data and operational security and data close to real-time. • The architecture is based on service-oriented architecture (SOA).
Integration of data sources and data generation	• Reporting data sources and methods clearly for trust to the dashboard. • Data quality was assessed by examining accuracy, real-time, and completeness. • Data input, storage and extraction process for the extraction of data warehousing. • Providing reliable, accurate, consistent and timely data.

Main principle & subsidiary principles	Sub-elements
5	**Infrastructure (continued)**
Data quality	• Completeness (e.g., missing data), correctness (e.g., accuracy), currency (e.g., timeliness) and provenance (e.g., reliability of the source).
Information standards	• Information exchange standards and content standards. • Privacy and security standards, functional standards (work processes, workflow and dataflow models). • Standard inputs for the dashboard frontend. • Standard architecture for including new datasets into the dashboard. • Standard dataset formats for the generation of data visualizations. • Data collection, data fusion logic, data curation and sharing, anomaly detection, data corrections, and supportive human resources.
System security	• Methods, techniques and technologies used to protect data security, which includes attention to system security.
Accessibility	• Web and mobile access, desktops, laptops and tablets.

Application of dashboard design principles to WBS

The principles for designing public health dashboards and key recommendations for WBS dashboard design in the literature are well aligned. The main principles are illustrated below with reference to primary WBS documents relevant to the Canadian context. However, there has not been a comprehensive analysis or development of guidance for applying the principles to WBS.

1. Aim and target users

With respect to dashboard design for WBS, Shazneen and colleagues note that trust is important. Different audiences require different outreach strategies based on what people have access to or feel comfortable with, including which sources they trust in their community. It is important to take time to understand information flows within a community to promote more effective outreach (Shazneen et al., 2022).

Information and data visualization for the interpretation of WBS data needs to integrate contextual insights from statistical analyses and modelling in order to support robust risk assessment for decision-making. Community and behavioural insights, along with real-time, data-driven interfaces and dashboards, should be leveraged for decision-making. This includes policymakers and the public who should have access to multisectoral data sources, tailored to target audiences, with accompanying guidance and public health advice/messages for interpretation (WHO, 2023a; Lok-Wah-Hoon et al., 2022).

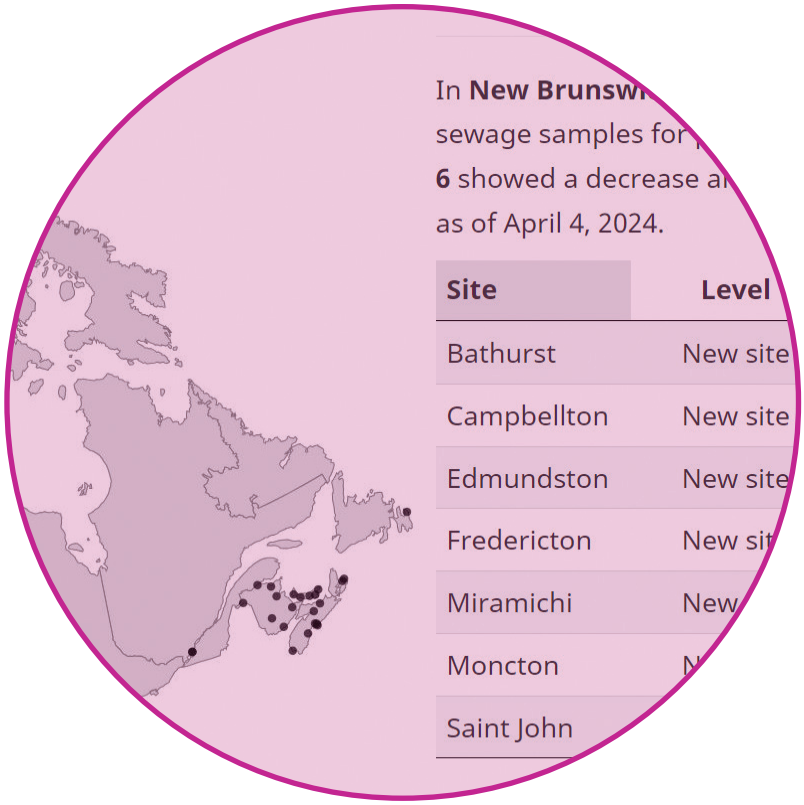
The World Health Organization's (WHO) report on "collaborative surveillance" emphasizes the need for a culture of open communication, "with surveillance outputs systematically fed back and disseminated to relevant stakeholders, and wherever appropriate, routinely

published and made accessible to the public. This should be complemented by mechanisms to leverage intelligence for mutual benefit and coordinated action" (WHO, 2023a, pg. 22).

2. Appropriate content

Ultimately, the information provided in the dashboard should support decision making by the users of the data, which means the right performance indicators need to be selected. The Royal Society of Canada Policy Briefing (August 2022) emphasized the value of providing WBS data to the public for personal risk management. The report describes how those who follow the WBS dashboards in their regions have been able to form judgements about the state of the COVID-19 pandemic in their area, and how this has guided personal decisions such as mask-wearing and engagement with larger groups.

The report shared an example of the increased use of the GIWS wastewater dashboard in Saskatchewan when the government site went from daily to weekly status reports in February 2022. Comments from the general public emphasized how important the regular updates are to their daily decision-making. While this may be true, Hrudey and colleagues note that most of the design of public-facing communications has had to be based on both experience and intuition due to a lack of evaluation of design principles (Hrudey et al., 2022).



3. Interface

There have been questions around how wastewater surveillance data can be communicated and shared between authorities and to the public. The authors of a WHO Q&A document on WBS for SARS-CoV-2 reinforce the need to identify all potential stakeholders and their communication needs early on, as per the principle "aim and target users." They recommend the use of dashboards to share data with the public. The authors also emphasize the value of dashboards to present data at various governance levels including at the local level, where most community level decisions need to be taken. The document recommends that the surveillance team seek ethical approval as it allows authorities to understand the critical and sensitive points that require attention. Information needs should be clearly presented to reduce misunderstandings while implementing risk communication strategies (Lok-Wah-Hoon et al., 2022, pg. 10).

4. Considering types of data analysis and presentation

Guidance from the WHO (2023b) recommends that dashboards be used to present data at local and national levels paired with public health advice. Combining SARS-CoV-2 environmental surveillance information with public health data and communication of public health advice helps with the COVID-19 response and health promotion. Specifically the:

- Interpretation of environmental surveillance results by public health agencies should include clinical testing response decision-support process flow diagrams or algorithms.
- Formulation and communication of public health advice should help to focus clinical testing and community messaging on areas with elevated viral presence and concentrations detected from SARS-CoV-2 ES. The communication should also provide early warning of trends in COVID-19 in the community to inform control initiatives (WHO, 2023b, pg. 31).

5. Infrastructure

It is recommended that public health surveillance invests in services supporting the derivation of information from data, including data analytics and visualization capabilities such as GIS, dashboards, integrated data reporting and query services, modelling and statistical analysis packages (Gotham et al., 2015).

Several reports on WBS emphasize the value and importance of an open science approach. This way of working seeks to rapidly advance measurement and reporting best practices through transparent and accessible knowledge (Hrudey et al., 2022; Manuel et al., 2022; WHO, 2023a).

> "Sharing surveillance data within and between programs and countries provides a key resource to understand the key sources of measurement variability. There are several data models and repositories to facilitate standard data storage and open data access following FAIR data sharing principles (for example, see the Public Health Environmental Surveillance Open Data Model [PHESODM]; the Global Water Pathogens Project; and the Norman Database System, SARS-CoV-2 in sewage [SC2S])" (Manuel et al., 2022, pg. 29).

Summary

Public health surveillance dashboards are a widely used communication tool and have been applied to WBS extensively. Dashboards are very effective for retrieving, analyzing and integrating large amounts of data. In doing so, dashboards support decision-making by both policymakers and the general public. High-level principles to guide the development of dashboards are available, along with data recommendations related to WBS. However, the effectiveness of different types of public health dashboards and content has not been adequately evaluated and there is a need for the development of guidance to better support Public Health in the use of this important risk communication and health promotion tool.

See **Part 2 – BC Centre for Disease Control and Part 2 – Ottawa Public Health** for more on the experience of developing and using dashboards.

Questions for Reflection

Thinking about your work/studies, community, and priorities for wastewater-based surveillance (WBS):

- How might you be able to use the **summary of principles** for public health dashboard design to develop or improve your own dashboard(s)?
- How well do the WHO (2023) recommendations for **minimum environmental surveillance data** for SARS-CoV-2 align with the principles for dashboard design? Where are the gaps and how might you address them?
- Given the **lack of evaluation** of public health dashboards, what could you start doing right away to better understand how impactful your dashboards are?
- Where are there opportunities for you to strengthen your **'intentional collaboration'** across disciplines and sectors to improve the public health surveillance system?

Examples of Dashboards

Government of Canada. COVID-19 wastewater surveillance dashboard
https://health-infobase.canada.ca/covid-19/wastewater/

Centers for Disease Control (US). Wastewater Surveillance Data Reporting and Analytics
https://www.cdc.gov/nwss/reporting.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fnwss%2Freporting%2Findex.html

COVID Poops 19. Global wastewater dashboard
https://www.covid19wbec.org/covidpoops19
https://twitter.com/covidpoops19?lang=en
https://www.nist.gov/system/files/documents/2021/07/23/AnaAlvarado-day2.pdf

World Health Organization. WHO dashboard of COVID-19 related recommendations [website].
http://bit.ly/3MGMq3o

Wastewater SPHERE (SARS Public Health Environmental REsponse)
https://sphere.waterpathogens.org/map

References

Canada's Drug and Health Technology Agency (CADTH) (2023). *Wastewater Surveillance for Communicable Disease*. Available from: https://www.cadth.ca/wastewater-surveillance-communicable-disease

Gotham, I.J., Le, L.H., Sottolano, D.L. et al. (2015). An informatics framework for public health information systems: a case study on how an informatics structure for integrated information systems provides benefit in supporting a statewide response to a public health emergency. *Inf Syst E-Bus Manage* 13, 713–749 (2015). https://doi.org/10.1007/s10257-014-0240-9

Hrudey, S. E., et al. (2022). Wastewater Surveillance for SARS-CoV-2 RNA in Canada. *Royal Society of Canada Policy Briefing*. 2022. Available from: https://rsc-src.ca/en/covid-19-policy-briefing/wastewater-surveillance-for-sars-cov-2-rna-in-canada

Lok-Wah-Hoon, J., van den Berg, H., Sprokholt, J., de Roda Husman, A.M. 2022. Wastewater surveillance of SARS-CoV-2: Questions and answers. *World Health Organization Regional Office for Europe and National Institute for Public Health and Environment (RIVM), the Netherlands*. Available from: https://apps.who.int/iris/bitstream/handle/10665/353058/WHO-EURO-2022-5274-45038-64164-eng.pdf?sequence=4&isAllowed=y

Manuel, D, Amadei, CA, Campbell, JR, Brault, J-M, Zierler, A, and Veillard, J (2022). Strengthening Public Health Surveillance Through Wastewater Testing: An Essential Investment for the COVID-19 Pandemic and Future Health Threats. *International Bank for Reconstruction and Development / The World Bank*, Washington. Available from: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/761521642623044776/strengthening-public-health-surveillance-through-wastewater-testing-an-essential-investment-for-the-covid-19-pandemic-and-future-health-threats

Rabiei, R., Bastani, P., Ahmadi, H. *et al*. (2024). Developing public health surveillance dashboards: a scoping review on the design principles. *BMC Public Health*, 24, 392 (2024). https://doi.org/10.1186/s12889-024-17841-2

Schulze A, Brand F, Geppert J and Böl G-F (2023). Digital dashboards visualizing public health data: a systematic review. *Front. Public Health* 11:999958. https://doi.org/10.3389/fpubh.2023.999958

Shazneen, D, Durry, S, Hilton, S, Jelks, NTO, Moe, CL, Wang, Y and Wolfe, M (2022). *Using Wastewater Data to Communicate About Infectious Disease Dynamics in Communities*. Washington, DC: Mathematica, 2022. Available from: https://www.mathematica.org/projects/translating-wastewater-data-into-public-health-action

Snelling, S., Ford, C., Cambourieu, C. & Dunbar, W. (2023). International Environmental Scan of Public Health Surveillance Functions. *National Collaborating Centre for Methods and Tools and National Collaborating Centre for Healthy Public Policy*. Available from: https://www.nccmt.ca/impact/publications/90

WHO (2023a). *Defining collaborative surveillance: a core concept for strengthening the global architecture for health emergency preparedness, response, and resilience (HEPR)*. Geneva: World Health Organization; 2023. Available from: https://www.who.int/publications/i/item/9789240074064

WHO (2023b). *Environmental surveillance for SARS-COV-2 to complement public health surveillance*. Available from: https://www.who.int/publications/i/item/9789240080638 (Original version, April 14, 2022. www.who.int/publications/i/item/WHO-HEP-ECH-WSH-2022.1)

OTHER TOPICS IN THIS SERIES

PART 1: OVERVIEW

PART 2: CASE EXAMPLES

The case examples in this Knowledge-to-Action Series are stories told from the perspective of the Public Health practitioners most closely involved in the development and implementation of the WBS program in their region. They are intended to provide a deeper understanding of the organizational and community context, and key learnings related to interpretation and communication of information related to wastewater-based surveillance.

- BC Centre for Disease Control.
- Ottawa Public Health.
- Nunavik Board of Health and Social Services.

PART 3: WBS RESOURCES AND TOOLS

The resources and tools in this Knowledge-to-Action Series are intended to provide a summary of key information and communication topics for public health practitioners related to WBS. Each document includes core concepts with references and links to additional materials. There is also a set of reflection questions at the end for individuals and teams to consider when applying the concepts to the development and implementation of WBS programs.

- Data Governance and Ethics.
- Dashboards for Communication and Decision Making.

Wastewater-Based Surveillance for Public Health:
The Knowledge-to-Action Series.
Part 3: WBS Resources and Tools.
Dashboards for Communication and Decision Making.

This project was undertaken with the financial support of the Government of Canada through the Public Health Agency of Canada's National Microbiology Laboratory and Indigenous Services Canada. The views expressed herein do not necessarily represent the views of the Public Health Agency of Canada or those of Indigenous Services Canada.

This is NCCID Project number 794.

ISBN: 978-92788-87-9

Contact Us

Canadian Water Network
Talia Glickman
Wastewater-Based Surveillance
Program Manager
Email: tglickman@cwn-rce.ca
cwn-rce.ca

National Collaborating Centre for Infectious Diseases
Rady Faculty of Health Sciences,
University of Manitoba
Tel: (204) 318-2591
Email: nccid@umanitoba.ca
www.nccid.ca

Financial contribution:

Canada

Canadian Water Network

National Collaborating Centre for Infectious Diseases

Centre de collaboration nationale des maladies infectieuses

WASTEWATER-BASED SURVEILLANCE FOR PUBLIC HEALTH:

KNOWLEDGE TO ACTION SERIES