# Community Surveillance of Omicron in Ontario: Wastewater-based Epidemiology Comes of Age.

**Authors presented in alphabetical order:**

**Eric Arts**
Department of Microbiology and Immunology, Western University, London, Ontario, Canada

**Stephen Brown**
Department of Chemistry and School of Environmental Studies, Queen's University, Kingston, Ontario, Canada

**David Bulir**
Department of Pathology and Molecular Medicine, McMaster University, Hamilton, Ontario, Canada

**Trevor C. Charles**
Department of Biology, University of Waterloo, Waterloo, Ontario, Canada

**Christopher T. DeGroot**
Department of Mechanical and Materials Engineering, Western University, London, Ontario, Canada

**Robert Delatolla**
Department of Civil Engineering, University of Ottawa, Ottawa, Ontario, Canada

**Jean-Paul Desaulniers**
Faculty of Science, Ontario Tech University, Oshawa, Ontario, Canada

**Elizabeth A. Edwards**
Department of Chemical Engineering and Applied Chemistry, University of Toronto, Ontario, Canada

**Meghan Fuzzen**
Department of Biology, University of Waterloo, Waterloo, Ontario, Canada

**Kimberley Gilbride**
Department of Chemistry and Biology, Ryerson University, Toronto, Ontario, Canada

**Jodi Gilchrist**
Department of Pathology and Molecular Medicine, McMaster University, Hamilton, Ontario, Canada

**Lawrence Goodridge**
Food Science Department, University of Guelph, Guelph, Ontario, Canada

**Tyson E. Graber** ( tgraber@cheo.on.ca )
Children's Hospital of Eastern Ontario Research Institute, Ottawa, Canada https://orcid.org/0000-0002-5337-3404

**Marc Habash**
School of Environmental Sciences, University of Guelph, Guelph, Ontario, Canada

**Peter Jüni**
Department of Medicine, University of Toronto, Toronto, Ontario, Canada
**Andrea Kirkwood**
Faculty of Science, Ontario Tech University, Oshawa, Ontario, Canada
**James Knockleby**
Health Sciences North Research Institute, Sudbury, Ontario, Canada
**Christopher Kyle**
Forensic Science Department, Trent University, Peterborough, Ontario, Canada
**Chrystal Landgraff**
National Microbiology Laboratory, Public Health Agency of Canada, Winnipeg, Manitoba, Canada
**Chand Mangat**
National Microbiology Laboratory, Public Health Agency of Canada, Winnipeg, Manitoba, Canada
**Douglas G. Manuel**
The Ottawa Hospital Research Institute, University of Ottawa, Ottawa, Ontario, Canada
**R. Michael McKay**
Great Lakes Institute for Environmental Research, University of Windsor, Windsor, Ontario, Canada
**Edgard Mejia**
National Microbiology Laboratory, Public Health Agency of Canada, Winnipeg, Manitoba, Canada
**Aleksandra Mloszewska**
Health Sciences North Research Institute, Sudbury, Ontario, Canada
**Banu Ormeci**
Department of Civil and Environmental Engineering, Carleton University, Ottawa, Ontario, Canada
**Claire Oswald**
Department of Geography and Environmental Studies, Ryerson University, Toronto, Ontario, Canada
**Sarah Jane Payne**
Department of Civil Engineering, Queen's University, Kingston, Ontario, Canada
**Hui Peng**
Department of Chemistry, University of Toronto, Toronto, Ontario, Canada
**Shelley Peterson**
National Microbiology Laboratory, Public Health Agency of Canada, Winnipeg, Manitoba, Canada
**Art F.Y. Poon**
Department of Microbiology and Immunology, Western University, London, Ontario, Canada
**Mark R. Servos**
Department of Biology, University of Waterloo, Waterloo, Ontario, Canada
**Denina Simmons**
Faculty of Science, Ontario Tech University, Oshawa, Ontario, Canada
**Jianxian Sun**
Department of Chemistry, University of Toronto, Toronto, Ontario, Canada
**Minqing Yang**

Department of Chemical Engineering and Applied Chemistry, University of Toronto, Ontario, Canada
**Gustavo Ybazeta**
Health Sciences North Research Institute, Sudbury, Ontario, Canada

**Short Report**

**Keywords:** wastewater, epidemiology, VOC, public health, sequencing, PCR

**Posted Date:** March 15th, 2022

**DOI:** https://doi.org/10.21203/rs.3.rs-1439969/v2

# Abstract

Wastewater-based surveillance of SARS-CoV-2 RNA has been implemented at building, neighbourhood, and city levels throughout the world. Implementation strategies and analysis methods differ, but they all aim to provide rapid and reliable information about community COVID-19 health states. A viable and sustainable SARS-CoV-2 surveillance network must not only provide reliable and timely information about COVID-19 trends, but also provide for scalability as well as accurate detection of known or unknown emerging variants. Emergence of the SARS-CoV-2 variant of concern Omicron in late Fall 2021 presented an excellent opportunity to benchmark individual and aggregated data outputs of the Ontario Wastewater Surveillance Initiative in Canada; this public health-integrated surveillance network monitors wastewaters from over 10 million people across major population centres of the province. We demonstrate that this coordinated approach provides excellent situational awareness, comparing favourably with traditional clinical surveillance measures. Thus, aggregated datasets compiled from multiple wastewater-based surveillance nodes can provide sufficient sensitivity (i.e., early indication of increasing and decreasing incidence of SARS-CoV-2) and specificity (i.e., allele frequency estimation of emerging variants) with which to make informed public health decisions at regional- and state-levels.

# Full Text

On November 24, 2021 (epiweek 47), the Ontario wastewater surveillance initiative (WSI), a province-wide COVID-19 surveillance program, sprang into action. One day prior, reports of a high incidence SARS-CoV-2 variant in South Africa with Pango designation B.1.1.529[1] led the WHO to swiftly assign it as VOC Omicron on November 26[2]. Thanks to capacity and expertise built during the COVID-19 pandemic, WSI and Public Health Agency of Canada (PHAC) researchers quickly implemented metagenomic sequencing[3] and allele-specific qRT-PCR to detect and quantify Omicron-specific viral fragments in wastewaters representing the major population areas of Ontario (**Figure 1**).

### Measurement of Omicron incidence via wastewater

The first cases of Omicron in North America were identified in Ottawa, Ontario on November 28, 2021[4] through Public Health Ontario's clinical genomic surveillance program which was prioritizing sequencing of test-positive travellers. On December 8 (epiweek 49), WSI reported its wastewater-based findings to Ontario's Office of the Chief Medical Officer of Health as follows: WSI and PHAC researchers found no conclusive evidence of omicron signature alleles at any of the Ontario sentinel sites reporting prior to or during epiweek 47. In epiweek 48, the City of Kingston (East Health Region) experienced an Omicron outbreak first confirmed and monitored by clinical surveillance coincident with increasing SARS-CoV-2 signal in wastewater.

Low frequency sequencing of wastewater samples during this dynamic period was supplemented with rapid implementation of bespoke qRT-PCR assays (targeting N:P13L, N:R203K, N:G204R) in epiweek 49 at laboratories servicing municipalities in East and Central West Health Regions. The strategy of deploying qRT-PCR, prior to or together with sequencing, provided real-time estimation and reporting (within 24 h of sampling) of increasing Omicron allele frequencies in epiweeks 48 and 49. The WSI implemented a similar plan of action during the Alpha and Delta waves[5]. Further, decreasing Delta allele frequency was observed and tracked at this time through metagenomic sequencing and a bespoke qRT-PCR assay targeting the N:D63G diagnostic mutation (**Figure 1**).

Concurrent with VOC frequency estimation, WSI laboratories continued to report near real-time (frequencies ranging from daily to weekly) measurement of variant-agnostic SARS-CoV-2 signal across sampled sites (**Figure 1**, right panel; using CDC N1 and N2 or E qRT-PCR assays). Thus, within 2 weeks of learning Omicron's existence, the WSI confirmed: 1) Omicron was not prevalent across Ontario prior to epiweek 49, and 2) SARS-CoV-2 viral load was low and stable across the province. These findings, obtained independently from clinical surveillance, provided timely situational awareness to municipal, regional, and provincial authorities; pointing to a low and stable COVID-19 community health state in Ontario prior to broad Omicron attack.

### Correlation of clinical and wastewater COVID-19 indicators

Preliminary comparison of province-wide clinical SGTF frequency estimates retrospectively analyzed December 28, 2021, and wastewater-based Omicron frequency estimates retrospectively analyzed at the time of submission, revealed that these independent measures correlated well with each other across time. A province-wide analysis of both clinical and wastewater-based surveillance showed that Omicron had supplanted Delta in much of the populous Southern portion of the province by epiweek 51, only 2 weeks following its first detection in travellers through clinical genomic surveillance.

### Inferring falling inflection point and forecasting peak hospitalizations

Due to the high incidence of Omicron in Ontario entering epiweek 51, universal clinical testing capacity was quickly saturated and case tracing overwhelmed. Restricted testing to high-risk individuals and those working in high-risk settings beginning December 31, resulted in underestimated cases and the inability to accurately identify a falling point of inflection along the epidemiological curve[6]. Province-wide estimation of SARS-CoV-2 RNA levels in wastewater (a population-weighted, aggregated dataset representing samples analyzed at 101 wastewater treatment plants, pumping stations and sewer shed access points within the WSI network) reported around January 12, 2022, indicated that the peak of the Omicron wave had been reached (**Figure 1**, right panel). Population-weighted aggregated signal is biased towards dense urban centres such as Toronto. Because population density across the province can vary by one order of magnitude, this can mask antipodal trends observed in less populated regions. Decision makers are therefore cautioned that both state- and city/region-level data should be evaluated in any decision-making framework that relies on wastewater-based surveillance.

Provincial and regional breakdowns of wastewater-based SARS-CoV-2 signal trends, along with clinical measures, are updated weekly and available at https://covid19-sciencetable.ca/ontario-dashboard/#wastewatersignal . Approximately 2 weeks following the observed decrease in wastewater signal, the number of hospitalized patients testing positive for COVID-19 appeared to have reached a peak and was beginning to decline. The number of hospitalized patients with COVID-19 in Ontario has since continued to decline, mirroring the SARS-CoV-2 wastewater signals that were observed several days prior.

# Declarations

### ACKNOWLEDGEMENTS

This work was funded by the Ontario Ministry of the Environment, Conservation and Parks (MECP), the Government of Canada through Health Canada, Genome Canada and Ontario Genomics (OGI-209), and NSERC (ALLRP 555041-20 to C.O.). The authors would also like to acknowledge the central role of MECP-WSI leadership including its scientists, engineers, and support staff, the numerous trainees in participating laboratories, along with the Ontario Clean Water Agency (OCWA) and the municipal, public health, community, and utility corporation partners across Ontario, including the Ontario Clean Water Agency (OCWA). These participants have devoted untold hours during the pandemic to successfully build a plane mid-flight.

Competing Interests: The authors declare no competing interests.

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# Figures

### Figure 1

**A coordinated network of wastewater surveillance provides integrated situational awareness capability akin to its clinical counterpart.** (Left panel) Heatmaps representing wastewater-based (orange) Omicron VOC allele frequency estimates across Ontario Health Regions, or province-wide Delta VOC, or clinical Omicron estimates (red; S-Gene Target Failure, SGTF). What was known to decision makers in the weeks prior to December 8, 2021, and a retrospective analysis of the period from 21 NOV-25 DEC (i.e., the leading edge of the omicron wave) are shown. Wastewater estimates are derived from VOC-specific qRT-PCR and/or metagenomic sequencing. Province-wide clinical estimates are derived from SGTF frequency estimates reported by Public Health Ontario. For reasons of clarity, not all sampling sites are indicated on the map. (Right panel) Aggregated SARS-CoV-2 wastewater signal across all 34 Public Health Units in Ontario (101 collection points; current visualizations and methods available at https://covid19-sciencetable.ca/ontario-dashboard/#wastewatersignal) and census of patients hospitalized with COVID-19 across the province during the Omicron wave (Open data available at https://covid-19.ontario.ca/data/hospitalizations).