

Pathogen genomics in the post-COVID-19 era

One core function of a provincial public health laboratory is to conduct pathogen surveillance by characterizing the genetic material of microbes, also known as “fingerprinting,” to monitor circulating strains, understand local and global epidemiology and transmission dynamics, and support outbreak investigations to determine the risks to individuals and the population. This function is key for many public health activities, including food safety investigations (e.g., *Salmonella* contamination of imported melon), emerging pathogen response (e.g., detection of a novel disease), and vaccine effectiveness (e.g., determining how closely the seasonal influenza vaccine matches the circulating influenza strain). The value of these functions has been demonstrated during the SARS-CoV-2 pandemic and multiple recent public health incidents, such as a *Listeria* outbreak associated with plant-based milk identified through the coordinated PulseNet Canada enteric surveillance program,¹ which is built on a pathogen genomics framework.

Advanced fingerprinting—Whole-genome sequencing

Many technologies have been evaluated in the past 2 decades to identify a pathogen’s unique fingerprint to inform possible pathways of transmission. The technology with the highest discriminatory power is the recently emerged next-generation sequencing. In 2015, the BC Centre for Disease Control Public Health Laboratory (BCCDC PHL) started transitioning to next-generation sequencing to

replace traditional fingerprinting of enteric pathogens. Supported by significant infrastructure and knowledge translation from the National Microbiology Laboratory, this new genomics era for foodborne illness monitoring revolutionized PulseNet Canada’s surveillance system for foodborne illness. Funding through external grants, including from Genome BC, enabled further sequencing advancements as modern technologies were evaluated for various

In the future, pathogen genomics and DNA sequencing technologies will be increasingly woven into all areas of public health and the health care system

microbial applications, including surveillance and outbreak response to multidrug-resistant bacterial infections in BC health care facilities. By the time the COVID-19 pandemic hit, the BCCDC PHL became a key leader in the national response to the pandemic by rapidly implementing a detection assay and high-throughput sequencing that informed public health, scientists, policy, decision-makers, and the public on the variants circulating in BC in real time.

Role of genomics during the pandemic

In response to the pandemic, the BCCDC PHL rapidly expanded the pathogen genomics program that transitioned SARS-CoV-2 detection and characterization into a robust surveillance tool that informed policy decisions in BC and Canada. The nature of the rapidly evolving

SARS-CoV-2 virus during the pandemic brought the need for genomics to the forefront. No other technology would have been capable of providing the means to track and characterize the variants that arose due to mutations across a broad range of applications, such as epidemiology, virulence, or antigenicity of the virus. These variants were monitored by public health officials for signs of potential impact on vaccine efficacy, effectiveness of antivirals, disease presentation, and transmissibility. In BC, genomic data for SARS-CoV-2 is accessible through the surveillance dashboards offered by the BCCDC and contributed significantly to global publicly available data.

How genomics is used today

The BCCDC PHL has gone from providing sequencing capacity for a few enteric organisms to now covering a range of respiratory (e.g., influenza), emerging (e.g., mpox), nosocomial (e.g., *Clostridioides difficile*), and wastewater pathogens, with the ability to respond to future pathogens.

These genomic innovations are transforming patient care. Much like how advances in molecular approaches such as nucleic acid testing became the standard for diagnosis compared with more traditional culture-based techniques, genomics is also proceeding in that direction. Genomics methods are now considered the standard of practice in the UK and part of a global strategy for surveillance by the World Health Organization.^{2,3} In 2023, the BCCDC PHL was the first laboratory in Canada to move to genomics-based testing for TB genotyping and offer amplicon sequencing for identification and macrolide resistance prediction for nontuberculous mycobacteria identification. Hepatitis C genotyping has also transitioned to an in-house

Continued on page 264

This article is the opinion of the BC Centre for Disease Control and has not been peer reviewed by the BCMJ Editorial Board.

Continued from page 263

next-generation sequencing method. In both cases, turnaround time for results has been dramatically reduced, to the benefit of patient care.

These genomic innovations are also transforming population care. With pathogen genomics, highly refined cluster detection for outbreak investigations is made possible through development of bioinformatic tools. The ability of PulseNet Canada to respond to enteric illness outbreaks has been advanced significantly with genomics, resulting in a decreased burden of illness and even food industry changes. Pathogen genomics has become an essential tool for managing antimicrobial-resistant organisms, such as carbapenemase-producing organisms, *Clostridioides difficile*, and methicillin-resistant *Staphylococcus aureus*, in health care facilities across BC. Along with infection prevention and control measures, the discriminatory power of pathogen genomics is essential for resolving outbreaks of health care-associated infections in acute care settings. Pathogen genomics also plays a significant role in quality assurance by enabling monitoring of validated assays to detect new variants of organisms with mutations that may impact assay performance, an essential function of a public health laboratory. Finally, the BCCDC PHL is positioned to be even more responsive to emerging zoonotic threats through a partnership with the BC Ministry of Agriculture's Animal Health Centre, where pathogen surveillance data is shared using a "One Health" approach. By sharing animal and human pathogen genomics information, we can monitor and respond to threats such as avian influenza (H5N1) in BC. Genomics can also inform rapid test development for novel pathogens so scale-up can occur to meet testing demands.

Pathogen genomics of tomorrow

In the future, pathogen genomics and DNA sequencing technologies will be increasingly woven into all areas of public health and the health care system for

patient care, population safety, and threat response. Sequencing can replace a range of traditional testing—from diagnostics to fingerprinting to treatment susceptibility. A single genomics test can replace multiple traditional tests.

While much of this work is invisible to the general health care system and to most health care providers, its ongoing application and support are important. It provides continuously innovative approaches and operational advancement along with the capacity to understand communicable disease transmission dynamics through routine surveillance activities. Genomics informs preparedness activities and, ultimately, prevention and control measures. ■

—**Natalie Prystajecy, PhD, SCCM**
Program Head, Environmental
Microbiology and Molecular and
Microbial Genomics, BCCDC PHL

—**Yin Chang, MSc**
Public Health Manager, BCCDC PHL

—**Shannon Russell, PhD**
Senior Scientist, BCCDC PHL

—**John Tyson, PhD**
Senior Scientist, BCCDC PHL

—**James Zlosnik, PhD**
Senior Scientist, BCCDC PHL

—**Linda Hoang, MSc, MD, DTM&H, FRCPC**
Medical Director, BCCDC PHL

References

1. Public Health Agency of Canada. PulseNet Canada. Last modified 27 June 2022. Accessed 21 July 2023. www.canada.ca/en/public-health/programs/pulsenet-canada.html.
2. UK Health Security Agency. UKHSA pathogen genomics strategy. 2024. Accessed 22 July 2024. https://assets.publishing.service.gov.uk/media/65aff68ef2718c000dfb1bd8/Pathogen_Genomics_Strategy_2024.pdf.
3. World Health Organization. Global genomic surveillance strategy for pathogens with pandemic and epidemic potential, 2022–2032. Accessed 22 July 2024. www.who.int/publications/i/item/9789240046979.

Continued from page 262

dental injury—whether at your medical clinic or in an emergency room—please submit a Physician's First Report (Form 8) to WorkSafeBC. Encourage the patient to file a claim with WorkSafeBC and consult with their dentist or a community dentist of their choice.

If you would like additional information or assistance for a patient with a work-related dental injury, contact the WorkSafeBC dental consultant through a medical advisor in your nearest WorkSafeBC office or through a RACE request (www.raceconnect.ca). ■

—**Alison Kaplen, DMD**
WorkSafeBC Dental Consultant

Nuance® Dragon® Medical One

Capture the Complete Patient Story

- Easy to learn & easy to use.
- Document visits quickly & accurately.
- Increase productivity with voice-activated text macros.
- One user profile synchronized across all your PC devices.
- Automate repetitive EMR & computer tasks with custom voice commands.

Contact us for a free demo!
604.264.9109 | 1.888.964.9109

speakeasysolutions.com

Professional Speech
Technology Specialists

