

Understanding heterogeneity to inform the public health response to COVID-19 in Canada

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Canada's early response to coronavirus disease 2019 (COVID-19) largely comprised universal strategies of confinement alongside efforts to isolate people infected with or exposed to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and to increase testing. Underscoring early predictions and the response was a tacit assumption of homogeneity in risks in mathematical models, driven by the need to inform a rapid response with limited data and time to examine nuanced strategies. Yet COVID-19, like respiratory and sexually transmitted infections before it, has highlighted the disparities and injustices that persist across Canada, with heterogeneity in risks of acquisition, spread and severity across people, places and time. As public health systems prepare for future waves of COVID-19, a sophisticated data-driven approach that leverages local heterogeneity would allow for more specific and equitable responses across Canada.

Mathematical models have supported the public health response to COVID-19 and will continue to do so. With limited COVID-19-specific data available, early models used forecasting and simple mechanistic structures, and simulated worst- and best-case scenarios based on data from epicentres around the world¹⁻³ (Appendix 1, available at www.cmaj.ca/lookup/suppl/doi:10.1503/cmaj.201112/-/DC1). This was followed by models that calibrated to regional trends in cases, hospital admissions and deaths;⁴ however, most such regional studies assumed homogeneity in risks beyond age (Appendix 1). Early models provided fundamental insights, such as how fast infections may spread and how quickly generic interventions needed to be deployed to halt early spread.¹⁻³ However, conditions that lead to differential risks of transmission, including socioeconomic status and residence in congregate settings such as long-term care facilities and shelters, were not accounted for.

There is not one COVID-19 epidemic in Canada but, as with other pathogens, many microepidemics. Risks of acquisition, spread, clinical symptoms and disease severity are heterogeneous, as are access to and uptake of universal strategies of confinement, testing and isolation. Although data within Canada remain limited,⁵ findings from other jurisdictions suggest heterogeneity in many domains.⁶ Communities may have different baseline risks due to variability in individual-, setting- and area-level factors.⁷ Individuals' age, sex, comorbidities, employment, Indigenous and ethnic identities, structural barriers to health care including racism, and experience of homelessness affect risk and outcomes. Settings such as multigenerational households, congregate-living facilities and essential-service

KEY POINTS

- Early modelling for coronavirus disease 2019 (COVID-19), by necessity, assumed relative homogeneity in risks of infection and outcomes across all individuals.
- The COVID-19 epidemic in Canada is marked by heterogeneity in risks of infection, spread and severity across people, places and time.
- Leveraging data on heterogeneity to guide nuanced, population- and setting-specific strategies is not new and will require greater effort than universal strategies; it will not be cheap, but it represents a path forward that affirms human rights and aligns with aspirations for equity in Canada's health systems.

workplaces with variable capacity for physical distancing and infection prevention and control practice, as well as neighbourhood factors such as variable housing density and level of reliance on public transit, affect risk too. Population-level interventions have potential adverse trade-offs. Use of universal strategies of confinement, testing and isolation is associated with direct adverse health consequences from disruptions in delivery of health care and indirect health consequences, such as the mental and physical health effects associated with financial hardship or the loss of employer-supported benefits. Emerging data suggest that these trade-offs reinforce existing disparities in COVID-19 risks because they disproportionately affect those already at higher risk of infection, spread and severity.⁵⁻⁷

Leveraging data on heterogeneity could inform a risk-tailored, population-specific response that involves prioritizing, designing and adapting interventions for specific populations or facilities to prevent the most infections, hospital admissions and deaths. Characterizing local heterogeneity could more reliably anticipate a surge in requirement for acute care beds in area hospitals and optimize the reopening of health and social services at various stages of the epidemic. Moreover, need for community-specific shield or herd immunity to control a local outbreak could be estimated by characterizing the local distribution of factors associated with severity and death, and how they intersect with characteristics that might facilitate spread, and interventions allocated accordingly.⁸ There is still much to learn about individual-level protective immunity.⁹ However, even under assumptions of durable immunity at the individual level, the level of shield immunity needed to control outbreaks is expected to vary between communities, such as between communities with

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mostly older and younger people, or between long-term care facilities and shelters. A careful analysis of the effects of interventions applied to date on reducing community-specific transmission could identify which interventions to scale up, which to scale down or stop, and what might work best for future waves of COVID-19 or communities not yet affected by the pandemic.

Using an understanding of heterogeneity to guide responses to infectious diseases is not new. It is the foundation of the “know your (local) epidemic, know your (local) response” HIV response framework,¹⁰ which enables rapid appraisal of local epidemics and alignment and tailoring of interventions to vulnerabilities (parenteral versus condomless sexual transmission in the context of same-sex practices among men, sex work, etc.) and hotspots that lead to disproportionate risks and sustained transmission. In practice, this framework requires greater effort to implement than a universal approach. Using a similar approach for COVID-19 would mean rigorously identifying which networks and settings may be most at risk and why, and tailoring a suite of interventions to improve the conditions that facilitate spread or, at worst, quickly contain microepidemics once they start. But a specific response is challenging and disruptive because it defies a singular, unified, one-size-fits-all public health message: it calls for nuanced messaging that will vary between communities and settings.¹¹

Top-down universal strategies can be mandated and are often enforced by law (www.policingthepandemic.ca), but responding to heterogeneity requires optimizing data systems and ensuring rapid access to actionable and granular data, creative and context-specific strategies to address underlying inequities, and funding for outreach and services to ensure the safety of those most vulnerable. Granular data systems include interoperability and integration across each layer of surveillance types and sites (e.g., laboratory, public health line-listing, event-driven surveillance of transmission clusters and vital statistics) via standardized indicators that ensure relevant strata (e.g., homelessness) are rapidly captured, as outlined by the World Health Organization in recent guidance.¹² Standardization, or surveillance harmonization, as per global guidance on collecting information on the HIV epidemic,¹³ would also enable rigorous assessments of how and why microepidemics are changing. Examples of context-specific strategies may include housing interventions for underhoused individuals, improved mandates for infection prevention and control at congregate facilities, better protection of staff and their networks, and addressing broader barriers to health care among staff of congregate facilities.

Canadian jurisdictions are likely to experience future waves of COVID-19 of uncertain intensity before the widespread delivery of potential vaccines. We have an opportunity to leverage established frameworks, address specific prevention needs, and meaningfully invest in strategies that address health inequities and better serve the elderly, people experiencing homelessness and those living with limited means. Leveraging data on heterogeneity in our COVID-19 response will not be easy and it will not be cheap, but it represents a path forward that affirms human rights and aligns with aspirations for equity in Canada’s health systems.

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