



Document: Situation, Background, Assessment, Recommendation (SBAR)  
Topic: Vaccine Breakthrough  
Date of review: May 22, 2021  
Date released: August 26, 2021  
Submitted by: CoVaRR-Net  
To: Deputy Minister of Health

---

## Definitions

**Vaccine efficacy/effectiveness:** Vaccine efficacy/effectiveness measure the proportionate reduction in cases among vaccinated persons. Vaccine efficacy is used when a study is carried out under ideal conditions (i.e., clinical trial). Vaccine effectiveness is used when a study is carried out under typical field (less than perfectly controlled) conditions [20].

**Vaccine breakthrough:** Vaccine breakthrough infections are defined as the detection of SARS-CoV-2 RNA or antigen in a respiratory specimen collected from a person  $\geq 14$  days after they have completed all recommended doses of an authorized COVID-19 vaccine [3].

## Situation

As of May 22nd, 2021, 50.6% of the eligible Canadian population has received at least one dose of the COVID-19 vaccine and 4.61% of the population is fully vaccinated [1]. With vaccine administration continuing at a strong pace, five provinces have released “re-opening” plans. However, no vaccine is 100% effective; there is a chance individuals may still become infected with COVID-19 after vaccination [2]. Vaccine breakthrough infections are defined as the detection of SARS-CoV-2 RNA or antigen in a respiratory specimen collected from a person  $\geq 14$  days after they have completed all recommended doses of an authorized COVID-19 vaccine [3]. Concerns of vaccine safety and effectiveness are the two most noted reasons for vaccine hesitancy and refusal [4]. Vaccine effectiveness and breakthrough research on identified variants of concern (VOCs) are in progress. The following brief explores the breakthrough rate for vaccines available in Canada by synthesizing the aforementioned research.

## Background

- The Government of Canada has identified the epidemiological characteristics of vaccine breakthrough illness as an emerging research priority [5]. As of June 1, 2021, 19.3 million Pfizer-BioNTech vaccines, 5.7 million Moderna vaccines, and 2.8 million Oxford-AstraZeneca vaccines have been distributed nationally [6]. Johnson & Johnson/Janssen vaccines have not yet been distributed in this country, but are approved for use in Canada.



- In clinical trials, the efficacy of the vaccines was as follows: Pfizer was 95% effective one week after the second dose, Moderna was 94.1% effective beginning two weeks after the second dose, AstraZeneca was 62% effective in preventing symptomatic COVID-19 two weeks after vaccination, and Janssen was 66% effective in preventing symptomatic COVID-19 two weeks after vaccination [7, 8, 9, 10].
- Four variants of concern (VOC) have been identified in Canada: Alpha, Beta, Gamma, and Delta [11]. Data suggests that vaccines authorized for use offer protection against most VOCs; however, VOCs may cause illness in some people after they are fully vaccinated [12], with some variants demonstrating greater risk than others [13]. The Government of Canada recommends that all vaccine recipients who develop symptoms should be tested for COVID-19 to help document breakthrough illnesses, especially in the context of VOCs [5]. Currently, there is a lack of available data on breakthrough infections across Canada.
- Randomized controlled trials and observational studies exploring COVID-19 vaccine breakthrough infections have shown that breakthrough infections from both the original SARS-CoV-2 (Wuhan-Hu-1) and the Alpha variant, following two doses of vaccine, are low [11]. Breakthrough infections were noted to be rare with the Pfizer, Moderna, and AstraZeneca vaccines – after two doses – as they all showed reduction of infection by greater than 90% in observational studies [11].
- In Ontario, of 6.5 million vaccinated people, 0.15% (9,703) became infected when they were partially vaccinated and 0.02% (1,292) became infected when they were fully vaccinated and were considered breakthrough cases as of May 15, 2021 [2]. The highest proportion of breakthrough cases in Ontario were among individuals 80 years of age and older [2]. Breakthrough cases by vaccine in Ontario reflected the proportion of vaccines distributed throughout the province [2]. The most common VOC detected among breakthrough cases was the Alpha variant, and this was likely due to this being the most common variant circulating from March to June 2021 [2]. Beta and Gamma variants were also detected [2].
- As of April 30th, 2021, the United States (U.S.) reported 10,262 breakthrough infections (0.001%) among the 101 million Americans who had been fully vaccinated for 14 days or more [14]. Among these breakthrough cases, 63% were in females and the median age was 58 years [14]. A total of 160 breakthrough cases were fatal (2%) and the median age of patients who died was 82 years [14]. This report was based on voluntary reporting by state health departments; therefore, it is not considered a complete tally of all breakthrough infections and is likely an underestimation. The proportion of breakthrough infections caused by VOCs was similar to the distribution of these VOCs circulating throughout the U.S. [14].
- No vaccine is 100% effective. Breakthrough cases are expected due to factors such as natural variation in immune systems, under-representation of racial or ethnic



minorities, individuals with co-morbidities in clinical trials, as well as virus evolution [2, 14, 15]. The higher the vaccine's effectiveness, the lower its breakthrough rate should be. As SARS-CoV-2 mutates and new variants emerge, the concern is whether current vaccines will remain effective in the future.

- According to recent research, the Pfizer vaccine prevents infection from both Alpha and Beta VOCs, as well as prevents severe infection from Alpha [16]. There is no data on Pfizer effectiveness on other VOCs, such as Gamma and Delta. Moderna also prevents against infection from Alpha, but there is low-quality evidence that it prevents infection from Beta and no data on Delta and Gamma [16]. It has been found that AstraZeneca prevents infection from Alpha; however, it does not prevent infection from Beta [16]. Lastly, there is evidence that Janssen prevents from the Beta VOC [16].

## Assessment

As evidence continues to emerge, the vaccine effectiveness and breakthrough values will continue to change given that studies are done at different times, in different places, with different vaccines, and with different VOCs [17]. There is limited data evaluating efficacy of COVID-19 vaccines, including measuring a decrease in viral loads for breakthrough infections, and efficacy on circulating VOCs [17]. Preliminary data collected, as well as clinical trials, indicate breakthrough infections are rare thus far.

Currently, Canada does not have publicly available data on vaccine breakthrough rates for COVID-19, other than press release data from Chief Medical Officers of Health in some provinces. Public data on COVID-19 vaccine breakthrough were available online in select provinces across the country, such as Ontario. The current situation of vaccine breakthrough in Canada is difficult to contextualize due to the lack of available data regarding which vaccines have lower or higher rates and the extent of the situation. Vaccination campaign schedules have also been changed, making it difficult to directly transfer data from other jurisdictions. As provinces start their re-opening plans based primarily on vaccine uptake, breakthrough rate data are important to surveil both provincially and nationally. The information can shed light on information leading to the potential of future booster shots and information on populations that were under-represented in clinical trials, for example.

In Canada, the higher efficacy mRNA vaccines have been prioritized and distributed to vulnerable populations such as the elderly, health care workers, and populations in the Canadian territories (northern rural and remote). Vaccine equity has prioritized access for Indigenous Peoples; however, further efforts are needed to overcome historical legacies of medical experimentation that have fostered vaccine hesitancy and even COVID-19 vaccine opposition [18, 19]. The pandemic has shed light on vast inequities across the country. By understanding vaccine distribution by population and subsequently the vaccine breakthrough



rates, officials will be able to address inequities. For example, evidence in Ontario suggested breakthroughs occurred in people aged 80 and older as well as in people with co-morbidities [2].

## Recommendations

1. Breakthrough rates should be under surveillance both provincially/territorially and nationally as Canadians start re-opening through a Pan-Canadian Surveillance System. Knowledge gaps need to be filled with research and data collection regarding breakthrough rates in certain populations, such as Indigenous, racialized, and low-income populations, demographics, and vaccines. High-quality studies on vaccine efficacy/effectiveness on identified VOCs are needed [11].
2. Increase testing and sequencing of viral DNA in infected persons to understand the transmissibility, virulence, and ability of variants to evade current vaccines [21].
3. Profile the immune response following vaccination in vulnerable groups not included in the vaccine manufacturer's clinical trials. Develop guidelines in certain individuals or populations that are mounting a weaker response to vaccination.
4. Continue to encourage local populations to receive vaccines as soon as eligible. Although, data suggests breakthrough rates are low and vaccine efficacy is high, encourage people to continue following public health recommendations by wearing a mask, maintaining appropriate distance from others, avoiding crowds, avoiding poorly ventilated spaces, and washing hands, until more data emerge to further recommendations [17, 12].
5. Use targeted messaging and public service announcement campaigns to increase vaccination rates and maintain public health recommendations.

## References

1. Public Health Agency of Canada. Canadian COVID-19 vaccination coverage report. Ottawa: Public Health Agency of Canada; June 4, 2021. <https://health-infobase.canada.ca/covid-19/vaccination-coverage/>
2. Public Health Ontario. Confirmed cases of COVID-19 following vaccination in Ontario: December 14, 2020 to May 15, 2021. Queen's Printer for Ontario. 2021. <https://www.publichealthontario.ca/-/media/documents/ncov/epi/covid-19-epi-confirmed-cases-post-vaccination.pdf?la=en>
3. Centre for Disease Control and Prevention. COVID-19 vaccine breakthrough case investigation and reporting. National Center for Immunization and Respiratory Disease 2021. <https://www.cdc.gov/vaccines/covid-19/health-departments/breakthrough-cases.html>



4. Public Health Agency Canada. Evergreen rapid review on COVID-19 vaccine attitudes and uptake - update 5. Public Health Agency Canada. 2021.
5. Government of Canada. Recommendations on the use of COVID-19 vaccines. National Advisory Committee on Immunization (NACI). 2021. <https://www.canada.ca/en/public-health/services/immunization/national-advisory-committee-on-immunization-naci/recommendations-use-covid-19-vaccines.html>
6. Government of Canada. Vaccines for COVID-19: Shipments and deliveries. Health Canada. 2021. <https://www.canada.ca/en/public-health/services/diseases/2019-novel-coronavirus-infection/prevention-risks/covid-19-vaccine-treatment/vaccine-rollout.html#a4a>
7. Government of Canada. Pfizer-BioNTech COVID-19 vaccine: What you should know. Health Canada. 2021. <https://www.canada.ca/en/health-canada/services/drugs-health-products/covid19-industry/drugs-vaccines-treatments/vaccines/pfizer-biontech.html>
8. Government of Canada. Moderna COVID-19 vaccine: What you should know. Health Canada. 2021. <https://www.canada.ca/en/health-canada/services/drugs-health-products/covid19-industry/drugs-vaccines-treatments/vaccines/moderna.html#a3>
9. Government of Canada. AstraZeneca/COVISHIELD COVID-19 vaccine: What you should know. Health Canada, Ottawa, ON. 2021. <https://www.canada.ca/en/health-canada/services/drugs-health-products/covid19-industry/drugs-vaccines-treatments/vaccines/astrazeneca.html>
10. Government of Canada. Janssen (Johnson & Johnson) COVID-19 vaccine: What you should know. Health Canada. 2021. <https://www.canada.ca/en/health-canada/services/drugs-health-products/covid19-industry/drugs-vaccines-treatments/vaccines/janssen.html>
11. Public Health Agency of Canada. Rapid review on protective immunity update 1. Emerging Science Group. 2021.
12. Centre for Disease Control and Prevention. What you should know about the possibility of COVID-19 illness after vaccination. National Center for Immunization and Respiratory Disease. 2021. <https://www.cdc.gov/coronavirus/2019-ncov/vaccines/effectiveness/why-measure-effectiveness/breakthrough-cases.html>
13. Bernal JL, Andrews N, Gower C, Gallagher E, Simmons R, Thelwall S, Tessier E, Groves N, Dabrera G, Myers R, Campbell C. Effectiveness of COVID-19 vaccines against the B.1.617.2 variant. medRxiv. 2021 Jan 1. <https://www.medrxiv.org/content/10.1101/2021.05.22.21257658v1.full-text>
14. Center for Disease Control and Prevention. COVID-19 vaccine breakthrough infections reported to CDC – United States, January 1–April 30, 2021. Morbidity and Mortality Weekly Report. p. 792-793. 2021 May 28. <https://www.cdc.gov/mmwr/volumes/70/wr/mm7021e3.htm>
15. Public Health Ontario. COVID-19 B.1.351 (501Y.V2) variant of concern – what we know so far. Queen’s Printer for Ontario. 2021. <https://www.publichealthontario.ca/>



- /media/documents/ncov/covid-wwksf/2021/02/wwksf-covid-19-b1351501yv2-variant-of-concern.pdf?la=en
16. COVID-19 Evidence Network to support Decision-making (COVID-END). COVID-19 Living Evidence Synthesis #6. Health Information Research Unit. 2021 May 3.  
[https://www.mcmasterforum.org/docs/default-source/product-documents/living-evidence-syntheses/covid-19-living-evidence-synthesis-5.1--public-health-and-health-system-impacts-of-sars-cov-2-variants-of-concern.pdf?sfvrsn=d2adf636\\_5](https://www.mcmasterforum.org/docs/default-source/product-documents/living-evidence-syntheses/covid-19-living-evidence-synthesis-5.1--public-health-and-health-system-impacts-of-sars-cov-2-variants-of-concern.pdf?sfvrsn=d2adf636_5)
  17. Alberta Health Services. COVID-19 Scientific Advisory Group Evidence Summary and Recommendations. COVID-19 Scientific Advisory Group. 2021 Mar 23.  
<https://www.albertahealthservices.ca/assets/info/ppih/if-ppih-covid-19-sag-post-vaccine-transmission-rapid-review.pdf>
  18. Mosby I, Swidrovich J. Medical experimentation and the roots of COVID-19 vaccine hesitancy among Indigenous Peoples in Canada. CMAJ. 2021 Mar 15;193(11):E381-3.  
<https://www.cmaj.ca/content/cmaj/193/11/E381.full.pdf>
  19. Driedger SM, Cooper E, Jardine C, Furgal C, Bartlett J. Communicating risk to Aboriginal Peoples: First Nations and Metis responses to H1N1 risk messages. PLOS one. 2013 Aug 7;8(8):e71106.  
<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0071106>
  20. Center for Disease Control and Prevention. Principles of epidemiology in public health practice, lesson 3 – section 6. 2012 May 18.  
<https://www.cdc.gov/csels/dsepd/ss1978/lesson3/section6.html>
  21. Hacısuleyman E, Hale C, Saito Y, Blachere NE, Bergh M, Conlon EG, Schaefer-Babajew DJ, DaSilva J, Muecksch F, Gaebler C, Lifton R. Vaccine breakthrough infections with SARS-CoV-2 variants. New England Journal of Medicine. 2021 Jun 10;384(23):2212-8. doi: 10.1056/NEJMoa2105000

### Suggested Citation

Rowein, S., Habbick, M., Marks, W.N., Camillo, C.A. Muhajarine, N. Vaccine breakthrough. June 2021. Document no.: [1.1] pilot. CoVaRR-Net Public Health, Health Systems, Social Policy Team, c2021.

### About CoVaRR-Net

Coronavirus Variants Rapid Response Network (CoVaRR-Net) is a network of interdisciplinary researchers from institutions across the country created to assist in the Government of Canada's overall strategy to address the potential threat of emerging SARS-CoV-2 variants. Pillar Six of CoVaRR-Net studies the impacts of Coronavirus variants on public health, our healthcare system, and on social policy, and reports these findings to decision-makers and government officials.



CoVaRR-Net is funded by the  
Canadian Institutes of Health Research (CIHR)

