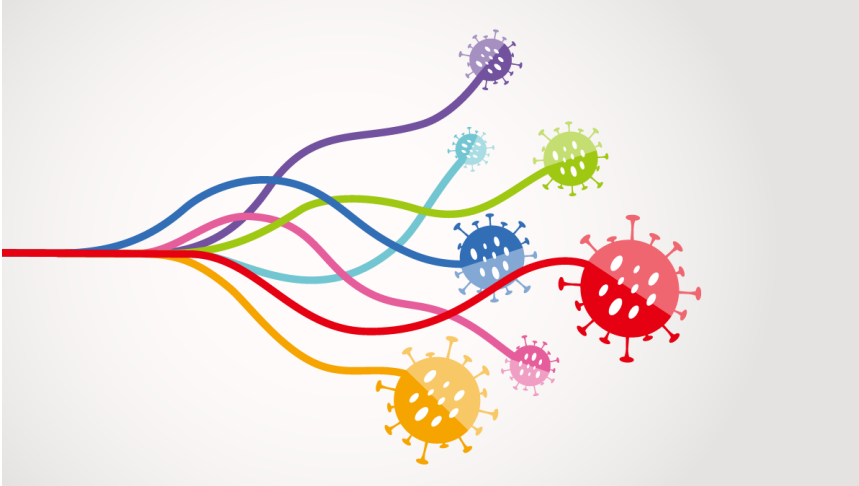


# Updates on COVID-19 Variants of Concern (VOC)



SARS-CoV-2, which causes COVID-19, is a virus from the Coronavirus family. Coronaviruses are named after the Latin word, “corona”, meaning “crown” because they express spike proteins on their surface which resembles the ‘throne of a crown’. The spike protein is comprised of three domains: a short cytoplasmic tail, a transmembrane domain, and an ectodomain. The ectodomain is arguably the most critical structure of the virus because of its role in facilitating the entry of SARS-CoV-2 into host cells. The ectodomain has two general subunits which can be denoted as S1 and S2. To infect host cells, SARS-CoV-2 uses its spike S1 unit to bind to the host entry receptor, angiotensin-converting enzyme 2 (ACE2). Once bound, SARS-CoV-2 then uses the spike S2 unit to fuse its viral envelope with the cellular outer membrane in order to enter the host cell.

Viruses including SARS-CoV-2 can undergo change by acquiring genetic mutations to generate new variants of the virus. As these new variants emerge, some will persist if their mutations improve their virulence and/or transmissibility. As a result, a major concern about the ongoing genetic evolution of SARS-CoV-2 is that the virus could acquire mutations to its spike protein that will improve the virus’ transmissibility and/or disguise its detection from the immune system.

**As of January, 21 2022** there have been **5 SARS-CoV-2 Variants of concern (VOC)** that have emerged and undergone transmission around the world. A variant becomes a concern when it exhibits features of increased infectivity and/or transmissibility.

# SARS-CoV-2 Variants of Concern

<b>Variant of Concern:</b> B.1.1.529   Omicron
<b>Location of Origin:</b> TBD
<b>Initial Emergence:</b> November, 2021(World Health Organization 2021)
<b>Impact on Vaccine Efficacy</b> <ul style="list-style-type: none"><li>- December 26, 2021: According to a pre-print study, a booster dose of the BBIBP-CorV vaccine can produce significantly higher neutralizing titers against the Omicron variant compared to its two-dose regimen. FYI: BBIBP-CorV is an inactivated virus vaccine produced by Sinopharm, a state-owned company in China, Beijing (Yu et al. 2021)</li><li>- December 16, 2021: Individuals who were vaccinated with the CoronaVac (2-dose regimen) were unable to produce detectable neutralizing titers against the Omicron variant. FYI: CoronaVac is a live inactivated whole virion vaccine produced by a Beijing-based company called Sinovac (Lu et al. 2021).</li><li>- November 29, 2021: Moderna announces three vaccine strategies under investigation for addressing Omicron variants: [a] Higher dose booster of mRNA-1273/Moderna vaccine. Development of [b] multi-valent boosters and [b] Omicron-specific boosters (mRNA-1273.529)(Moderna 2021d)</li><li>- November 30, 2021: Chief executive of Moderna, Stéphane Bancel, predicts the existing vaccines will be less effective against Omicron compared to past SARS-CoV-2 variants (Smyth 2021)</li><li>- December 7, 2021: According to preliminary data collected from researchers in South Africa, the ability of the Pfizer vaccine to induce antibody neutralization against the Omicron variant is reduced by 41-folds compared to the wild type SARS-CoV-2 (Joseph and Branswell 2021; Sigallab 2021).</li><li>- December 8, 2021: Data released by Pfizer showed a 25-fold increase in vaccine-induced antibody neutralization of the Omicron variant in patients who received a booster dose of the Pfizer vaccine (Pfizer 2021a; Pfizer and BionTech 2021).</li><li>- December 14, 2021: A pre-print study from Israel found a booster shot of the Pfizer vaccine to be associated with increased protection against Omicron. In comparison, individuals who received only two vaccine doses were found to be less protected against Omicron (Peer-reviewed &amp; Published: December 29, 2021) (Nemet et al. 2021a, 2021b)</li><li>- December 14, 2021: According to a study by South Africa's largest health insurance company, Discovery Ltd., individuals with two vaccine doses had 33% protection against Omicron compared to 80% in the pre-Omicron period. Protection against hospitalisation by Omicron infection also reduced from 93% to 70% post-Omicron period (Discovery Ltd. 2021)</li><li>- December 15, 2021: A study by researchers from The University of Hong Kong showed the Omicron variant can infect and replicate 70-times faster than SARS-CoV-2 wild type and Delta variant in isolated human bronchial tissue(HKUMed 2021).</li><li>- December 20, 2021: Moderna Inc. released data showing high antibody neutralization of Omicron using two different booster doses of Moderna. Further, a booster vaccination of Moderna at either 50 µg or 100 µg were able to increase antibody neutralization against Omicron by ~37- and ~83-folds, compared to pre-boost, respectively (Moderna 2021b)</li></ul>

- December 22, 2021: A study by Oxford University found a third-dose of the AstraZeneca vaccine to increase antibody neutralization against the Omicron variant (AstraZeneca 2021; Dejnirattisai et al. 2021)

### **Impact on Transmission**

- December 1, 2021: South Africa reported 8,561 cases of the Omicron variant; about 2.5-fold increase from its total cases on November 26, 2021 (3,402) (Callaway and Ledford 2021)
- December 2, 2021: A pre-print study found an increase in Omicron cases among individuals previously infected with SAR-CoV-2, suggesting that the variant might be able to evade natural immunity (Pulliam et al. 2021)
- December 3, 2021: World Health Organization's chief scientist, Soumya Swaminathan, speculated that the Omicron variant might be able to displace the Delta variant in community/global transmissions (Guarascio and Nebehay 2021)

### **Arrival to Canada:**

- November 28, 2021: Ontario detected its first two cases of the Omicron variant in Ottawa. Both individuals had recently travelled to Nigeria (Aguilar 2021a; Government of Ontario 2021; Paas-Lang 2021)
- November 29, 2021: Quebec confirmed first case of the Omicron variant who had recent travels from Nigeria (Lofaro 2021; Marchand 2021)
- November 30, 2021: British Columbia confirmed its first case of the Omicron variant in Fraser health who traveled to Nigeria (Dickson 2021; Martins 2021; Zussman 2021)
- November 30, 2021: Alberta confirmed first case of the Omicron variant from an individual travelling from Nigeria and the Netherlands(Gervais 2021).
- December 7, 2021: Manitoba confirmed its first case of the Omicron variant from an individual with recent international travel (Bergen 2021a).
- December 8, 2021: Yukon confirmed its first two cases of the Omicron variant (Ritchie 2021)
- December 8, 2021: Saskatchewan detected its first four cases of the Omicron variant from one household with recent international travels (Giles 2021)
- December 13, 2021: Nova Scotia detected its first cases of the Omicron variant from an outbreak at St. Francis Xavier University in Antigonish. A total of 40 cases from the outbreak were linked to the Omicron variant. (Doucette 2021; Munro 2021)
- December 13, 2021: New Brunswick confirmed its three first cases of the Omicron variant: two in the Miramichi region and one in the Moncton region. All of these cases were linked to a past outbreak at St. Francis Xavier University in Antigonish, Nova Scotia (L. Brown 2021; Perry 2021)
- December 14, 2021: Prince Edward Island linked its first case of the Omicron variant to the outbreak at St. Francis Xavier University in Antigonish, Nova Scotia (Government of Prince Edward Island 2021; Price 2021)
- December 15, 2021: Newfoundland and Labrador reported its first case of the Omicron variant from the province's Eastern Health region (CBC News 2021d; Whiffen 2021)

<ul style="list-style-type: none"> <li>- December 19, 2021: Northwest Territories confirmed first case of the Omicron variant with direct links to interprovincial travel (Down 2021; Government of Northwest Territories 2021; Williams 2021)</li> </ul>
<p><b>Risk to Canadians:</b></p> <ul style="list-style-type: none"> <li>- January 14, 2022: The Public Health of Agency Canada (PHAC) released data showing an intense surge in COVID-19 cases due to the Omicron variant, which has quickly replaced Delta as the dominant variant in Canada. The high infection rates are speculated to stress healthcare capacity within the near future (Public Health Agency of Canada 2022).</li> <li>- December 27, 2021: A pre-print study showed booster-vaccinated individuals were more protected against household secondary transmission of the Omicron variant than those who were unvaccinated or fully vaccinated (2-dose) (Lyngse et al. 2021)</li> <li>- December 14, 2021: According to a study by South Africa’s largest health insurance company, Discovery Ltd., the relative risk for re-infection with Omicron was 40% and 60% for individuals that were previously infected with either Delta or Beta, respectively. (Discovery Ltd. 2021).</li> <li>- December 22, 2021: A report from the Imperial College London found the risk of hospitalization by Omicron infections to be lower than Delta by at least 20-25% (Imperial College London 2021)</li> <li>- December 28, 2021: According to the US Food and Drug Administration, rapid antigen tests might be less sensitive for detecting Omicron infections (i.e. more false negatives) (U.S Food &amp; Drug Administration 2021)</li> </ul>
<p><b>Disease Severity</b></p> <ul style="list-style-type: none"> <li>- December 14, 2021: A study by South Africa’s largest health insurance company, Discovery Ltd., described a 29% decrease in hospital admissions for adults in South Africa, compared to its first COVID-19 wave in 2020 (Discovery Ltd. 2021).</li> <li>- December 21, 2021: A pre-print study by researchers in South Africa found the risk for severe disease by Omicron infection to be lower than Delta infection by 70% (Wolter et al. 2021)</li> </ul>
<p><b>Critical Mutations</b></p> <ul style="list-style-type: none"> <li>- November 23, 2021: The global science initiative, GISAID, confirmed 32 spike mutations on Omicron (UK Health Security Agency 2021).</li> <li>- November 25, 2021: There are speculations that these 32 spike mutations might contribute to increased immune evasion and transmission (Callaway 2021).</li> </ul>

<b>Variant Under Investigation:</b> B.1.617   Delta
<b>Location of Origin:</b> India
<b>Initial Emergence:</b> October, 2020 (World Health Organization 2021)
<p><b>Impact Vaccine Efficacy:</b></p> <ul style="list-style-type: none"> <li>- September 6, 2021: Compared to the original strain in March/2020, the Delta variant was found 9-folds less sensitive to neutralization by sera from AstraZeneca-vaccinated individuals and 8.4-folds less sensitive to neutralization by sera from Pfizer-vaccinated individuals (Mlcochova et al. 2021).</li> </ul>

- July 7, 2021: Despite vaccination, individuals infected by the Delta can exhibit equally high viral loads in their nose/mouth as those who are unvaccinated. However, vaccine efficacy remains at 85% against severe illness by the Delta variant (Mcmorrow 2021).
- June 26, 2021: National Microbiology Lab confirmed 2 case of the Delta variant in Nova Scotia (Cooke 2021; Government of Nova Scotia 2021a)
- June 14, 2021: Public Health England reported that one- and two-doses of the Pfizer vaccine were 94% and 96% protective against hospitalization by the Delta variant, respectively. Whereas, one- and two doses of the AstraZeneca were found to be 71% and 92% protective against hospitalization from Delta, respectively (Stowe et al. 2021).
- June 7, 2021: Sera from both COVID-19 recovered individuals and vaccinees of the two-dose COVAXX vaccine were able to neutralize both the Beta and Delta variants. However, the neutralization titers were reduced against Delta in sera from recovered cases (4.6-fold) and vaccinees (2.7-fold) (Yadav, Sapkal, Ella, et al. 2021)
- June 5, 2021: According to a pre-print study, one dose of either the Pfizer or Moderna vaccine were able to confer high vaccine effectiveness against variants P.1 (61%) and B.1.1.7 (67%) among  $\geq 70$ -year-olds from British Columbia at  $\geq 21$  days post-vaccination (Skowronski et al. 2021)
- June 3, 2021: Sera from vaccinees with two-doses of the Pfizer vaccine were able to neutralize all three variants, although at reduced levels compared to the wild-type strain: B.1.17 (-2.6 fold), B.1.617.2 (-5.8 fold) and B.1.351 (-4.9 fold). Conversely, one-dose of the Pfizer vaccine was associated with reduced neutralization titers against the aforementioned variants at statistically significant levels compared to the wild-type (Wall et al. 2021)
- May 24: A study by the Public Health England found that one dose of either the Astra Zeneca or Pfizer vaccine was  $\sim 20\%$  less effective in preventing symptomatic disease from the delta variant (33.5%) than the alpha variant (51.1%). Fortunately, vaccine effectiveness against the Delta variant was much higher following the second dose of the Astra Zeneca (60%) or Pfizer (88%) vaccine (Lopez Bernal et al. 2021)
- May 20, 2021: BioNTech released a public statement that their Pfizer vaccine is expected to be 70-75% protective against the B.1.617 variant (Toksabay and Reuters 2021)
- April 23, 2021: In a pre-print study, researchers showed Covaxin – a vaccine candidate in India – was able to neutralize the B.1.617 variant (Yadav, Sapkal, Abraham, et al. 2021).

#### **Impact on Transmission:**

- July 7, 2021: The viral load of the Delta variant upon early infection was found  $\sim 1000$  times higher than the original SARS-COV-2 strain in 2020, thus indicating a higher viral replication rate and increased infectiousness (Li et al. 2021).
- June 21, 2021: A pre-print study found the growth rate of Delta variant to be the highest among other variants in the United States (Bolze et al. 2021)
- June 11, 2021: UK public health reported delta as the dominant variant in the country (Public Health England 2021c)

- June 4, 2021: Professor and leading UK epidemiologist, Neil Ferguson, from Imperial College London estimated that the Delta variant is 60% more transmissible than the alpha variant (Cecil 2021; Le Page et al. 2021)

#### **Arrival to Canada:**

- June 11, 2021: Nova Scotia reported two cases of the Delta (B.1.617) . Both have been linked to travel (Government of Nova Scotia 2021c)
- May 19, 2021: Manitoba confirmed 18 cases of the B.1.617 variant in which some of the cases had been identified since late April (Gibson 2021a; Rosen 2021)
- May 14, 2021: Saskatchewan confirmed first case of the B.1.617 variant (Ellis 2021a)
- April 28, 2021: Newfoundland and Labrador confirmed first case of the B.1.617 variant(The Canadian Press 2021a)
- May 4, 2021: Prince Edward Island confirmed first two cases of the B.1.617 variant(Long 2021)
- April 26, 2021: New Brunswick reported first case of the B.1.617 variant in the Fredericton region, Zone 3 (MacKinnon and Fraser 2021)
- April 23, 2021: Ontario confirmed 36 cases of the B.1.617 variant (Aguilar 2021b; Patton and Westoll 2021)
- April 22, 2021: Alberta confirmed first case of the B.1.617 variant from an inter-provincial traveller (CBC News 2021a, 2021b).
- April 21, 2021: Quebec confirmed province's first case of the B.1.617 variant from the Mauricie and Centre-du-Quebec region (Bruemmer 2021; Laframboise 2021b).
- April 21, 2021: British Columbia confirmed 39 cases of the B.1.617 variant which had been identified since April 4, 2021 (Little 2021b)

#### **Risk to Canadians**

- August 28, 2021: A Delta variant outbreak of 23 cases was confirmed at the George M. Guimond Care Centre – a First Nation care home in Manitoba (Unger 2021b)
- August 27, 2021: According to a study on 43 338 COVID-19 positive patients from England, those infected with the Delta variant were twice more likely to be hospitalized than those infected by the Alpha variant(Twohig et al. 2021).
- August 24, 2021: The Korea Disease Control and Prevention Agency (KDCA) found those infected by the Delta variant to have 300-times the viral load than the original 2020 SARS-CoV-2 strain (Cha 2021)
- August 23, 2021: Among 829 patients infected with one of three SARS-COV-2 variants (Alpha, Beta, Delta), those infected with the Delta variant had a higher risk for oxygen requirement, ICU admission, or death (adjusted odds ratio: 4.90 [1.43-30.78])(Ong et al. 2021)
- August 11, 2021: A pre-print study found that vaccinated individuals can harbour equally high levels of viral load in their nasal swabs as unvaccinated individuals. This would suggest that vaccinated individuals can still contribute to community transmission and/or become infected (Riemersma et al. 2021)

- August 11, 2021: Data published by the Government of Canada showed that ~90% of COVID-19 cases, since the start of the vaccine campaign (July 24, 2021), has mainly been unvaccinated individuals (Public Health Agency of Canada 2021a)
- August 7, 2021: Three of the 26 active outbreaks in Saskatchewan were confirmed as being caused by the Delta variant. These outbreaks were reported from a private gathering, a school, and widespread community (Djuric 2021)
- August 6, 2021: After several large public gatherings at a beach town in Massachusetts, the CDC reported an outbreak of 469 COVID-19 cases, of which 74% (346) were fully vaccinated individuals (i.e. 2 doses of Pfizer or Moderna, 1 dose of Johnson & Johnson). Among those with vaccine breakthrough infections, 79% (274) were symptomatic (C. M. Brown et al. 2021)
- August 4, 2021: In a retrospective analysis of those infected in Ontario between Feb. 7 – June 27, 2021 (n=212,332), patients infected with the Delta variant were at higher risk for hospitalization, ICU admission, and death compared to non-variants of concerns (Fisman and Tuite 2021)
- August 1, 2021: A pre-print study showed the Delta variant was able to infect vaccinated individuals at about three-times the rate of other COVID-19 variants (17.4% vs 5.8%)(Musser et al. 2021)
- July 29, 2021: According to the CDC, the Delta variant has a reproduction number (Ro) of 5-9, thus indicating that this variant could be more transmissible than other viruses such as, Ebola, Smallpox, Spanish Flu, MERs, and SARS. The Delta variant has also been associated with longer periods of infectivity compared to past variants (Mcmorrow 2021).
- July 20, 2021: According Infectious Disease Expert, Dr Anthony Fauci, more than 80% of COVID-19 cases in the U.S are attributed to the Delta variant (O'donnell and Roy 2021)
- June 26, 2021: Those infected with Delta were likely to be younger individuals and had double the risk for hospital admission than those infected with the Alpha variant. (Sheikh et al. 2021)
- June 18, 2021: Public Health Agency confirmed over 2000 cases of the Delta variant across Canada. Canadian chief public health officer, Dr Theresa Tam, shared concerns about the rapid spread of the variant across all provinces (Rabson 2021).
- June 17, 2021: A pre-print study found the rate of COVID-19 cases among children aged 5-12 years old were 5-folds higher than adults (18-24) in the UK. The authors speculated that this rapid increase in infection among children is potentially driving the surge in Delta cases in the UK (Riley et al. 2021).
- June 16, 2021: The Delta variant outbreak at Calgary's Foothill Medical Centre reported two deaths: a patient with both doses of vaccination and another individual who did not receive any doses (Short 2021)
- June 12, 2021: Calgary's Foothill Medical Centre reported Delta variant outbreak with 16 patients and 6 health-care workers who tested positive for the Delta variant, despite receiving the mRNA vaccines: 6 patients & 5 health-care workers (2 doses); 7 patients and 1 health-care worker (1 dose)(CBC News 2021e)
- May 27, 2021: Public Health Ontario reported that the number of Delta cases changed from 45 to 260 between May 12 to May 19, thus indicating almost a 6-fold increase within a week (Herhalt 2021)

- May 26, 2021: Newfoundland and Labrador public health reported the Delta variant was driving the COVID-19 outbreak through their central province (Moore 2021b; The Canadian Press Staff 2021)
- May 10, 2021: A pre-print study showed the B.1.617 variant was 6.8-fold more resistant to neutralization than the Wuhan strain in response to sera from both convalescent individuals and Pfizer- and Moderna-vaccinated individuals. However, all sera from vaccinated individuals and majority of sera from convalescent individuals remained effective in neutralizing the variant. (Venkata-Viswanadh Edara et al. 2021).
- May 10, 2021: The World Health Organization declared the B.1.617 as a global variant of concern (Reuters 2021)
- April 22, 2021: To address the spread of the B.1.617 variant, the Canadian government has declared a 30-day ban on all flights travelling from India and Pakistan (Cochrane and Jones Patrick 2021; Gilmore and Connolly 2021; Hunter 2021)
- April 21, 2021: Researchers speculated that the B.1.617 could be driving the second wave of COVID-19 cases in India (Mallapaty 2021).
- April 16, 2021: United Kingdom reported 77 cases of the B.1.617 variant (Public Health England 2021a)
- April 15, 2021: India reported 60% of 361 COVID-19 cases between January and March were derived from the B.1.617 variant (Press Trust of India 2021)
- March 24, 2021: Researchers from India characterized the B.1.617 variant and discovered the presence of two mutations which have been identified in past variants: E484Q (B.1.1.7, B.1.351) and L452R (B.1.427/B.1.429). This variant is believed to exhibit increased infectivity and capacity for immune escape (Press Information Bureau Delhi 2021).

<b>Variant of Concern</b> P.1   Gamma
<b>Other Names:</b> B.1.1.248
<b>Initial Date of Emergence:</b> November 2020 (World Health Organization 2021)
<b>Initial Location:</b> Brazil
<b>Impact Vaccine Efficacy</b>
<ul style="list-style-type: none"> <li>- June 5, 2021: According to a pre-print study, one dose of either the Pfizer or Moderna vaccine were able to confer high vaccine effectiveness against variants P.1 (61%) and B.1.1.7 (67%) among ≥70-year-olds from British Columbia at ≥21 days post-vaccination (Skowronski et al. 2021)</li> <li>- March 9, 2021: A study published by the New England Journal of Medicine found the Pfizer vaccine, vaccine, BNT162b2, to be effective in neutralizing both the P.1 and B.1.1.7 at equally high levels. Even though the vaccine efficacy against the B.1.351 was effective, it was relatively lower (Liu et al. 2021).</li> <li>- January 25, 2021: Due to its mutation similarities with the B.1.1.7 variant, researchers predict that the Moderna vaccine will be equally protective against both variants (Pietsch and Mandavilli 2021)</li> </ul>
<b>Impact on Transmission</b>



- March 5, 2021: In a pre-print study, researchers predicted the P.1 variant was 2.5-times more transmissible than the wild variant and was associated with a reinfection probability of 6.4% (Mendes Coutinho et al. 2021)
- January 27, 2021: Researchers declared the P.1 variant as the dominant SARS-CoV-2 strain in Manaus Brazil (France24 2021).
- January 25, 2021: Minnesota confirmed America's first case of the P.1 variant (Health 2021).
- January 12, 2021: The Center for Arbovirus Discovery, Diagnostics, Genomics, and Epidemiology (CADDE) Genomic Network reported 85% of genotyped samples from Manaus Brazil to be from the P.1 variant (N. R. Faria, Claro, et al. 2021)
- December 16-23: Researchers discovered 13 out of 31 (42%) RT-PCR tests in Manaus, Brazil to be positive for the new P.1 variant. Data were published onto a public domain on January 12, 2021 (N. Faria and Et-al 2021)

### **Arrival to Canada**

- May 6, 2021: New Brunswick confirmed first case of the P.1 variant from the Bathurst region, Zone 6 (Sutherland 2021)
- April 28, 2021: Newfoundland and Labrador reported first case of the P.1 variant (The Canadian Press 2021a)
- April 20, 2021: Saskatchewan confirmed first five cases of the P.1 variant from southwest region (Ellis 2021c; Quenneville 2021).
- April 18, 2021: Nova Scotia reported first P.1 case (April 2021; Government of Nova Scotia 2021b).
- April 15, 2021: Manitoba confirmed first case of the P.1 variant from the Interlake-Eastern health region (Gibson 2021b; Unger 2021a).
- March 14, 2021: Alberta confirmed first two cases of the P.1 variant from the Calgary zone (Babych 2021; CBC 2021a).
- March 10, 2021: Quebec confirmed first case of the P.1 variant from Montreal (Laframboise 2021a; The Canadian Press 2021b).
- February 8, 2021: Ontario confirmed Canada's first case of the P.1 variant in Toronto, Ontario. The case was linked to international travel to Brazil (Favaro, St. Philip, and Jones Mae 2021).

### **Risk to Canadians**

- April 6, 2021: Total P.1 cases in British Columbia increases up to 872, thereby rendering the province as the world's largest sequenced P.1 outbreak outside of Brazil (BC Centre for Disease Control 2021)
- April 5, 2021: Alberta Public Health reported a P.1 variant outbreak at three major work sites. The outbreaks were traced back to one individual who recently travelled outside the province (Junker 2021; Woo and Hunter 2021)
- March 3, 2021: In a pre-print study by the Centre for Arbovirus Discovery, Diagnosis, Genomics and Epidemiology (CADDE), researchers predicted the P.1 variant to be 1.4-2.2 times more transmissible than non-P.1. variants. Researchers also found a 25-61% increase in likelihood that the P.1 variant can evade protective immunity induced by non-P.1 lineages (N. R. Faria, Mellan, et al. 2021).
- January 17, 2021: First confirmation of re-infection with the P.1 variant in a 29-year-old female with no signs of immunosuppression (Naveca et al. 2021).

**Disease Severity:**

No Data (2021-03-08)

**Notable Mutations**

- Three mutations in the receptor binding domain (RBD) of the spike protein: N501Y, K417T and E484K  
Consists of 3 deletions and 17 unique changes in amino acid sequence (CDC 2020)

**Variant of Concern:** B.1.351 | Beta

**Other Names:** 501Y.V2

**Initial Date of Emergence:** May 2020 (World Health Organization 2021)

**Initial Location:** South Africa

**Impact Vaccine Efficacy**

- June 7, 2021: Sera from both COVID-19 recovered individuals and vaccinees of the two-dose COVAXX vaccine were able to neutralize both the Beta and Delta variants. However, the neutralization titers of the beta variant were reduced in sera from recovered cases (-3.3 fold) and vaccinees (-3.0 fold) (Yadav, Sapkal, Ella, et al. 2021)
- June 3, 2021: Sera from vaccinees with two-doses of the Pfizer vaccine were able to neutralize all three variants, although at reduced levels compared to the wild-type strain: B.1.17 (-2.6 fold), B.1.617.2 (-5.8 fold) and B.1.351 (-4.9 fold). Conversely, one-dose of the Pfizer vaccine was associated with reduced neutralization titers against the aforementioned variants at statistically significant levels compared to the wild-type (Wall et al. 2021)
- March 9, 2021: A study published by the New England Journal of Medicine found the Pfizer vaccine, vaccine, BNT162b2, to be effective in neutralizing both the P.1 and B.1.1.7 at equally high levels. Even though the vaccine efficacy against the B.1.351 was effective, it was relatively lower (Liu et al. 2021).
- February 7, 2021: AstraZeneca released vaccine trial results in South Africa showing reduced vaccine efficacy against the B.1.351 variant (Wits University 2021). The study is currently under peer-review.
- January 29, 2021: Johnson & Johnson, also the only drug corporation that is developing a one-shot vaccine, released results from its phase 3 vaccine trials in the United States, Latin America, and South Africa. Analysis of the results found the vaccine efficacy to be 72%, 66%, and 57% in the United States, Latin America, and South Africa, respectively. The reduced vaccine efficacy found in the South African clinical trial has been attributed to the B.1.351 variant (Johnson & Johnson 2021a; Zimmer, Weiland, and LaFraniere 2021).
- January 28, 2021: Novavax shared interim results from its clinical trial in South Africa, revealing reduced protective efficacy (40-60%) of its vaccine against the variant B.1.351 (Novavax 2021b).
- January 25, 2021: Moderna Inc. found a six-fold reduction in the neutralizing titer induced by their vaccine, mRNA-1273, in response to the B.1.351 variant. Despite the reduced efficacy, the neutralizing titers remained above levels required for protection against SARS-CoV-2 infection (Moderna 2021c; Wu et al. 2021). Moderna Inc. is looking to study how an additional booster of its vaccine can impact the level of neutralizing titers against the B.1.351 variant. Additionally, the

company is also seeking to develop a booster vaccine, mRNA- 1273.351, against the B.1.351 variant (Moderna 2021c).

### **Impact on Transmission**

- January 28, 2021: The United States' first two cases of B.1.351 variant was detected in South Carolina (Johnson and Achenbach 2021; LIU and STOBBE 2021)
- December 23, 2020: Professor Salim Abdool Karim, Chairperson of the COVID-19 Ministerial Advisory Committee, suggest there is evidence that the B.1.351 variant is 50% more infectious than previous strains (SABC 2021).

### **Arrival to Canada:**

- April 12, 2021: New Brunswick reported first two cases of the B.1.351 variant in Saint John region (Renic 2021)
- March 31, 2021: Newfoundland and Labrador confirmed first case of the B.1.351 variant in the Eastern Health region (Moore 2021a).
- March 2, 2021: Manitoba confirmed first two cases of the B.1.351 variant in Winnipeg (Gibson 2021c; Government of Manitoba 2021).
- February 23, 2021: Saskatchewan confirmed first case of the B.1.351 variant in the North Central region of Saskatchewan (Ellis 2021b).
- February 9, 2021: Quebec confirmed first two cases of the B.1.351 variant in Abitibi-Témiscamingue of Western Quebec. Both cases had no history of international travel (Montpetit and Shingler 2021; Ross 2021; Simona Maratta 2021).
- February 2, 2021: Ontario confirmed first case of B.1.351 in the Peel region of Southern Ontario (Freeman 2021)
- January 22, 2021: Nova Scotia confirmed first two variant cases of COVID-19, B.1.1.7 and B.1.351. Both cases were associated with international travel and did not result in community transmission (Farnell 2021).
- January 14, 2021: British Columbia confirmed first case of B.1.351 variant (Holliday 2021; Little 2021a).
- January 8, 2021: Alberta confirmed Canada's first case of the B.1.351 variant (Heidenreich and Ramsay 2021).

### **Risk to Canadians**

- March 2, 2021: Public health found a second SARS-CoV-2 variant from the outbreak at the Skyline Lancelot Apartment, in North Bay, Ontario; two positive cases of the B.1.1.7 variant (MacDonald 2021b).
  - o March 1, 2021: Third person has been confirmed dead due to the COVID-19 variant outbreak at the Skyline Lancelot Apartment (MacDonald 2021c).
  - o February 26, 2021: The North Bay Parry Health Unit confirmed 42 positive COVID-19 cases from the outbreak at the Skyline Lancelot Apartment. Public health also found 12 of the positive COVID-19 cases to be from the B.1.351 variant (MacDonald 2021a).
  - o February 11, 2021: A COVID-19 variant outbreak was declared at the Skyline Lancelot Apartment. Public Health confirmed 24 positive cases of COVID-19 (Mullan 2021).

- February 9, 2021: According to Quebec’s Public Health Director, Dr. Horacio Arruda, the B.1.351 may have been responsible for two COVID-19 outbreaks in Abitibi-Témiscamingue during January, 2021. According to Abitibi-Témiscamingue's medical officer, Dr. Omobola Sobanjo, preliminary results suggest that up to 30 cases can be directly linked back to the two first cases of B.1.351 in Quebec (Montpetit and Shingler 2021; Ross 2021; Simona Maratta 2021).
- January 28, 2021: Novavax Inc. releases findings from their phase 3 and 2b clinical trials in the United Kingdom and South Africa, respectively. In their preliminary analysis, they have provided data suggesting that patients who were previously infected with the original SARS-CoV-2 strain can still be re-infected with the B.1.351 strain (Novavax 2021b). Data was later published in the following report (Novavax 2021a).

**Disease Severity**  
No Data (2021-02-14)

**Notable Mutations**  
Acquired several mutations in the spike proteins: N501Y, E484K, K417N, D614G, and A701V (CDC 2020)

**Variant of Concern:** B.1.1.7 | Alpha

**Other Names:** 202012/01

**Location of Origin:** UK

**Initial Emergence:** September, 2020 (World Health Organization 2021)

- Impact on Vaccine Efficacy**
- June 3, 2021: Sera from vaccinees with two-doses of the Pfizer vaccine were able to neutralize all three variants, although at reduced levels compared to the wild-type strain: B.1.17 (-2.6 fold), B.1.617.2 (-5.8 fold) and B.1.351 (-4.9 fold). Conversely, one-dose of the Pfizer vaccine was associated with reduced neutralization titers against the aforementioned variants at statistically significant levels compared to the wild-type (Wall et al. 2021)
  - March 9, 2021: A study published by the New England Journal of Medicine found the Pfizer vaccine, vaccine, BNT162b2, to be effective in neutralizing both the P.1 and B.1.1.7 at equally high levels. Even though the vaccine efficacy against the B.1.351 was effective, it was relatively lower (Liu et al. 2021).
  - January 28, 2021: Novavax announced results from their phase 3 clinical trials in the United Kingdom showing their vaccine, NVX-CoV2373, had a protective efficacy of 89.3% against SARS-CoV-2 (Novavax 2021b). About 50% of PCR-confirmed symptomatic cases from their placebo group, who did not receive the vaccine, were infected by the B.1.1.7 variant. Thus, these results suggest that the NVX-CoV2373 vaccine can still confer protection against the B.1.1.7 variant.
  - January 25, 2021: Moderna Inc. announced their vaccine, mRNA-1273, was able to induce similar levels of neutralizing antibodies against the B.1.1.7 variant as prior variants (Moderna 2021c; Wu et al. 2021)

- January 19, 2021: Pfizer and BioNTech constructed a pseudovirus with the B.1.1.7 variant mutation, N501Y. The company tested their vaccine, BNT162b2, against the pseudovirus and found the protective efficacy to remain unaffected (Muik et al. 2021)

### **Impact on Transmission**

- January 7, 2021: One peer-reviewed study detected a 75% increase in transmissibility of the B.1.1.7 variant than the original strain (Leung et al. 2021)
- December 18, 2021: UK's New and Emerging Respiratory Virus Threats Advisory Group (NERVTAG) released a report suggesting that B.1.1.7 exhibits a higher rate of transmission than previous SARS-CoV-2 strains (Hayward, Shen Lim Julian Hiscox, and Edmunds 2020). Within three months of its emergence (September), the B.1.1.7 variant has become the predominant circulating strain in the UK (Ecdc 2021)

### **Arrival to Canada:**

- April 26, 2021: Nunavut confirmed province's first cases of B.1.1.7 variant. A total of 21 positive cases of the B.1.1.7 variant were confirmed on this date. (Tranter 2021)
- April 2, 2021: Northwest Territories reported first case of the B.1.1.7 variant at remote mining site (CBC News 2021c)
- March 25, 2021: Yukon confirmed first case of the B.1.1.7 variant (Government of Yukon 2021; PLONKA 2021).
- February 13, 2021: Prince Edward Island confirmed first case of B.1.1.7 variant which has been linked to international travel. The individual was reported to be their 20s and had no close contacts upon their return to Canada (MacLeod 2021; Press 2021).
- February 12, 2021: Newfoundland and Labrador confirmed an outbreak of the B.1.1.7 variant in St John's Metro region. Pre-liminary testing of 19 cases sent by the Newfoundland and Labrador government found all samples to be positive for the B.1.1.7 variant (Quon 2021)
- February 9, 2021: Manitoba confirmed first case of the B.1.1.7 variant from a sample that was collected on January 22, 2021. The case has been linked to international travel. Further reports revealed the infected individual was in contact with 5 other people, all of whom remained negative for COVID-19 to date (Bergen 2021b; Billeck 2021).
- February 2, 2021: New Brunswick confirmed first three cases of the B.1.1.7 variant; 2 from the St. John area and 1 one from the Miramichi area. Two of the cases were linked to international traveling, whereas the one case was linked to travel within Canada (L. Brown and Horne Van 2021).
- February 2, 2021: Saskatchewan confirmed first two positive cases of the B.1.1.7 variant infection in two residents from Regina (Saskatchewan 2021; Sciarpettetti 2020). Two days later, Saskatchewan confirmed first case of B.1.1.7 variant infection in Saskatoon (Government of Saskatchewan 2021).
- January 22, 2021: Nova Scotia confirmed first two variant cases of COVID-19, B.1.1.7 and B.1.351. Both cases were associated with international travel and did not result in community transmission (Farnell 2021; Government of Nova Scotia 2021d)
- December 29, 2020: Quebec confirmed first case of the B.1.1.7 variant from an individual whose family member travelled to the UK and returned on December 11. The traveller was then tested positive for COVID-19 on December 13<sup>th</sup>. The traveller continued follow quarantine rules and

remained at home with three members of their immediate family. The B.1.1.7 variant was later confirmed in a member of this family. Further testing revealed all three members to be infected with COVID-19 (Caruso-Moro 2020; Cori-Manocchio 2020; Magder 2020; Québec 2020).

- December 25, 2020: Alberta confirmed first positive case of the B.1.1.7 variant from an individual that recently travelled to the UK (Franson 2020; Mertz 2020).
- December 27, 2020: British Columbia confirms first positive case of the B.1.1.7 variant from an individual that returned from the UK on December 15th (Uguen-Csenge and Kearney 2020).
- December 26, 2020: Ontario confirmed Canada's first cases of the B.1.1.7 variant in two individuals from Toronto (Aziz 2020; Jabakhanji 2020; Rocca 2020).

#### **Risk to Canadians:**

- March 29, 2021: A report by Ontario's COVID-19 Science Advisory Table stated that 67% of all COVID-19 cases in Ontario were due to variants of concern (VOC). Cases of VOC were associated with increased risk of hospitalization (63%), intensive care unit admission (103%), and death (56%). The report also found 90% of VOC cases in Ontario were from the B.1.1.7 variant (Tuite et al. 2021)
- March 30, 2021: One published study predicted that the B.1.1.7 variant is 50% more transmissible than the wild-type strain and is increasing in proportions at a rate of ~7.5% per day in the United States (Washington et al. 2021)
- March 23, 2021: Canada's Chief Public Health Officer, Dr. Theresa Tam, reports that COVID-19 cases due to the B.1.1.7 variant are currently the highest among young age groups in Canada (D'Amore 2021)
- March 19, 2021: Dr. Theresa Tam reports there are approximately 4,500 variant cases of COVID-19 in Canada, in which 90% are from the B.1.1.7 variant (Zuber 2021).
- March 18, 2021: A pre-print study reported first case of infection by the B.1.1.7 variant in domestic cats and dogs (Ferasin et al. 2021).
- March 16, 2021: Quebec's Premier, François Legault, shares warning that the B.1.1.7 variant will become the province's dominant strain by the end of April (Derfel 2021)
- March 2, 2021: Public health found a second SARS-CoV-2 variant from the outbreak at the Skyline Lancelot Apartment, in North Bay, Ontario; two positive cases of the B.1.1.7 variant (MacDonald 2021b).
  - o March 1, 2021: Third person has been confirmed dead due to the COVID-19 variant outbreak at the Skyline Lancelot Apartment (MacDonald 2021c).
  - o February 26, 2021: The North Bay Parry Health Unit confirmed 42 positive COVID-19 cases from the outbreak at the Skyline Lancelot Apartment. Public health also found 12 of the positive COVID-19 cases to be from the B.1.351 variant (MacDonald 2021a).
  - o February 11, 2021: A COVID-19 variant outbreak was declared at the Skyline Lancelot Apartment. Public Health confirmed 24 positive cases of COVID-19 (Mullan 2021).
- February 13, 2021: In a modeling study by epidemiologist Caroline Colijn, researcher shows that failure to contain and prevent transmission of the B.1.1.7 variant can lead to an outbreak in March with more than 5,000 cases per day in British Columbia, Ontario, and Saskatchewan (Are and Colijn 2021).

- February 12, 2021: Newfoundland and Labrador government declared outbreak in St. John area due to a spike in positive cases for SARS-CoV-2. The province has transitioned to Alert Level 5 with the assumption that the variant B.1.1.7 is responsible for the outbreak. Pre-liminary testing of 19 cases sent by the Newfoundland and Labrador government found all samples to be positive for the B.1.1.7 variant (Quon 2021).
- February 12,2021: According to a pre-print study, the B.1.1.7 variant was able to accelerate its transmission in the Greater Toronto Area by 1.8 fold per week during the month of January (K. A. Brown et al. 2021).
- February 11, 2021: Scientific experts predict that the B.1.1.7 variant will eventually become the dominant strain of SARS-CoV-2 in Ontario. Cases of the B.1.1.7 variant are believed to increase in late February (Update on COVID-19 Projections Science Advisory and Modelling Consensus Tables 2021).
- January 25, 2021: Alberta confirmed its first case of B.1.1.7 variant without links to travel exposure. Alberta’s Minister of Health, Tyler Shandro, shares the concern that the variant may have begun circulating inside the community (Antoneshyn 2021).
- January 8, 2021: Long-term care home, Roberta House, from Barrie Ontario was deemed to be in a COVID-19 outbreak.
  - o January 2: preliminary testing detected 6 positive cases were from the B.1.1.7 variant. This variant was believed to have spread onto at least 21 household members of staff and those that visited the facility (CBC 2021b)
  - o January 26, 2021: The Simcoe Muskoka District Health Unit discovered over 100 cases of the B.1.1.7 variant which were linked to the Roberta House outbreak (Momney 2021)
  - o February 8, 2021: Reports found 129 residents at Roberta House to be positive for COVID-19 in which 69 have died (Goldfinger 2021; Morris 2021)
  - o February 9, 2021: 65 cases of infected residents were confirmed to be from the B.1.1.7 variant. 18 additional cases have been screened positive for presence of mutation and will require further validation of the variant (CP24 2021).
- December 12, 2020: Public Health England releases a report suggesting that the B.1.1.7 variant can evade detection by PCR assays which use the ‘S’ gene as the amplification target, also known as a S gene target failure (SGTF) (England 2020; Galloway et al. 2021; Public Health England 2021b).

### **Disease Severity**

- April 12, 2021: Two published studies found no evidence of increased disease severity among patients infected with the B.1.1.7 variant (Frampton et al. 2021; Graham et al. 2021).
- March 15, 2021: A study published in Nature estimated a 61% increase in risk of death among those infected with the B.1.1.7 variant(Davies et al. 2021).
- March 10, 2021: A study published in BMJ estimated a 64% increase in risk of death among those infected with the B.1.1.7 variant (Challen et al. 2021)
- January 21, 2021: NERVTAG published a report suggesting that B.1.1.7 was linked to a 30% increase in risk of death compared to previous strains (Horby et al. 2021). The same report also identified several limitations in their conclusion including their small sample size.

### Critical Mutations

- N501Y: Mutation at genomic position 501 in the receptor binding domain (RBD) of the spike protein. This resulted in an amino acid change from asparagine (N) to tyrosine (Y)
- P681H: Mutation at the cleavage site of the spike protein (CDC 2020)

**SARS-CoV-2 Variants of interest:** are characterized by genetic changes that alter the viral traits of SARS-CoV-2, thereby resulting in increased viral transmission, immune evasion, therapeutic/diagnostic evasion, and/or increased disease severity. VOC should also be linked with increased prevalence across both local and global communities (World Health Organization 2021).

**Variant of Under Investigation:** C.37 | Lambda

**Location of Origin:** Peru

**Initial Emergence:** December, 2020

#### Recent Developments

- July 28, 2021: A pre-print by researchers in Japan identified several mutations in the Lambda variant that were associated with high viral infectivity and resistance to vaccine-induced neutralization (Kimura et al. 2021)
- July 3, 2021: The Lambda spike protein was associated with higher infectivity compared to the wild-type strain in 2020, however, it remained highly susceptible to vaccine-induced neutralization (Tada et al. 2021)

**Variant of Under Investigation:** B.1.621 | Mu

**Location of Origin:** Colombia

**Initial Emergence:** January, 2021

#### Recent Developments

- August 30, 2021: The World Health Organization deemed Mu to be a variant of interest (Elliott 2021)
- August 31, 2021: A report released by the World Health Organization showed detection of the Mu variant across 39 different countries (The World Health Organization 2021).

**SARS-CoV-2 Variants Under Monitoring:** are characterized by genetic changes that are suspected to affect the viral traits of SARS-CoV-2 and could potentially become a future risk (World Health Organization 2021).

**Variant of Under Investigation:** B.1.640 | IHU

**Location of Origin:** TBD



**Initial Emergence:** September, 2021

**Recent Developments:**

- December 29, 2021: A pre-print study by researchers from France identified a new variant of SARS-CoV-2, denoted as "IHU", in 12 individuals. The variant contained 14 amino acid substitutions and 9 deletions affecting its spike protein (Colson et al. 2021).

**Variant of Under Investigation:** C.1.2

**Location of Origin:** South Africa

**Initial Emergence:** May, 2021

**Recent Developments:**

- August 24, 2021: C.1.2 shares similar mutations with 4 other variants of concern (Alpha, Beta, Delta, and Gamma). Since its emergence, C.1.2 has been detected in seven other countries located in Asia, Africa, Oceania, and Europe (Scheepers et al. 2021).
- August 30, 2021: The Network for Genomics Surveillance in South Africa stated in a press release that the C.1.2 variant has been detected in all provinces across South Africa (The National Institute for Communicable Diseases 2021).
- August 31, 2021: In a United Nations briefing, WHO spokesperson, Margaret Harris, states that the C.1.2 variant "does not appear to be increasing in circulation" (Thomasson 2021)

**Variant of Under Investigation:** B.1.1.318

**Location of Origin:** TBD

**Initial Emergence:** January, 2021

**Recent Developments:**

- June 16, 2021: A second wave of SARS-CoV-2 infections in Mauritius was directly linked to a new variant known as B.1.1.318 (accounted for 76% of sequenced cases). Further genomic analysis of B.1.1.318 revealed 14 mutations in the SARS-CoV-2 spike protein. The variant was also identified in 34 other countries, including Canada that had 1.10% of its sequenced cases identified as B.1.1.318 (Tegally et al. 2021)

# Information and Resources

## Updates about Vaccine Development

- November 29, 2021: Moderna announces three vaccine strategies under investigation for addressing Omicron variants: [a] Higher dose booster of mRNA-1273/Moderna vaccine. Development of [b] multi-valent boosters and [b] Omicron-specific boosters (mRNA-1273.529)(Moderna 2021d)
- November 30, 2021: Chief executive of Moderna, Stéphane Bancel, predicts the existing vaccines will be less effective against Omicron compared to past SARS-CoV-2 variants (Smyth 2021)
- July 28, 2021: Findings released by Pfizer suggested that a third dose of the Pfizer/BioNTech COVID-19 vaccine could increase neutralizing antibody titers by >5-folds against the Delta variant (Stevo 2021)
- February 24, 2021: Moderna announced its shipment of the B.1.351 variant-specific vaccine candidate to NIH for Phase 1 clinical trials (Moderna 2021a).
- February 27, 2020: FDA approves Johnson & Johnson vaccine for emergency use (FDA NEWS RELEASE 2021).
- February 19, 2021: Pfizer submits vaccine stability data to the Food and Drug Administration (FDA) revealing that their vaccine, BNT162b2, can be stored at higher temperatures between -25 to -15 °C. This current label requires that the vaccine be stored between -80 to -60 °C. New storage conditions is currently pending approval from the FDA (Pfizer 2021b; Reuters Staff 2021).
- February 10, 2021: South Africa replaced its original vaccine candidate, AstraZeneca, with the Johnson & Johnson vaccine, which has not yet been approved by the U.S. Food and Drug Administration and the South Africa's regulatory authority. The South African government intends to provide this vaccine to its front-line health workers in the following week (Meldrum 2021; Meyer 2021).
- February 7, 2021: South Africa halted their rollout of the AstraZeneca vaccines due to its reduced efficacy against the B.1.351 variant (Mueller, Robbins, and Chutel 2021)
- February 7, 2021: AstraZeneca is developing a 2<sup>nd</sup> generation vaccine that is effective against the B.1.351 variant. This is a response to its recent clinical trials in South Africa where researchers deemed the AstraZeneca to be ineffective against the B.1.351 variant (Wits University 2021).
- February 4, 2021: Johnson & Johnson is pursuing Emergency Use Authorization (EUA) from the U.S. Food and Drug Administration (FDA) for its single-dose vaccine, Janssen (Johnson & Johnson 2021b)
- January 25, 2021: Moderna Inc. is looking to study how an additional booster of its vaccine can impact the level of neutralizing titers against the B.1.351 variant. Additionally, the company is also seeking to develop a booster vaccine, mRNA- 1273.351, against the B.1.351 variant (Moderna 2021c; Wu et al. 2021).

## Key Events

- January 18, 2022: Pfizer presents pre-print data from three independent laboratory studies showing high *in vitro* efficacy of its new COVID-19 oral drug, Paxlovid™, against the Omicron variant (Pfizer 2022)
- January 11, 2022: BioNTech and InstaDeep Ltd announces their newly developed computational method to sequence and predict SARS-CoV-2 variants of concern (BioNTech 2022)
- August 6, 2021: Among those who were infected with SARS-CoV-2 in 2020, researchers found that risk of re-infection was 2.34-times higher among those who were unvaccinated than vaccinated (Cavanaugh et al. 2021).
- March 26, 2021: Data released by the Public Health Agency of Canada (PHAC) showed increased COVID-19 cases among young adults aged 20-39. Daily cases of COVID-19 are predicted to spike to new record levels (Public Health Agency of Canada 2021b)
- February 27, 2020: FDA approves Johnson & Johnson vaccine for emergency use (FDA NEWS RELEASE 2021).
- February 19, 2021: The Public Health Agency of Canada (PHAC) released modeling predicting a high resurgence in COVID-19 cases if stringent public health measures are not implemented as vaccine programs expand (Public Health Agency of Canada 2020)
- February 10, 2021: South Africa replaced its original vaccine candidate, AstraZeneca, with the Johnson & Johnson vaccine, which has not yet been approved by the U.S. Food and Drug Administration and the South Africa's regulatory authority. The South African government intends to provide this vaccine to its front-line health workers in the following week (Meldrum 2021; Meyer 2021).
- February 8, 2021: Ontario confirmed Canada's first case of the P.1 variant in Toronto, Ontario. The case was linked to international travel to Brazil (Favaro, St. Philip, and Jones Mae 2021).
- February 7, 2021: AstraZeneca is developing a 2<sup>nd</sup> generation vaccine that is effective against the B.1.351 variant. This is a response to its recent clinical trials in South Africa where researchers deemed the AstraZeneca to be ineffective against the B.1.351 variant (Wits University 2021).
- February 7, 2021: South Africa halted their rollout of the AstraZeneca vaccines due to its reduced efficacy against the B.1.351 variant (Mueller, Robbins, and Chutel 2021)
- January 27, 2021: Researchers declared the P.1 variant as the dominant SARS-CoV-2 strain in Manaus Brazil (France24 2021).
- January 25, 2021: Moderna Inc. is looking to study how an additional booster of its vaccine can impact the level of neutralizing titers against the B.1.351 variant. Additionally, the company is also seeking to develop a booster vaccine, mRNA- 1273.351, against the B.1.351 variant (Moderna 2021c; Wu et al. 2021).
- January 8, 2021: Alberta confirmed Canada's first case of the B.1.351 variant (Heidenreich and Ramsay 2021).
- December 26, 2020: Ontario confirmed Canada's first cases of the B.1.1.7 variant in two individuals from Toronto (Aziz 2020; Jabakhanji 2020; Rocca 2020).

- December 2020: Emergence of P.1 variant in Brazil.
- October, 2020: Emergence of B.1.351 variant in South Africa.
- September, 2020: Emergence of B.1.1.7 variant in the United Kingdom.

## Global COVID-19 Variants Trackers

### [NextStrain](#)

This phylogeny shows evolutionary relationships of SARS-CoV-2 viruses from the ongoing COVID-19 pandemic. Although the genetic relationships among sampled viruses are quite clear, there is considerable uncertainty surrounding estimates of specific transmission dates and in reconstruction of geographic spread. Please be aware that specific inferred geographic transmission patterns and temporal estimates are only a hypothesis.

### [GSAID](#)

GSAID obtained COVID-19 virus sequence data from several sources in Saudi Arabia (CDC, Hospitals) and worldwide. They process genome isolates to first obtain a fingerprint of mutations appearing in sampled populations across different locations, which helps to understand COVID-19 virus variants and their infection track.

Additional [GSAID COVID-19 variant tracker](#) featuring relative variant genome frequency per region.

## Other informational sources

[https://www.cdc.gov/mmwr/volumes/70/wr/mm7003e2.htm?s\\_cid=mm7003e2\\_e](https://www.cdc.gov/mmwr/volumes/70/wr/mm7003e2.htm?s_cid=mm7003e2_e)

<https://www.cdc.gov/coronavirus/2019-ncov/more/science-and-research/scientific-brief-emerging-variants.html>

<https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/variant-surveillance/variant-info.html>

[https://cov-lineages.org/global\\_report.html](https://cov-lineages.org/global_report.html)

<https://www.nytimes.com/interactive/2021/health/coronavirus-variant-tracker.html>

<https://covariants.org/>

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