Court File No. CV-22-00682682-0000

ONTARIO
SUPERIOR COURT OF JUSTICE

BETWEEN:

RANDY HILLIER

Applicant

and

HIS MAJESTY THE KING
IN RIGHT OF THE PROVINCE OF ONTARIO

Respondent

AFFIDAVIT OF DR. DAVID McKEOWN
(Affirmed on November 22, 2022)

I, **DAVID MCKEOWN,** of the City of Toronto, in the Province of Ontario, **AFFIRM:**

I. Background

1. I am the Associate Chief Medical Officer of Health ("**ACMOH**") with the Ontario Ministry of Health. I am semi-retired and currently work in that position part time. Prior to my retirement in July 2016, I held the position of ACMOH part-time from August 2016 to July 2017, from March 2020 to November 2021, and from April 2022 to the present. Pursuant to section 81.1 of *Health Protection and Promotion Act*, my responsibilities as ACMOH include acting in the capacity of the Chief Medical Officer of Health when he is unavailable and performing such functions and duties as the Chief Medical Officer of Health may specify or direct.

2. I am a licensed physician in Ontario and have practiced medicine for 35 years. I have a medical degree from McGill University and a Master's degree in Community Health and

Epidemiology from the University of Toronto. I am a certified specialist in Canada and the United States in the areas of public health and preventative medicine. Prior to being appointed ACMOH in 2016, I was the Medical Officer of Health for the City of Toronto for 12 years. Prior to the COVID-19 pandemic, I led local public health responses to the H1N1 pandemic, a major outbreak of Legionnaire's Disease, and the first outbreak of West Nile Virus in Canada.

3. I directly participated in events related to COVID-19 pandemic. My responsibilities as ACMOH included monitoring the spread of COVID-19 and advising on the government's policy response to the pandemic. As part of that role, I continuously reviewed and assessed information related to COVID-19, including published peer-reviewed literature, "scientific grey literature" (i.e. literature published outside of traditional peer-reviewed publishing channels), and publications from Public Health Ontario ("**PHO**"). That information informed the advice that I provided, along with others in the office of the Chief Medical Officer of Health, to the government. I reviewed information and provided advice related to COVID-19 as part of the ordinary exercise of my skill, knowledge, training and experience as ACMOH.

4. As such, I have personal knowledge of the contents of this affidavit. Where in this affidavit I have indicated I have received information from others, I have identified the source of the information and I believe the information to be true.

5. Below are some of the public health considerations that informed Ontario's policy response to the COVID-19 pandemic. These considerations are not exhaustive and no single factor was determinative. It should also be noted that the state of the pandemic was constantly changing and Ontario's policy response had to adapt to those changing circumstances. When determining which health protection measures should be implemented at what time to mitigate the spread of the virus, Ontario attempted to use the best information available at the time about the

transmissibility of COVID-19, which was also changing as research about the virus was regularly being updated.

6. I understand that the COVID-19 legislation at issue in this proceeding is the legislation that was in force in April and May 2021. In light of that, I have focused my evidence below on the information that was available in or around that time.

II. COVID-19 and SARS-CoV-2

(i) The Harms Caused by COVID-19

7. COVID-19 is a highly contagious and potentially deadly respiratory disease that has caused the worst global pandemic in more than a century. COVID-19 is transmitted by the novel coronavirus SARS-CoV-2, which was first recognized by the World Health Organization ("**WHO**") in December 2019. As of the date of this affidavit, COVID-19 has caused approximately 59,171 hospitalizations and 14,799 deaths in Ontario alone, and 193,686 hospitalizations and 46,710 deaths across Canada.[1]

8. COVID-19 can vary significantly in its clinical severity, ranging from asymptomatic or mild symptoms to severe illness that results in hospitalization and death. Common symptoms of COVID-19 include fever, cough and fatigue. Common symptoms of severe COVID-19, which may require hospitalization, include shortness of breath, chest pain, difficulty breathing, and high fever (above 38 degrees Celsius). Complications of COVID-19 that could lead to death include respiratory failure, acute respiratory distress syndrome, sepsis and septic shock, thromboembolism, and/or multiorgan failure, including injury of the heart, liver or kidneys.[2]

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[1] Attached as **Exhibit "A"** is the COVID-19 epidemiology updated published by Health Canada dated November 7, 2022; attached as **Exhibit "B"** is a copy of a webpage from Public Health Ontario that summarizes COVID-19 confirmed cases, hospitalizations and death in Ontario as of October 29, 2022.

[2] Attached as **Exhibit "C":** World Health Organization, "Coronavirus disease (COVID-19): What happens to people who get COVID-19?", (May 13, 2021), online <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/coronavirus-disease-covid-19>.

9. Severe COVID-19 occurs more often in older people, particularly those over age 60, and in those with underlying medical conditions, such as cancer, diabetes, heart disease, asthma, HIV infection, obesity, immunodeficiency diseases, cystic fibrosis, or chronic lung or liver diseases. However, people of any age or state of health can develop serious and sometimes fatal complications from COVID-19.

10. Some people who have had COVID-19 continue to experience symptoms for months after the onset of symptoms. These long-term symptoms are found more often in people who had severe COVID-19 illness, but anyone who has been infected with the virus that causes COVID-19 can experience post-COVID conditions, even people who had mild illness or no symptoms from COVID-19. Those long-term symptoms can include fatigue, fever, respiratory symptoms (e.g. cough or difficulty breathing) and neurological symptoms (e.g. headaches and difficulty concentrating).[3]

(ii) Methods of SARS-COV-2 Transmission

11. The primary method of transmission of SARS-COV-2 is through direct contact with respiratory droplets from an infected person, which have the potential to be propelled various distances when that person coughs, sneezes, sings, shouts or talks. Transmission occurs predominantly through close contact (2 metres or less) with an infected individual, but transmission over longer distances (more than 2 metres) is possible, although less common. In general, the closer a person is to someone infected with SARS-COV-2, the greater the likelihood of transmission.[4]

[3] Attached as **Exhibit "D"** is a copy of a website from the Center for Disease Control ("CDC") dated September 1, 2022, which summarizes information about the long-term effects of COVID-19.
[4] Attached as **Exhibit "E"** is a document dated December 1, 2020, from PHO entitled "COVID-19 Routes of Transmission," which summarizes some of the evidence related to SARS-COV-2 transmission.

12. The risk of transmission increases if a person is in close physical proximity to someone with COVID-19 for a prolonged period of time. In general, the longer someone is in close proximity to a person with COVID-19, the greater the likelihood of transmission, as it provides more opportunities for respiratory particles to be transmitted from one person to another. The risk of transmission is especially high in settings with poor ventilation or where there is recirculation of unfiltered air, which may allow droplets (or, in some cases, smaller particles known as "aerosols") to travel further distances. For example, there is evidence of high rates of transmission in household settings, where individuals are in close proximity in enclosed areas and physical distancing is not feasible. There is also evidence that indoor settings have a higher risk of transmission relative to outdoor settings, although (as discussed below) there remains a risk of transmission when people gather outdoors.

13. Because SARS-COV-2 is spread primarily through close contact with an infected individual, large gatherings, whether indoors or outdoors, present a risk of SARS-COV-2 transmission. The larger the gathering, the greater the likelihood that there will be individuals in that gathering who have SARS-COV-2 and will transmit the virus to others. If individuals in a gathering become infected, they can transmit the virus to other members of their households. As a result, gatherings of people from different households present an especially high risk of widespread transmission throughout the population.

14. Certain behaviours may increase the risk of SARS-COV-2 transmission. For example, activities such as coughing, shouting, loud talking or heavy breathing can result in more forceful exhalation of droplets (or, in some cases, aerosols), which increases the likelihood of transmitting

the virus to others in close proximity and may also increase the distance that droplets or aerosols travel.[5]

15. SARS-COV-2 can be transmitted by people who are symptomatic (i.e. currently experiencing COVID-19 symptoms), pre-symptomatic (i.e. have not yet developed symptoms), or asymptomatic (i.e. never developed symptoms). Some studies have shown that transmission can occur as early as six days before the onset of symptoms, or possibly earlier. As a result, screening for symptoms is insufficient to prevent the spread of SARS-COV-2 when individuals gather in groups, particularly when the level of COVID-19 in the general population is high.[6]

(iii) Masks and Physical Distancing

16. There are several measures that can help reduce, but not eliminate, the risk of SARS-COV-2 transmission. One of those measures is mask wearing. Masks have two potential functions. First, they can be used as personal protective equipment ("PPE") to protect the wearer from being exposed to droplets expelled by others who have been infected with COVID-19. Second, they can be used as "source control" to protect others from the wearer by reducing the degree to which a person who is infected with COVID-19 expels droplets.

17. There is evidence that the use of non-medical masks can be an effective form of source control when worn by persons shedding the virus (i.e. it protects others from a mask wearer with COVID-19). A literature review conducted by PHO found that "[m]andatory public mask policies have been associated with a decrease in new COVID-19 cases compared to regions without such policies."[7]

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[5] Attached as **Exhibit "F"** is a document dated May 21, 2021, from PHO entitled "COVID-19 Transmission Through Large Respiratory Droplets and Aerosols."
[6] Attached as **Exhibit "G"** is a document dated May 22, 2020, from PHO entitled "Asymptomatic Infection and Asymptomatic Transmission."
[7] Attached as **Exhibit "H"** is a document dated September 14, 2020, from PHO entitled "Wearing Masks in Public and COVID-19."

18. However, the same review by PHO found that the use of masks to protect the wearer (i.e. as PPE) is "unlikely to be effective in non-healthcare settings." As a result, if one or more infected individuals within a gathering do not wear a mask (or do not wear a mask consistently), the fact that others within the gathering are wearing masks is unlikely to provide sufficient protection against transmission. The efficacy of mask mandates is, therefore, highly dependent on the degree to which participants strictly and uniformly adhere to those mandates, especially in large gatherings or settings with poor ventilation. In practice, there will often be circumstances when individuals wear their masks inconsistently or incorrectly.

19. There is an extremely high degree of variability in the efficacy of non-medical masks in public settings, depending on the materials used and whether the mask is the appropriate fit for the wearer. For example, one review of 42 studies on the effectiveness of non-medical masks in reducing SARS-COV-2 transmission found that the filtration efficiency of non-medical masks (with variable designs and fabrics) ranged from less than 10% to more than 95%.[8]

20. Guidance from the World Health Organization ("**WHO**") states that masks should be used as "part of a comprehensive package of prevention and control measures" to limit the spread of SARS-COV-2. However, that guidance also notes that "the use of a mask alone, even when correctly used…is insufficient to provide an adequate level of protection for an uninfected individual or prevent onward transmission from an infected individual (source control)."[9]

21. Another measure that can help reduce, but not eliminate, the risk of SARS-COV-2 transmission is physical distancing. As noted above, respiratory droplets from an infected person have the potential to be propelled various distances when that person coughs, sneezes, sings, shouts

[8] Attached as **Exhibit "I"** is a document dated February 2, 2021 from PHO entitled "Review of 'Rapid review on the characteristics of effective non-medical face masks in reducing the risk of SARS-CoV-2 transmission.'"
[9] Attached as **Exhibit "J"** is document dated December 1, 2020, from the WHO entitled "Mask use in the context of COVID-19."

or talks. While transmission is most likely to occur through close contact of 2 metres or less, there is evidence that transmission over longer distances can occur, especially in areas with poor ventilation. Behaviours such as shouting or loud talking have been shown to increase the distance that droplets can spread. Some studies have suggested that droplets can travel as much as 4 to 8 metres under favourable conditions.

22. Similar to masks, physical distancing is one part of a comprehensive package of public health measures that can help reduce the risk of SARS-COV-2 transmission, but is insufficient on its own to eliminate the risk of SARS-COV-2 transmission. Furthermore, the efficacy of physical distancing depends on the degree to which individuals strictly adhere to distance of at least 2 metres. In practice, there are often circumstances where the requirement for physical distancing of at least 2 metres is not strictly observed. There are also circumstances where physical distancing will be impractical, such as within households.

(iv) Community Prevalence and Burden on the Healthcare System

23. The risk of SARS-COV-2 transmission in any setting or gathering is related to the baseline level of COVID-19 in the community. The higher the number of COVID-19 cases in the population, the more likely it is that people who participate in a gathering will have COVID-19 and pass the SARS-COV-2 virus on to others. While some types of gatherings may pose a relatively low risk of transmission when the level of COVID-19 in the population is low, those same gatherings may pose a higher risk of transmission when the level of COVID-19 in the population is high.

24. Ontario's policy response to COVID-19 was also informed by the burdens that the pandemic placed on the healthcare system. Several times during the pandemic, the spread of COVID-19 caused hospitalizations and ICU occupancy to increase significantly. This placed a

substantial burden on the healthcare system, as Ontario has limited capacity to treat seriously ill patients who require hospitalization or intensive care. The increase in ICU patients was particularly concerning because it not only threatened the ability of the healthcare system to deal with COVID-19 patients, it also compromised the ability of the healthcare system to care for other non-COVID-19 patients. The diversion of healthcare resources to serve seriously ill patients with COVID-19 also creates a backlog of surgical and other medical treatments for other medical problems.

25. When the burdens on the healthcare system are high, even small increases in transmission within the population can have a significant negative impact on the healthcare system and potentially impact patient care. As discussed below, in April 2021, ICU occupancy in some regions in Ontario was over 88%.[10] At that time, there was a risk that ICU capacity would be stretched beyond its limits, even with small increases in the number of critically ill patients. Within that context, activities that pose a relatively low risk of transmission could significantly increase the burden on an already strained healthcare system.

(v) Variants of Concern

26. The risk of SARS-COV-2 transmission also depends on the degree of transmissibility of the virus, which has evolved over time as new variants have emerged. Several variants of concern ("**VOCs**") have been identified that are associated with factors such as increased transmissibility, detrimental change in COVID-19 epidemiology, increased virulence or change in clinical disease presentation, and decreased effectiveness of public health and social measures.

27. In or around April and May 2021, four VOCs that were particularly concerning in Ontario:

- the B.1.1.7 (Alpha) variant, which was first detected in the United Kingdom;

[10] Attached as **Exhibit "K"** is a table showing the number of COVID-19 cases in ICU and ICU occupancy in Ontario as of April 18, 2021.

- the B.1.351 (Beta) variant, which was first detected in South Africa;
- the P.1 (Gamma) variant, which was first detected in Brazil; and
- the B.1.617 (Delta) variant, which was first detected in India.

28. All four of those VOCs were associated with increased transmissibility of SARS-COV-2. The Alpha, Beta and Gamma variants were each estimated to be at least 50% more transmissible than the original SARS-COV-2 virus. The Delta variant was first reported in India in March 2021 and quickly spread to over 40 countries, including Canada. In April and May 2021, there was preliminary evidence to suggest that the Delta variant was more transmissible than previous strains of SARS-COV-2, but the reasons for the increased transmissibility were still not well understood.[11] There was also evidence that Delta may cause more severe illness. Subsequent studies have confirmed that the Delta variant is more transmissible than previous SARS-CoV-2 strains (likely due to higher viral load and potentially shorter incubation period) and causes more severe illness.[12]

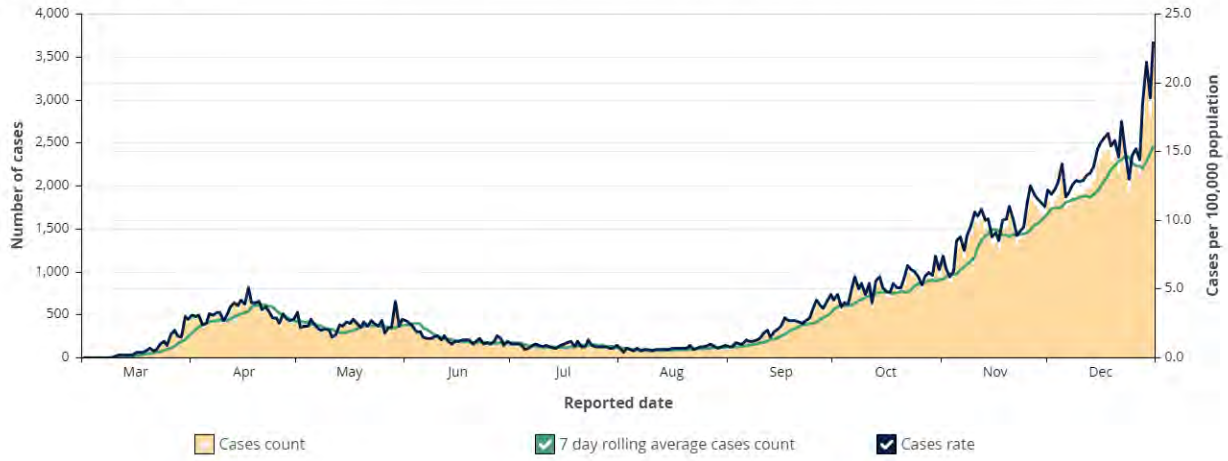
III. The State of the Pandemic from December 2020 to May 2021

(i) The State of Emergency in January 2021

29. In November and December 2020, there was a significant increase in COVID-19 cases and hospitalizations in Ontario. The number of reported cases increased from approximately 1,100 cases on November 1, 2020, to approximately 3,400 cases on December 31, 2020. The graph below from Public Health Ontario ("**PHO**") shows daily COVID-19 cases in Ontario from March 1, 2020 to December 31, 2020:

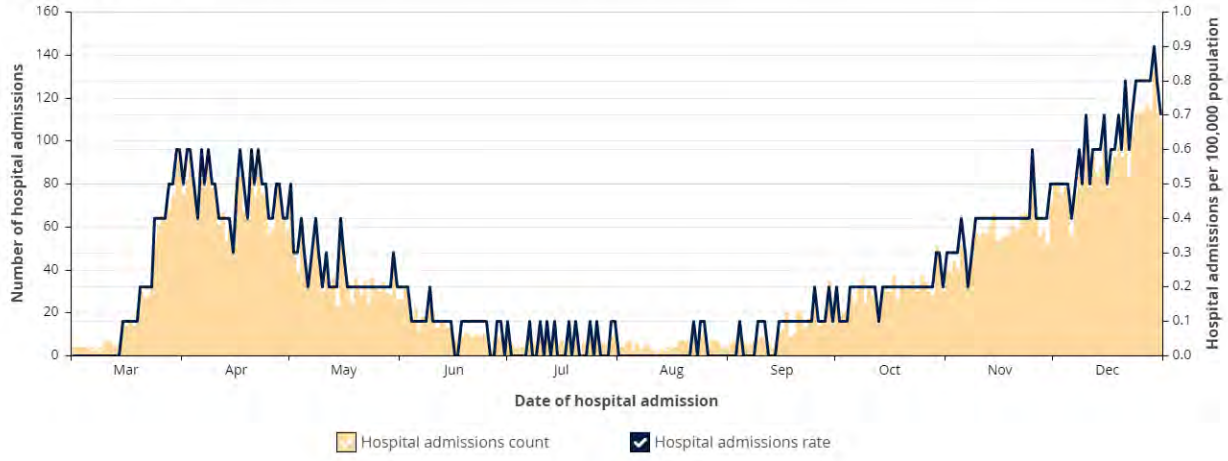
[11] Attached as **Exhibit "L"** is a publication by PHO entitled "Comparing SARS-CoV-2 Variants of Concern (VOCs) as of May 31, 2021"; attached as **Exhibit "M"** is a publication by PHO dated May 26, 2021, entitled "COVID-19 B.1.617 Variant of Concern – What We Know So Far."
[12] Attached as **Exhibit "N"** is a publication by PHO entitled "COVID-19 Delta: Risk Assessment and Implications for Practice (September 20, 2021 Update)" dated September 24, 2021.

Laboratory confirmed COVID-19 daily case counts and rates by reported date in Ontario - March 1, 2020 to December 31, 2020



30. During the same time period, there was a significant increase in daily COVID-19 hospital admissions. Below is a graph from PHO that shows the number of daily COVID-19 hospital admissions in Ontario from March 1, 2020 to December 31, 2020:

COVID-19 daily hospital admission counts and rates by admission date in Ontario - March 1, 2020 to December 31, 2020



31. On December 21, 2020, the worsening COVID-19 situation led the government to announce a Provincewide Shutdown effective December 26, 2020.[13]

32. On January 12, 2021, the Premier of Ontario declared a province-wide state of emergency pursuant due to the significant increases in the number of COVID-19 cases, hospitalizations and ICU patients.[14] Among other measures, effective January 14, 2021, the Province issued a stay-at-home order requiring everyone to remain at home, with exceptions for certain permitted purposes or activities, such as going to the grocery store or pharmacy, accessing health care services, attending school or a post-secondary institution, or performing work that cannot be done remotely.[15]

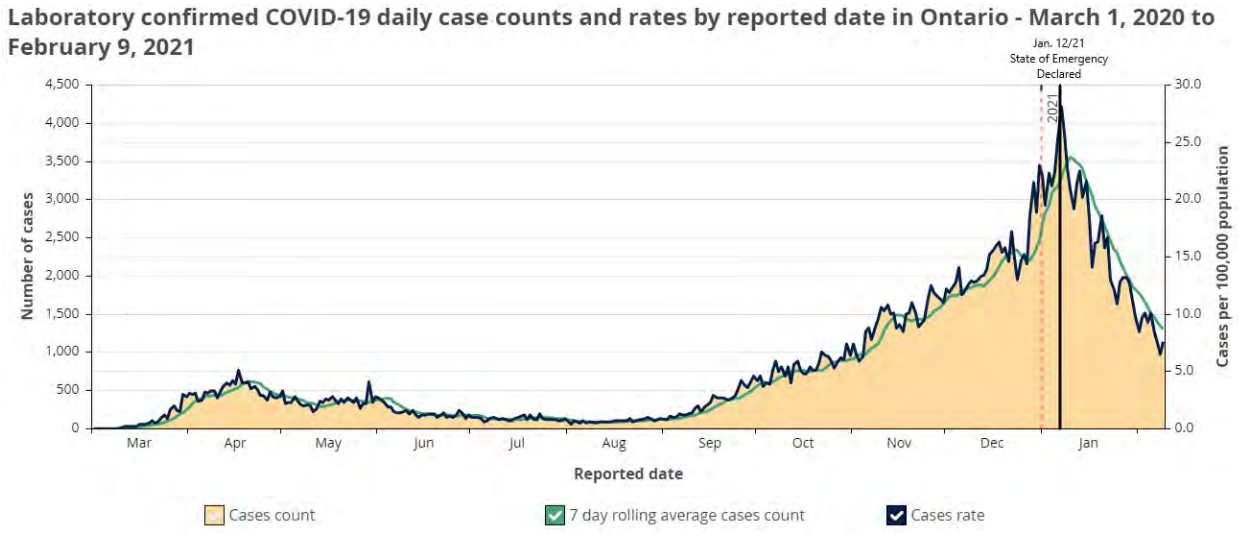
33. In addition, effective January 13, 2021, there were restrictions on indoor and outdoor gatherings that applied across the province. Indoor gatherings were limited to members of a single household or a gathering of a single household and one other person from outside that household who lives alone. Outdoor events and gatherings were limited to a maximum of 5 people, which could include members of different households.[16]

(ii) The End of the State of Emergency in February 2021

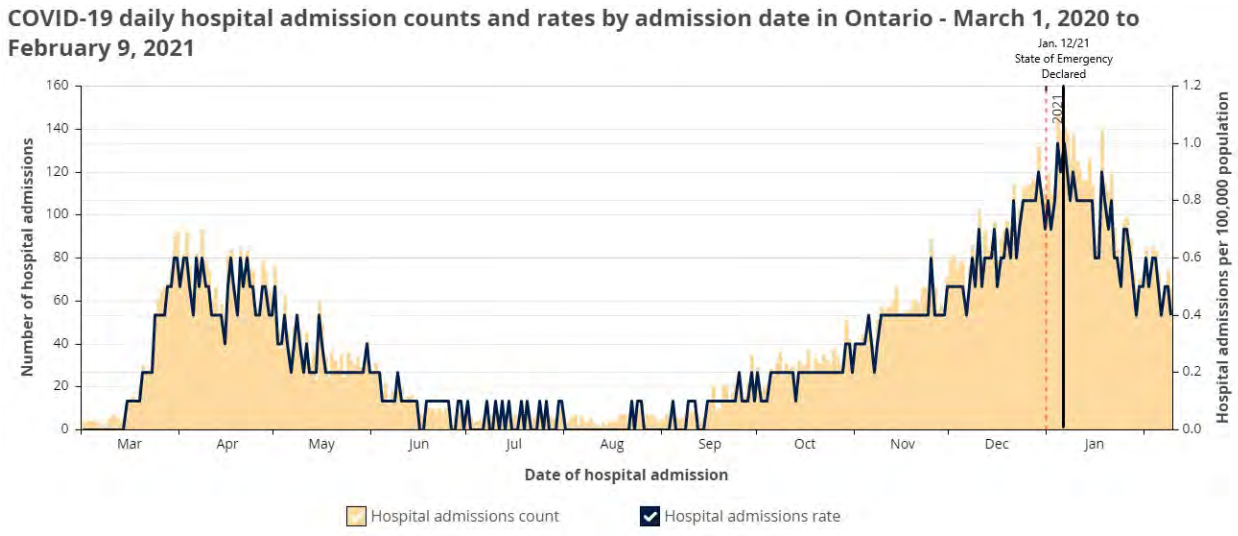
34. Shortly after the province implemented the second state of emergency, COVID-19 cases in Ontario began to level off and then steadily decline. On December 26, 2020, the rolling 7-day average of new COVID-19 cases in Ontario was 2,488. By February 9, 2021, that number had

[13] Attached as **Exhibit "O"** is a press release dated December 21, 2020, entitled "Ontario Announces Provincewide Shutdown to Stop Spread of COVID-19 and Save Lives."
[14] Attached as **Exhibit "P"** is a press release dated January 12, 2021, entitled "Ontario Declares Second Provincial Emergency to Address COVID-19 Crisis and Save Lives."
[15] O. Reg. 11/21, s. 1 (January 13, 2021 to February 7, 2021).
[16] O. Reg. 82/20, Schedule 4, s. 1 (December 26, 2020 to February 9, 2021); O. Reg. 363/20, Schedule 1, s. 1 (December 26, 2020 to February 9, 2021).

declined to 1,210. Below is graph from PHO showing the number of new COVID-19 cases in Ontario from March 1, 2020 to February 9, 2021:



35. There was a similar decline in the number of hospitalizations. Below is a graph from PHO showing daily hospitalizations from March 1, 2020 to February 9, 2021:



36. Following a significant decline in COVID-19 cases, the second provincial state of emergency ended on February 9, 2021. In February and March 2021, Ontario moved various

regional public health units ("**PHUs**") into and out of various levels of public health protections, depending on the state of the pandemic in those regions.[17]

37. I have been advised by counsel that the applicants in this proceeding are challenging the public health regulations that applied in the Eastern PHU (which includes Cornwall) and the Leeds, Grenville and Lanark District PHU (which includes Brockville). On February 16, 2021, the Eastern PHU and the Leeds, Grenville and Lanark District PHU moved into Stage 3 (Orange Zone and Green Zone, respectively) of the province's re-opening framework.[18] Under Stage 3 (as it existed at the time), most organized public events were limited to 50 people if the event was held indoors or 100 people if the event was held outdoors.[19] At the same time, the Stay-At-Home order was lifted for the Eastern PHU and the Leeds, Grenville and Lanark District PHU.[20]

(iii) The Increase in COVID-19 Cases and Hospitalizations in March and April 2021

38. In March and April 2021, shortly after the end of the state of emergency, COVID-19 cases and hospitalizations in Ontario began to rapidly increase. On March 1, 2021, the average number of new COVID-19 cases reported each day based on a 7-day rolling average was 1,113. By April 1, 2021, the 7-day rolling average of new cases per day had increased to 3,327 (a nearly 200% increase). By April 12, 2021, that number reached 4,484 (an increase of over 300% from early

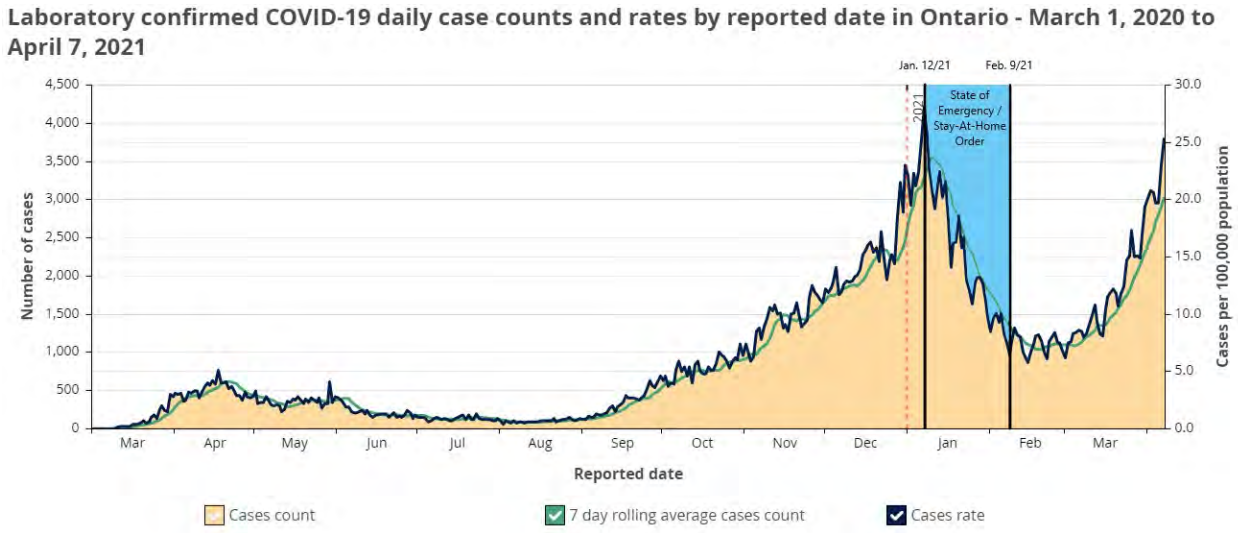
[17] Attached as **Exhibit "Q"** is a press release dated February 19, 2021, entitled "Stay-at-Home Order Extended in Toronto and Peel Public Health Regions Along with North Bay-Parry Sound"; Attached as **Exhibit "R"** is a press release dated February 26, 2021, entitled "Ontario Activates Emergency Brake in Thunder Bay District Health Unit and Simcoe-Muskoka District Health Unit."; Attached as **Exhibit "S"** is a press release dated March 5, 2021, entitled "Toronto, Peel and North Bay-Parry Sound Public Health Regions Returning to Strengthened COVID-19 Response Framework"; Attached as **Exhibit "T"** is a press release dated March 11, 2021, entitled "Ontario Activates Emergency Brake in Sudbury Public Health Region."

[18] Attached as **Exhibit "U"** is a press release dated February 12, 2021, entitled "Ontario Returning 27 Public Health Regions to Strengthened COVID-19 Response Framework."

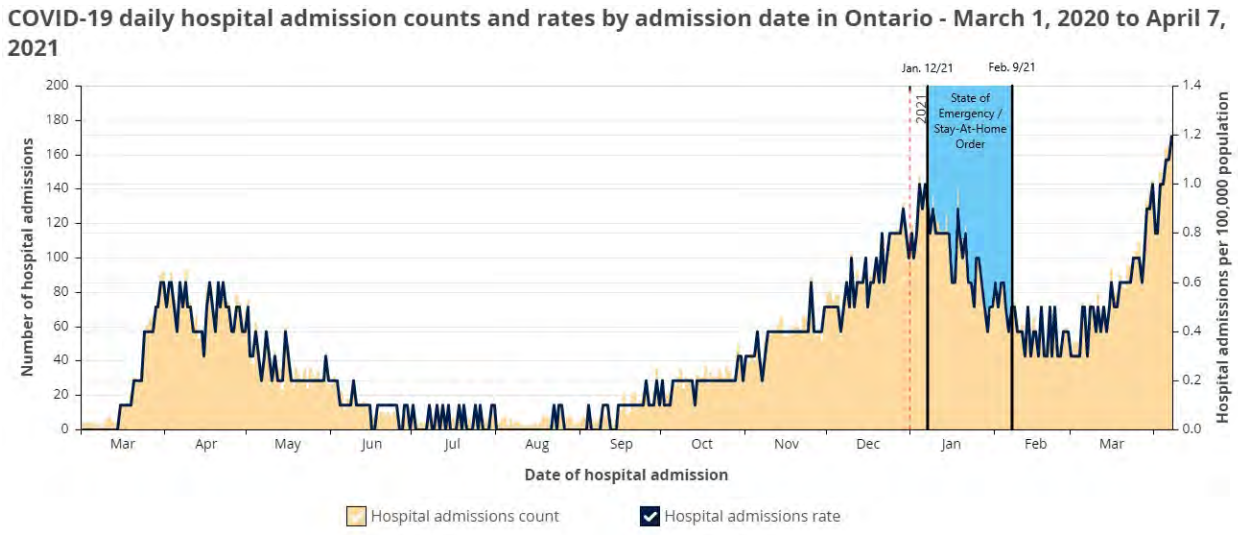
[19] O. Reg. 364/20, Schedule 3, s. 1(1); O. Reg. 364/20, Schedule 3, ss. 1 and 3 (February 16, 2021).

[20] O. Reg. 11/21, s. 2(2); O. Reg. 86/21, Schedule 1, s.1 (Eastern PHU), s. 1; O. Reg. 79/21, Schedule 1, s.1 (Leeds, Grenville and Lanark District PHU).

March 2021). Below is a graph from PHO of daily COVID-19 cases from March 1, 2020 to April 7, 2021, which shows a significant increase in cases in March and April 2021:



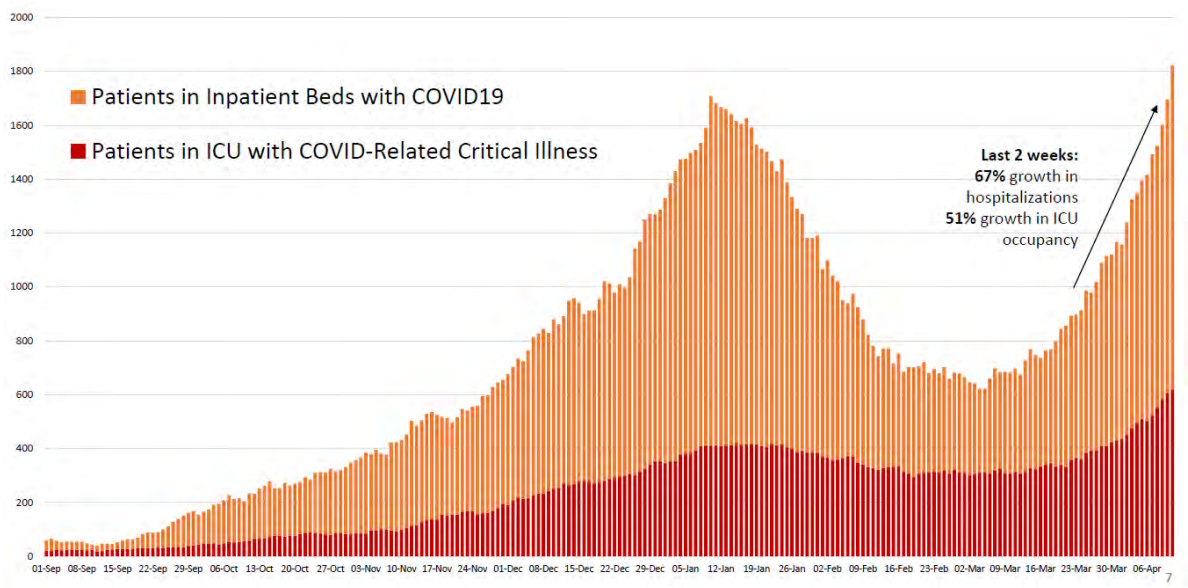
39. The number of hospitalizations followed a similar trend. Below is a graph from PHO that shows daily COVID-19 hospitalizations in Ontario from March 1, 2020 to April 7, 2021:



40. By early April 2021, the Ontario COVID-19 Science Advisory Table ("**Science Table**"), a group of scientific experts and health system leaders who evaluate and reported on emerging

evidence relevant to the COVID-19 pandemic, projected dramatic increases in cases, hospitalizations and ICU admissions.[21] ICU occupancy in some regions in Ontario was over 88%.[22] By April 16, 2021, COVID-19 cases, hospitalizations and ICU occupancy were at their highest levels since the start of the pandemic.[23]

41. Below is a graph produced by the Science Table for its COVID-19 epidemiological update dated April 16, 2021, showing the number of COVID-19 patients in Ontario in hospital beds and in ICUs:

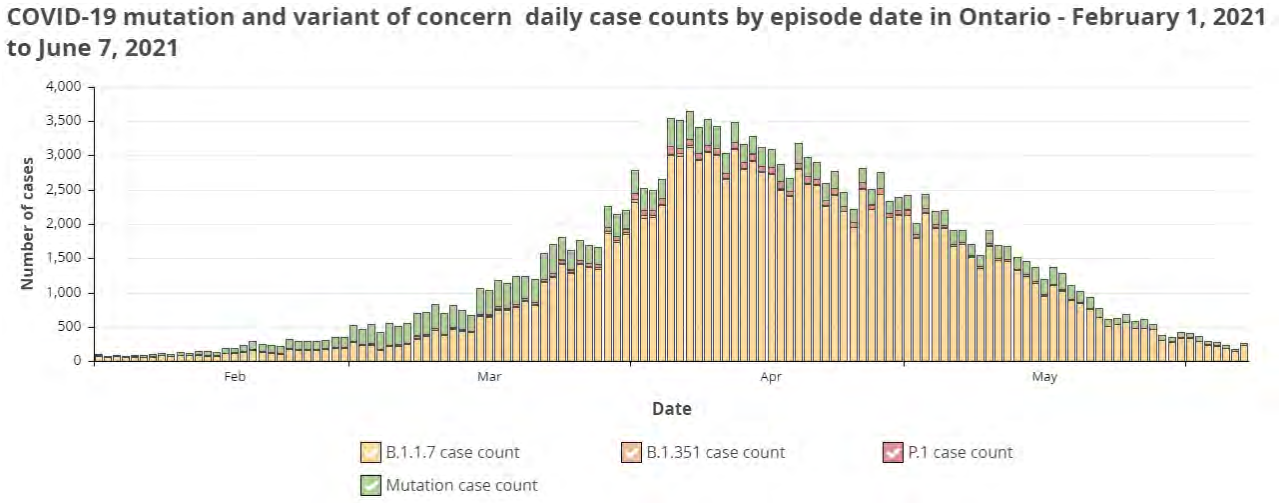


42. The dramatic increases in hospitalizations and ICU occupancy created a serious risk that the healthcare system would be stretched beyond its limits. Within that context, activities that pose a relatively low risk of transmission could significantly increase the burden on an already strained healthcare system. The increase in hospitalized and ICU patients not only threatened the

[21] Attached as **Exhibit "V"** is an Update on COVID-19 Projections dated April 1, 2021, from the Ontario COVID-19 Science Advisory Table; attached as **Exhibit "W"** is an Update on COVID-19 Projections dated April 16, 2021, from the Ontario COVID-19 Science Table.
[22] See **Exhibit "K"**, *supra* note 10.
[23] Attached as **Exhibit "X"** is a graph from the Ontario COVID-19 website showing the number of patients hospitalized and in ICUs in Ontario with COVID-19 from April 2, 2020 to July 5, 2021.

ability of the healthcare system to care for COVID-19 patients, it also compromised the ability of the healthcare system to care for patients with other medical issues. The diversion of healthcare resources to serve seriously ill patients with COVID-19 created a backlog of surgical and other medical treatments. By April 2021, the Science Table estimated that there was a cumulative backlog of nearly 250,000 surgical cases delayed due to COVID-19.[24]

43. The increase in cases and hospitalizations was largely being driven by the emergence of more transmissible VOCs. In February and March 2021, the proportion of cases involving VOCs increased substantially. By April 2021, the Alpha variant had become the dominant strain in Ontario and over 70% of reported cases in the province tested positive for one of the VOCs.[25] Below is a graph from PHO showing the progression of COVID-19 cases with a VOC from February 1, 2021 to June 7, 2021 (excluding the Delta variant):



[24] See **Exhibit "W"**, *supra* note 21.
[25] Attached as **Exhibit "Y"** is a graph summarizing the percentage of COVID-19 associated with a VOC from March 31, 2021, to April 13, 2021.

44. In May and June 2021, there was also a significant increase in the number of cases in Ontario testing positive for the Delta variant.[26] The increase in VOCs was concerning because there was evidence that the Alpha, Beta, Gamma and Delta variants were more transmissible than the original strain of SARS-CoV-2. However, evidence about all those variants was still evolving, particularly regarding the Delta variant, which had only recently been identified in March 2021. In April and May 2021, there was still considerable uncertainty regarding the new variants' levels of transmissibility, their methods of transmission, and the degree to which the new variants caused more severe illness that could significantly increase hospital admissions and ICU patients.

45. In April and May 2021, very few Ontarians had received any COVID-19 vaccinations, as vaccine supply was still limited. According to PHO, on April 1, 2021, only 2.8% of the Ontario population were fully vaccinated (two doses) against COVID-19 and most of those individuals were in nursing or long-term care facilities. The protective effects of the vaccine (for both the first and the second dose) take several weeks to develop. While approved COVID-19 vaccines had been shown to be effective in preventing symptomatic illness, the evidence at the time was less clear on the degree to which vaccines prevented asymptomatic transmission. A single dose of vaccine does not provide complete protection against symptomatic illness.

IV. The Risks of Gatherings and Out-of-Home Mobility in April and May 2021

46. In April and May 2021, gatherings of large groups of people posed a significant risk for the spread of SARS-CoV-2. Gatherings of people from different households who spend prolonged periods of time in the same physical space is precisely the scenario that had been shown to be associated with a high risk of SARS-CoV-2 transmission. The risk of transmission at gatherings

[26] Attached as **Exhibit "Z"** is the daily epidemiological summary from PHO dated July 3, 2021, which contains data regarding VOCs, including the Delta variant, from January 15, 2020 to July 3, 2021.

was not confined to those who attended those gatherings. If someone was infected with SARS-CoV-2 at a gathering, it was very likely that he or she would transmit the virus to other members of his or her household who, in turn, may have transmitted SARS-CoV-2 to others in the community, leading to significant growth in infection rates. If individuals who attended gatherings engaged in behaviours that increased the spread of respiratory droplet, such as talking, chanting or shouting, that would have further increased the risk of spreading SARS-CoV-2.

47. The risk of transmission at a gathering was particularly high in April and May 2021 when the number of new daily COVID-19 cases and hospitalizations were at their highest. The higher the number of COVID-19 cases in the general population, the more likely it is that people who participate in a gathering or interact with others will have COVID-19 and pass it on. In addition, the number of COVID-19 cases in April and May 2021 was placing a significant burden on the healthcare system. At that time, even small increases in transmission risked increasing hospitalizations and ICU admissions beyond the healthcare system's capacity, potentially impacting patient care for those with COVID-19 and those with other medical conditions.

48. Masks and physical distancing can help reduce the risk of COVID-19 transmission but are insufficient to stop the spread of the virus, particularly when the prevalence of COVID-19 in the population is high. That risk is especially high if physical distancing is not strictly observed or if masks are worn inconsistently or incorrectly. In practice, there will often be circumstances where physical distancing and masking are imperfect.

49. There was a risk of SARS-CoV-2 transmission at both indoor and outdoor gatherings. While the evidence suggested that there was a *lower* risk of SARS-CoV-2 in outdoor settings, likely due to increased air circulation that dispersed infectious respiratory particles, being outdoors did not *eliminate* the risk of SARS-CoV-2 transmission. The risk of transmission at any particular

gathering is based on a number of inter-related factors and the setting of the gathering (e.g. whether it is indoors or outdoors) is only one of those factors. Other factors include the size of the gathering, the physical proximity of the participants, the number of participants who wear masks properly, whether the participants are speaking, chanting or shouting, and the prevalence of COVID-19 in the community. Holding gatherings outdoors instead of indoors could reduce the risk of SARS-CoV-2 transmission, but outdoor transmission could still occur, especially in large gatherings with inconsistent adherence to mask or physical distancing requirements.

50. There are also specific risk factors associated with outdoor gatherings that could make them susceptible to the spread of the virus. Outdoor gatherings are often very fluid, unpredictable and can be difficult to control. In indoor settings such as retail establishments, there are typically clear barriers to entry and the person in charge of the establishment can exercise a degree of oversight over the venue and those within it. That level of control allows them to enforce rules that limit the spread of the virus, such as capacity limits, mandatory mask wearing and physical distancing requirements. In contrast, it is much more difficult to exercise the same degree of control and oversight at outdoor gatherings. There are often no barriers to entry at outdoor gatherings, which allows bystanders who may have no connection to organizers of the gathering to join and leave the gathering at any time. The nature of those gatherings makes it much more difficult for organizers or law enforcement officials to ensure that participants strictly comply with masking and physical distancing requirements. In addition, it is much more difficult at outdoor gatherings to keep accurate records of everyone who attended, which makes it challenging to conduct effective contact tracing if someone is subsequently diagnosed with COVID-19.

51. It is also important to consider the risks of ancillary activities that may be connected to, or associated with, an outdoor gathering. Large gatherings, whether indoors or outdoors, do not

occur in a vacuum. People need to travel to the gathering, they may get something to eat with other people who attend the gathering, or they may use shared bathroom facilities. People may use variety of travel methods to get to outdoor gatherings, including public transportation where individuals may be in close in contact with each other or carpooling in enclosed vehicles. In practice, outdoor gatherings are often associated with indoor activities, and this was an important public health consideration when the level of COVID-19 in the community was high. In addition, people may travel to an outdoor gathering from a variety of different communities, which risks spreading COVID-19 from one community to another.

52. Whether indoors or outdoors, gatherings are also likely to increase the level of out-of-home mobility (i.e. time spent outside of the home). Out-of-home mobility increases the risk of COVID-19 transmission because it is more likely that people will associate with others who are not in their household and pass on the virus. There was evidence that high levels of out-of-home mobility led to increased in the spread of SARS-CoV-2 and that low levels of out-of-home mobility were needed to control SARS-CoV-2 through spring 2021.[27] In an update dated April 16, 2021, the Science Table identified an increase in out-of-home mobility as one of the key factors leading to an increase in COVID-19 cases in Ontario.[28]

53. Another factor that increased the potential risk of indoor or outdoor gatherings was the uncertainty related to new VOCs. In April and May 2021, there was preliminary evidence that the VOCs spreading in Ontario were more transmissible than the original SARS-CoV-2. However, information about the new VOCs was still evolving and it was unclear how those VOCs might differ from the original SARS-CoV-2, including with respect to transmissibility and clinical

[27] Attached as **Exhibit "AA"** is an early-released article of the *Canadian Medical Association Journal*, entitled "The mobility gap: estimating mobility thresholds required to control SARS-CoV-2 in Canada" (April 7, 2021).
[28] See **Exhibit "W"**, *supra* note 21.

severity. Among other things, it was not clear whether the Delta variant would spread more easily or whether it would result in more severe illness that would significantly increase the number of hospitalizations.

54. In light of that uncertainty, the precautionary principle was an important factor for public health officials to consider. In the public health context, the precautionary principle holds that, where there is a threat that could cause significant and irreversible harm to public health, measures to prevent the harm should be taken, even if some cause and effect relationships have not yet been fully established scientifically.

55. In April and May 2021, there was strong evidence that the new VOCs could pose a significant risk to public health. The new VOCs were spreading rapidly throughout the province and the healthcare system was nearing capacity. Waiting for scientific certainty before taking actions to prevent the spread of SARS-CoV-2 could have resulted in substantial numbers of preventable infections, severe illnesses and deaths.

V. The Emergency Public Health Measures to Protect Ontario from COVID-19

56. In order to limit the spread of SARS-CoV-2, Ontario implemented several public health restrictions throughout the pandemic that placed limits on the size of gatherings. The objective of those restrictions was to reduce transmission by limiting the number of people who would be in close contact with each other and by requiring participants to take certain precautions to reduce the spread of the virus, such as mask wearing and physical distancing. The gathering limits were part of a broader set of overlapping and interrelated public health measures that applied to a wide variety of businesses, organizations and events throughout the province. All of those factors worked together to reduce the spread of COVID-19.

57. The public health measures Ontario imposed at each stage of the pandemic were informed by several key indicators, such as weekly incidence of COVID-19 cases, the test positivity rate, the effective reproduction number (Rt), and evidence of recent outbreaks. Where feasible, public health measures were tailored to the circumstances in each region of the province. During some phases of the pandemic, however, the rapid spread of COVID-19 or the need to discourage travel between different areas of the province required Ontario to implement restrictions that applied across the entire province.

58. The time periods with the lowest (or strictest) gathering limits corresponded to the time periods when the rate of SARS-CoV-2 transmission in the Ontario population and the burden on the Ontario healthcare system were at their highest levels. This is consistent with the principles discussed above regarding SARS-CoV-2 transmission, including that there are higher risks of SARS-CoV-2 transmission when the baseline number of COVID-19 cases in the general population is higher.

59. On April 1, 2021, the surge in case numbers and COVID-19 hospitalizations across the province led Ontario, in consultation with the Chief Medical Officer of Health and other health experts, to announce a provincewide "emergency brake," effective April 3, 2021. All PHUs were moved into the "Shutdown Zone".[29]

60. The public health measures applicable in the Shutdown Zone included restrictions on indoor and outdoor gatherings. Indoor public events and social gatherings were limited to members of the same household (or to one household and one other person from another household who lives alone). Outdoor public events or social gatherings were limited to a maximum of 5 people (except for gatherings with members of the same household or of one household and one

[29] Attached as **Exhibit "BB"** is a press release dated April 1, 2021, entitled "Ontario Implements Provincewide Emergency Brake."

other person from another household who lives alone).[30] For weddings, funerals, and religious services, rites or ceremonies, indoor capacity was limited to 15% capacity of the room and outdoor capacity was limited to the number of individuals who could consistently maintain 2-metres of physical distancing.[31]

61. On April 7, 2021, the Premier of Ontario announced a province-wide state of emergency.[32] On April 8, 2021, a province-wide stay-at-home order came into effect requiring everyone to remain at home, except for certain essential purposes, such as going to the grocery store, accessing health care services, engaging in outdoor exercise, attending school or post-secondary institution, or conducting work that cannot be done remotely.[33] Other public health measures that applied during the state of emergency included limiting the majority of non-essential retailers to curbside pick-up and delivery, imposing more restrictive capacity limits for business that remained open to the public, and limiting restaurants and bars to providing take-out, delivery and drive-through service only.[34]

62. On April 17, 2021, in response to the worsening public health situation, Ontario started to implement additional health protection measures, including more restrictive gathering limits. Both indoor and outdoor public events and social gatherings were limited to members of the same household (or to one household and one other person from another household who lives alone). Effective April 19, 2021, indoor and outdoor religious, wedding and funeral services were limited to a maximum of 10 people (drive-in religious, wedding and funeral services were permitted

[30] O. Reg. 82/20, Schedule 4, s. 1.
[31] O. Reg. 82/20, Schedule 4, s. 1(1)(d) and (2).
[32] O. Reg. 264/21; attached as **Exhibit "CC"** is a press release dated April 7, 2021, entitled "Ontario Enacts Provincial Emergency and Stay-at-Home Order."
[33] O. Reg. 265/21.
[34] O. Reg. 82/20.

without any capacity limits).[35] The stay-at-home order that came into effect on April 8, 2021, remained in force.

63. Given the state of the pandemic in April 2021, the restrictions on indoor and outdoor gatherings were critical to stopping the spread of COVID-19, reducing the number of hospitalizations, and saving lives. COVID-19 cases, hospitalizations and ICU occupancy were at their highest levels since the start of the pandemic.[36] Hospitals and ICUs were nearing full capacity and there was a serious risk they would be stretched beyond their limits, even with small increases in the number of critically ill patients. The high prevalence of COVID-19 in the community increased the risk that gatherings of people from different households, whether indoors or outdoors, could result in further spread of the virus and more hospitalizations that could overwhelm the healthcare system.

64. The stay-at-home order was also an important public health measure to reduce the spread of SARS-CoV-2 during a critical stage of the pandemic. As noted above, there was evidence that out-of-home mobility was a key factor that contributed the rise in COVID-19 cases and hospitalizations. On April 16, 2021, the Science Table recommended that a 6-week stay-at-home order was necessary, along with a vaccination rate of 100,000 doses per day, in order to curb the sharp increase in COVID-19 cases.[37]

65. Throughout most of the pandemic, the capacity limits for outdoor gatherings were higher (or less strict) than the capacity limits for indoor gatherings. This was consistent with the evidence that the risk of SARS-CoV-2 transmission is generally higher indoors compared to outdoors. However, when the rate of SARS-CoV-2 transmission and the burden on the healthcare system

[35] O. Reg. 82/20, Schedule 4, s. 1 (April 17, 2021).
[36] See **Exhibit "X"**, *supra* note 23.
[37] See **Exhibit "W"**, *supra* note 21.

were at their highest, such as in April and May 2021, capacity limits for both indoor and outdoor gatherings were the same. During those periods, the rate of transmission was so high that outdoor gatherings, which may otherwise have posed a relatively small risk of transmission, could still have a significant impact on the overall spread of the virus across the province. The higher the number of COVID-19 cases in the population, the more likely it is that people who participate in a gathering will have COVID-19 and pass it on to others. While each individual outdoor gathering may result in a relatively small risk of additional cases, the cumulative impact of many such gatherings could result in a significant increase in transmission across the province.

66. There are several reasons why Ontario imposed slightly different measures for religious gatherings. Among other things, the higher capacity limits allowed a small number of people who may not be in the same household to produce and disseminate virtual religious services to a wider community. A capacity limit of 10 people permitted a few individuals (such as readers, cantors, videographers, etc.) to assist officiants in conducting the online services that remained permitted. Ontario recognized that religious services can be a source of support, comfort and guidance for the communities they serve. Religious leaders can also provide pastoral and spiritual support during public health emergencies and other health challenges. The public health measures for religious gatherings attempted to allow religious services to continue to the extent possible so that members of religious communities could access the benefits of those services, but with strict capacity limits that mitigate the spread of COVID-19.

67. It should be noted that the various restrictions imposed by Ontario to reduce the spread of COVID-19 at different times, in different regions of the province, and in different sectors are based on the unique circumstances of each region and sector and the changing nature of the COVID-19 pandemic. Comparing the restrictions that apply in one circumstance to those that

apply in another is not a useful or appropriate exercise without taking into account the full context of each circumstance. Every health protection measure implemented by Ontario was assessed on its own merits and the factors that apply in determining whether a measure is appropriate in one circumstance may not apply, or may not apply to the same degree, in another.

68. When deciding whether to implement public health measures at the various stages of the pandemic, including the gathering limits and stay-at-home orders, Ontario considered the potential adverse impacts of those measures and weighed them against the urgent need to reduce the spread of COVID-19. Public health decision-making often requires a complex balancing of the costs and benefits of proposed policy interventions in light of several competing objectives. That decision-making process was particularly challenging during the COVID-19 pandemic, when the public health situation was constantly changing, the threats to the healthcare system were unprecedented, and there was a limited set of non-pharmaceutical interventions that could effectively reduce the spread of the virus. None of those interventions could be implemented without some risk of adverse public health consequences.

69. When considering whether to impose the stay-at-home order and gathering limits in April 2021, Ontario considered their potential adverse impacts, particularly related to the mental health of children and other vulnerable populations. However, the potential for adverse impacts had to be weighed against the cost of not taking sufficient steps to stop the spread of COVID-19 at a critical stage of the pandemic. There was serious concern that, if Ontario failed to take effective actions to control the spread of the virus, the number of COVID-19 cases would continue to grow, the healthcare system would be stretched beyond capacity, and there would be many additional deaths. The stay-at-home order and gathering limits, along with the other public health measures

during the state of emergency, were critical to getting the virus under control and preventing those serious consequences from occurring.

70. Whenever possible, Ontario sought to minimize the adverse impacts of its public health measures. For example, Ontario maintained in-person learning in schools as long as possible, even when stringent gathering limits and stay-at-home orders were in place, which reflected the importance of in-person learning for students' mental health. It was only when COVID-19 cases and hospitalizations risked overwhelming the healthcare system that Ontario moved schools to remote learning. In addition, the stay-at-home orders had exceptions for activities that were important for physical or mental health, such as an exception for outdoor exercise. With respect to social gatherings, there were measures in place to prevent social isolation, such as an exception that allowed individuals who lived alone to attend a social gathering with members of one other household. As noted above, there were also measures that permitted some weddings, funerals and religious services, as Ontario recognized that those services can be important for mental health and are often sources of support, guidance and comfort.

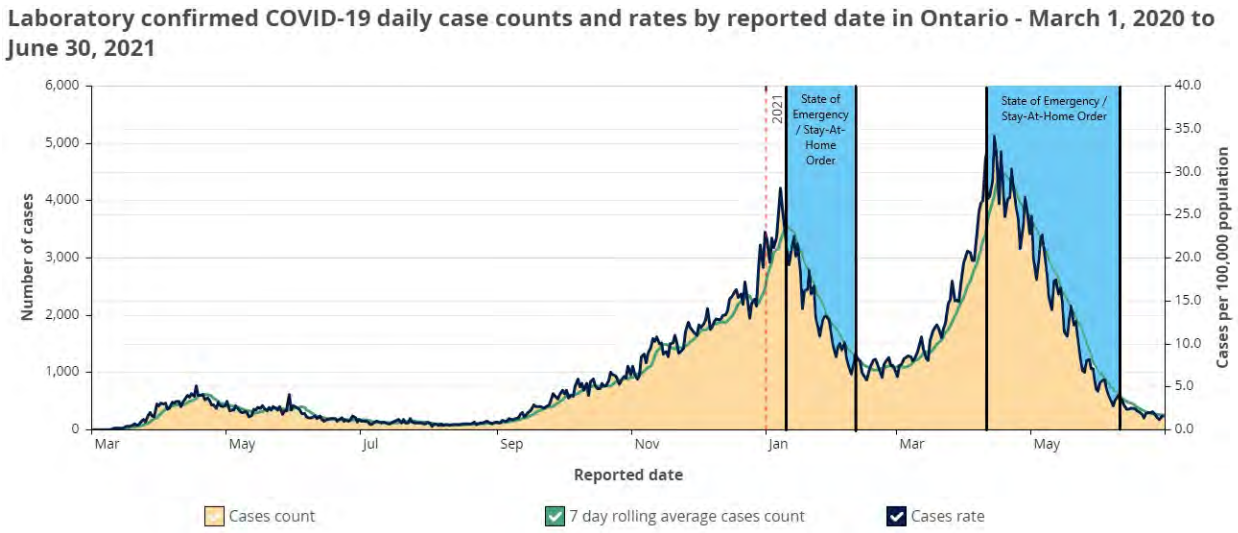
71. Furthermore, Ontario's public health measures were part of a tiered framework that allowed the province to scale up and scale back public health restrictions on a regional basis. This resulted in a tailored approach that allowed restrictions to be increased or decreased depending on the local public health situation. Ontario's priorities when developing this policy framework included keeping schools and childcare open and safe, maintaining health care and public health system capacity, protecting vulnerable populations, and providing additional support to those disproportionately affected by the pandemic.[38] It should also be noted that all of Ontario's public health interventions were intended be temporary to allow sufficient time to rollout vaccines and

[38] Attached as **Exhibit "DD"** is a press release dated November 3, 2020, entitled "Ontario Releases COVID-19 Response Framework to Help Keep the Province Safe."

increase population-level immunity. Once the public health situation improved, Ontario lifted the stay-at-home orders and relaxed gathering limits.[39]

VI. The Impact of Ontario's Public Health Measures

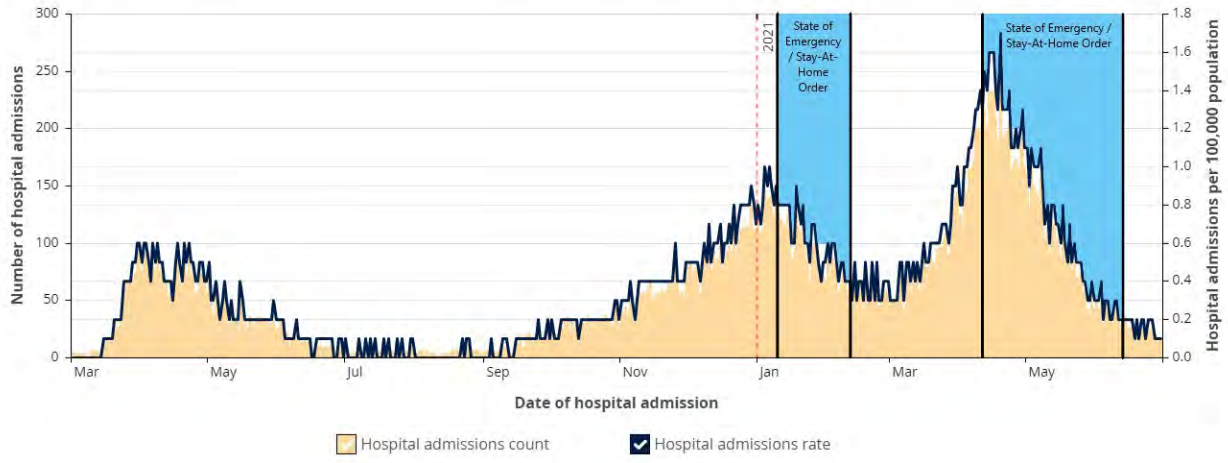
72. There is evidence that the public health measures implemented by Ontario likely helped decrease the transmission of COVID-19 across the province and reduce the strain on the healthcare system. Shortly after the implementation of public health measures during the states of emergency, there were substantial decreases in the number of COVID-19 cases and hospitalizations. This is illustrated in the graph below with data from PHO showing the number of daily new cases from March 1, 2020 to June 30, 2021:



73. The number of daily new hospitalizations followed a similar trend. The graph below shows the number of daily new hospitalizations from March 1, 2020 to June 30, 2021:

[39] See, e.g., O. Reg. 263/20, Schedule 3, s. 1 (June 30, 2021); O. Reg. 363/20, Schedule 1, s. 1 (June 30, 2021); O. Reg. 364/20, Schedule 3, s. 1 (October 27, 2021).

COVID-19 daily hospital admission counts and rates by admission date in Ontario - March 1, 2020 to June 30, 2021



74. These decreases in COVID-19 cases and hospitalizations occurred before widespread rollout of the vaccine. For example, new daily COVID-19 cases decreased from approximately 3,000 cases on April 7, 2021, to under 1,000 cases on June 1, 2021, when only 5.7% of the Ontario population had received two doses of the COVID-19 vaccine.

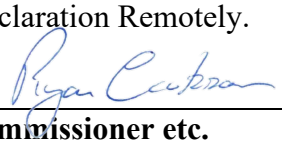
75. In short, many key public health indicators showed signs of significant improvement following the implementation of Ontario's strictest public health measures, including the limits on public gatherings and the stay-at-home orders. While there are many factors that contribute to the transmission of SARS-CoV-2, this data suggests that Ontario's public health measures likely decreased the spread of COVID-19 across the province, reduced the overall strain on the healthcare system, and saved lives.

76. On June 2, 2021, based on the increase in provincewide vaccination rates and improvements in key public health indicators, the province-wide stay-at-home order was lifted. On June 9, 2021, Ontario ended the state of emergency. [40]

[40] Attached as **Exhibit "EE"** is a press release dated June 1, 2021, entitled "Ontario Maintains COVID-19 Restrictions as Stay-at-Home Order is Set to Expire."

77. On June 11, 2021, all public health units were moved from the Shutdown Zone to Step 1 of the re-opening framework, which allowed for more permissive gathering limits.[41] Ontario subsequently relaxed the indoor and outdoor gathering limits as the public health situation improved.[42]

AFFIRMED remotely by David McKeown at the City of Toronto, on the 22nd day of November, 2021, in accordance with O. Reg. 431/20, Administer the Oath or Declaration Remotely.



A Commissioner etc.

DAVID MCKEOWN

[41] O. Reg. 441/21; O. Reg. 363/20, Schedule 1, s. 1 (June 11, 2021); O. Reg. 82/20, Schedule 9, s. 1.
[42] O. Reg. 263/20, Schedule 3, s. 1 (June 30, 2021); O. Reg. 363/20, Schedule 1, s. 1 (June 30, 2021); O. Reg. 364/20, Schedule 3, s. 1 (October 27, 2021); Attached as **Exhibit "FF"** is a press release dated July 9, 2021, entitled "Ontario Moving to Step Three of Roadmap to Reopen on July 16".

Court File No.: CV-22-006282-0000

RANDY HILLER	**-and -**	**HIS MAJESTY THE KING IN RIGHT OF THE PROVINCE OF ONTARIO**
Applicants		Respondent

ONTARIO
SUPERIOR COURT OF JUSTICE
Proceedings Commenced at Toronto

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Counsel for the Respondent

This is **"Exhibit A"**
to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022

A Commissioner, etc.

Government of Canada | Gouvernement du Canada

COVID-19 epidemiology update

Summary of COVID-19 cases, hospitalizations and deaths, cases following vaccination, testing and variants of concern across Canada and over time. Older versions of this report are available on the archived reports page.

Current situation

Update schedule: We update all sections of this page every Monday, except for 'Hospital use', which we update every Thursday. This page was last updated on November 7, 2022, 10 am ET.

Changes to update schedule

Change in update schedule: We now update the following sections on Mondays, instead of Fridays: Current situation (except for 'Hospital use'), Key COVID-19 testing updates, Testing in Canada, and Outbreaks.

Key COVID-19 case and death updates (Last data update November 7, 2022, 10 am ET)

Weekly change in cases	Total cases	Weekly change in deaths	Total deaths
20,627	4,357,478	294	46,710

- Case and death information are up to October 29, 2022.
- Weekly change in cases and deaths includes data from 10 of the 13 Canadian provinces and territories reporting updates for the week of October 23 to October 29, 2022.
- These reflect the changes in the case and death counts at the end of the week compared to the end of the previous week.
- Due to changes in COVID-19 testing policies in many jurisdictions since December 2021, case counts are under-estimated.
- As of October 19, 2022, the Statistics Canada population estimates as of July 1, 2022 are being used for denominators in rate calculations.

Key COVID-19 statements

General statements

- Nationally, very recent decreases or stabilization in COVID-19 case counts, percent positivity, and outbreak incidence indicate that COVID-19 transmission may be slowing, following a period of general increase. Trends in these indicators of transmission vary across provinces and territories.

Cases, hospitalizations and deaths

- Nationally, there are very early signs of decreases in hospital use by COVID-19 patients and COVID-19 deaths, following a period of increase.
- The weekly rate of COVID-19 cases hospitalized and admitted to ICU remained highest among individuals aged 60 years and older.

Cases following vaccination

- People who were diagnosed with COVID-19 after completing their primary vaccine series were significantly less likely to be hospitalized or to die, particularly if they received additional dose(s).

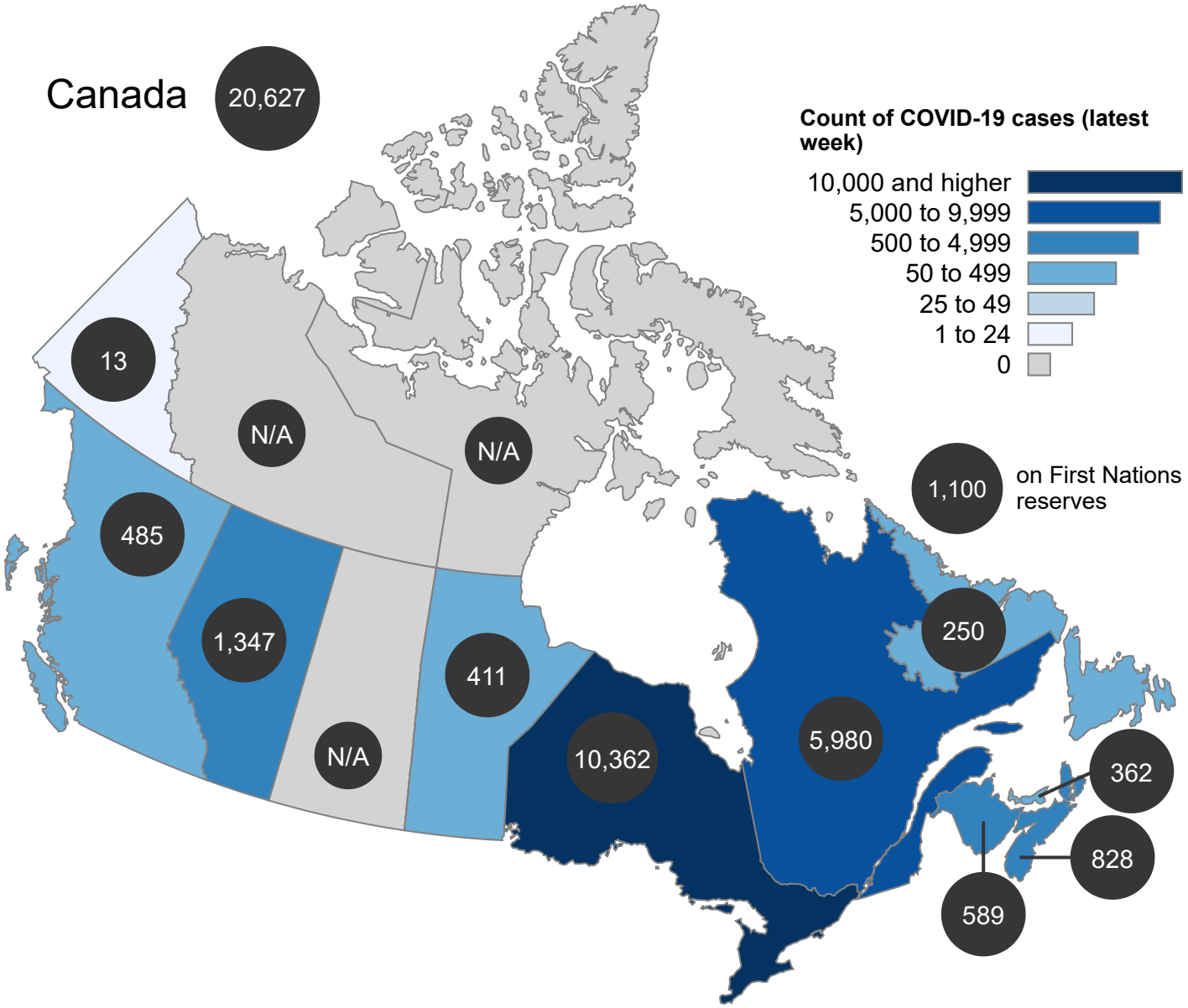
Testing and variants

- The top BA.5 lineages and sub-lineages, which have been stable over recent weeks, are slowly declining, with clinical sequencing showing steady increases in immune evasive variants BQ.1.1 and BF.7.

Case and death trends

Figure 1. Count of cases (latest week) of COVID-19, province/territory for the week of October 23 to October 29, 2022

(Last data update November 7, 2022, 10 am ET)



The count of cases of COVID-19 for the week of October 23 to October 29, 2022 in **Canada** was **20,627**.

a. This information is based on data our provincial and territorial partners published on cases and deaths. The numbers provided reflect cases, deaths up to up to October 29, 2022. For the most up to date data for any province, territory or city, please visit their website. The number of cases or deaths reported may differ slightly from those on the provincial and territorial websites as these websites may update historic case and death counts as new information becomes available.

b. Due to changes in COVID-19 testing policies in many jurisdictions since December 2021, case counts are under-estimated.
c. As of April 11, 2022, Nunavut no longer publishes regular COVID-19 updates.
d. As of June 13, 2022, Northwest Territories no longer publishes regular COVID-19 updates.
e. Due to technical issues, Ontario was not able to provide daily case or death updates for October 15-17. To estimate cases and deaths for October 9-15, we subtracted the cumulative total from October 14 from the cumulative total from October 18, 2022 and calculated the average increase per day for the missing days missing days (e.g. October 15-17, 2022). This average increase was added to the cumulative total on October 14, 2022 to calculate the estimated number of cases and deaths for October 15, 2022.

Areas in Canada with cases of COVID-19

	Total cases		Cases (latest week)		Cases (latest 2 weeks)		Total deaths		Deaths (latest week)		Deaths (latest 2 weeks)	
Location	**Count**	**Rate***	**Count**	**Rate***	**Count**	**Rate***	**Count**	**Rate***	**Count**	**Rate***	**Count**	**Rate***
British Columbia	387,936	7,293	485	9	1,016	19	4,525	85	40	0.8	102	1.9
Alberta	613,649	13,507	1,347	30	2,761	61	5,044	111	20	0.4	40	0.9
Saskatchewan	146,888	12,294	N/A	N/A	N/A	N/A	1,604	134	N/A	N/A	N/A	N/A
Manitoba	151,730	10,767	411	29	773	55	2,232	158	21	1.5	33	2.3
Ontario	1,492,399	9,877	10,362	69	20,695	137	14,765	98	126	0.8	243	1.6
Quebec	1,227,255	14,113	5,980	69	12,049	139	16,963	195	57	0.7	118	1.4
Newfoundland and Labrador	52,802	10,039	250	48	467	89	257	49	3	0.5	7	1.3
New Brunswick	80,715	9,940	589	73	1,281	158	592	73	7	0.9	16	2.0
Nova Scotia	130,534	12,801	828	81	1,820	178	598	59	15	1.4	31	3.0
Prince Edward Island	53,561	31,379	362	212	878	514	69	41	4	2.1	6	3.4
Yukon	4,954	11,313	13	30	25	56	32	73	1	1.5	1	2.3
Northwest Territories	11,511	25,241	N/A	N/A	N/A	N/A	22	48	N/A	N/A	N/A	N/A
Nunavut	3,531	8,713	N/A	N/A	N/A	N/A	7	17	N/A	N/A	N/A	N/A
Canada	**4,357,478**	**11,193**	**20,627**	**53**	**42,430**	**109**	**46,710**	**120**	**294**	**0.8**	**611**	**1.6**

a. * Rate per 100,000 population

Epidemic curve

As of November 7, 2022, 9 am ET, PHAC has received detailed case report data on 4,163,090 cases.

The shaded area for Figures 2 and 3 represents a period of accumulating data where it is known or expected that cases, and severe outcomes have occurred but have not yet been reported nationally. We update this information as it becomes available.

Due to changes in COVID-19 testing policies in many jurisdictions since December 2021, case counts are under-estimated.

Figure 2a. COVID-19 cases (n=4,162,298) in Canada by date as of November 7, 2022, 9 am ET (total cases)

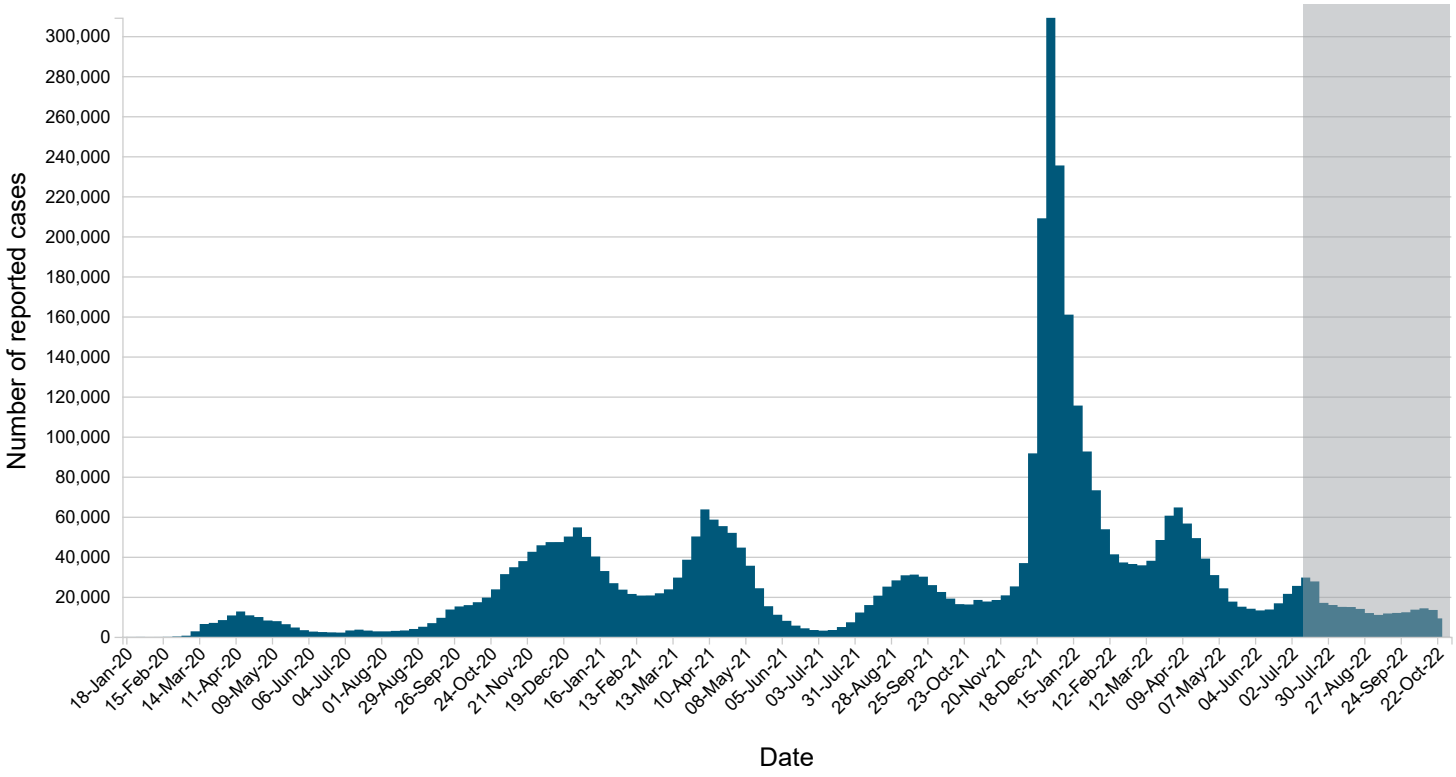
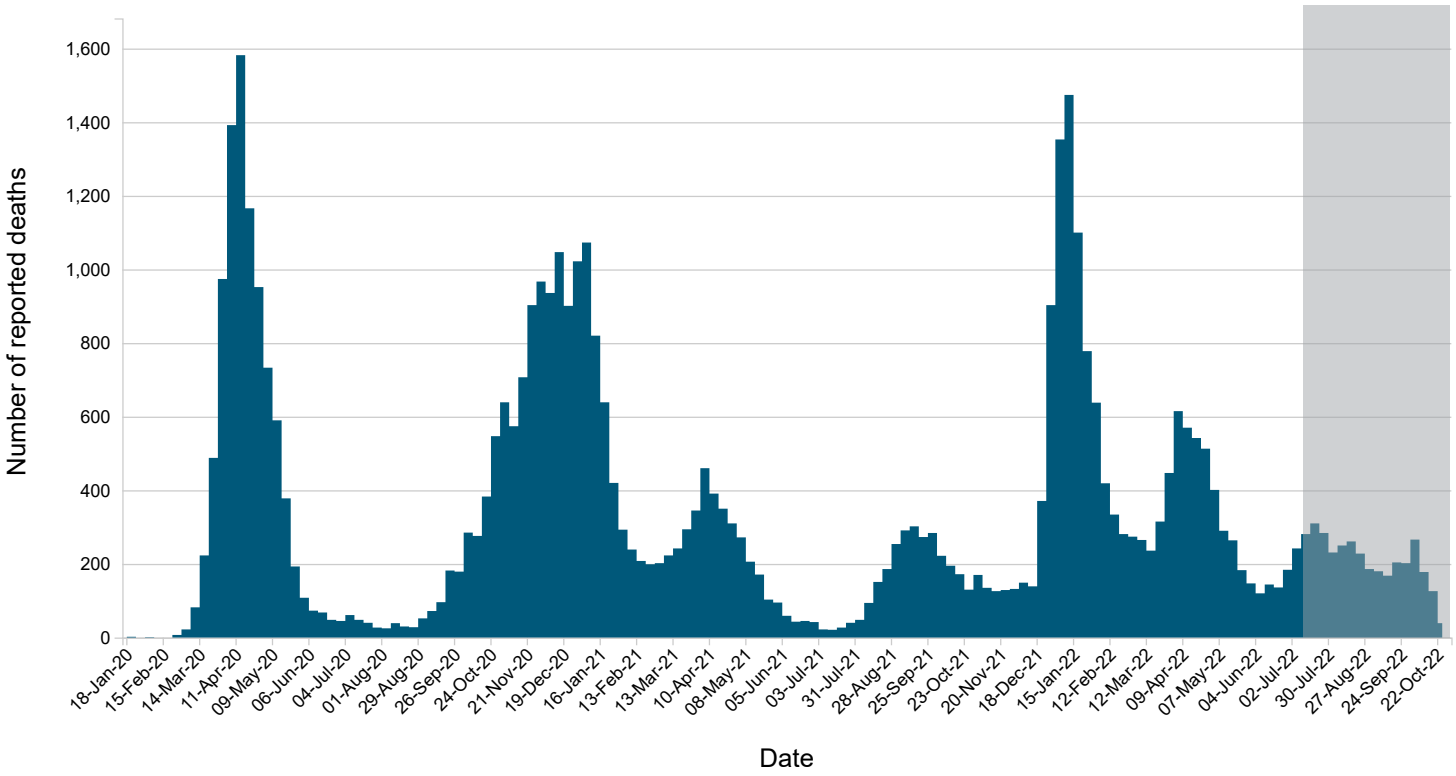


Figure 2b. COVID-19 cases (n=) in Canada by date as of November 7, 2022, 9 am ET (total deaths)



a. This figure reflects detailed case information provided to the Public Health Agency of Canada (PHAC) by health authorities in the provinces and territories. This data is updated every week. It may change as we get more information about cases.

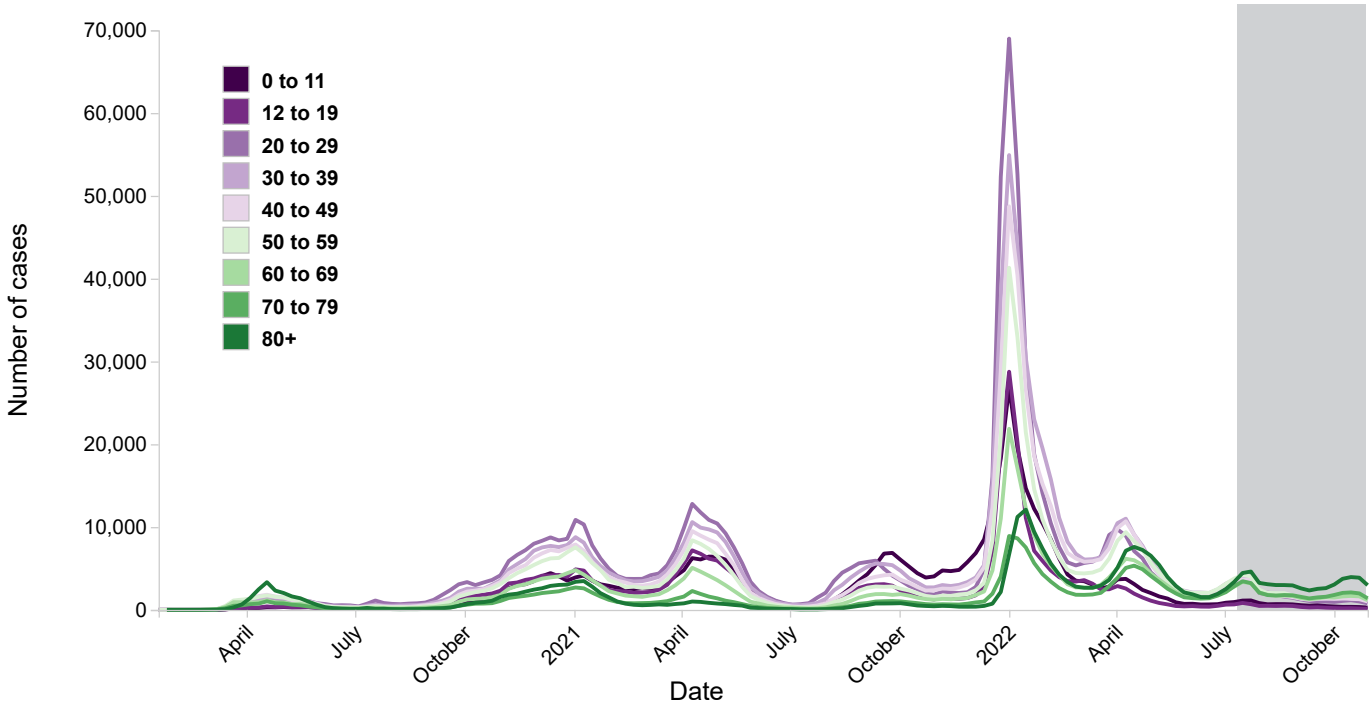
b. The earliest of the following dates were used to determine the week in which a case or death is presented: Onset date, Specimen Collection Date, Laboratory Testing Date, Date Reported to Province or Territory, or Date Reported to PHAC.

Cases by age and gender

We have detailed case report data from 4,163,090 cases. We know the age of patients in 99.9% of cases, and both age and gender in 99.7% of cases.

Of the cases reported in Canada so far, 54.5% were female and 35.0% were between 20 and 39 years old (Figure 2).

Figure 3. Weekly number of COVID-19 cases by age group in Canada as of October 29, 2022



a. This figure reflects detailed case information provided to the Public Health Agency of Canada (PHAC) by health authorities in the provinces and territories. This data is updated every week. It may change as we get more information about cases.
b. The earliest of the following dates were used to determine the week in which a case or death is presented: Onset date, Specimen Collection Date, Laboratory Testing Date, Date Reported to Province or Territory, or Date Reported to PHAC.
c. Due to changes in COVID-19 testing policies in many jurisdictions since December 2021, case counts are under-estimated
d. As of October 19, 2022, the Statistics Canada population estimates as of July 1, 2022 are being used for denominators in rate calculations.

Figure 4a. Age and gender distribution of COVID-19 cases in Canada as of November 7, 2022, 9 am ET (n=4,093,695)

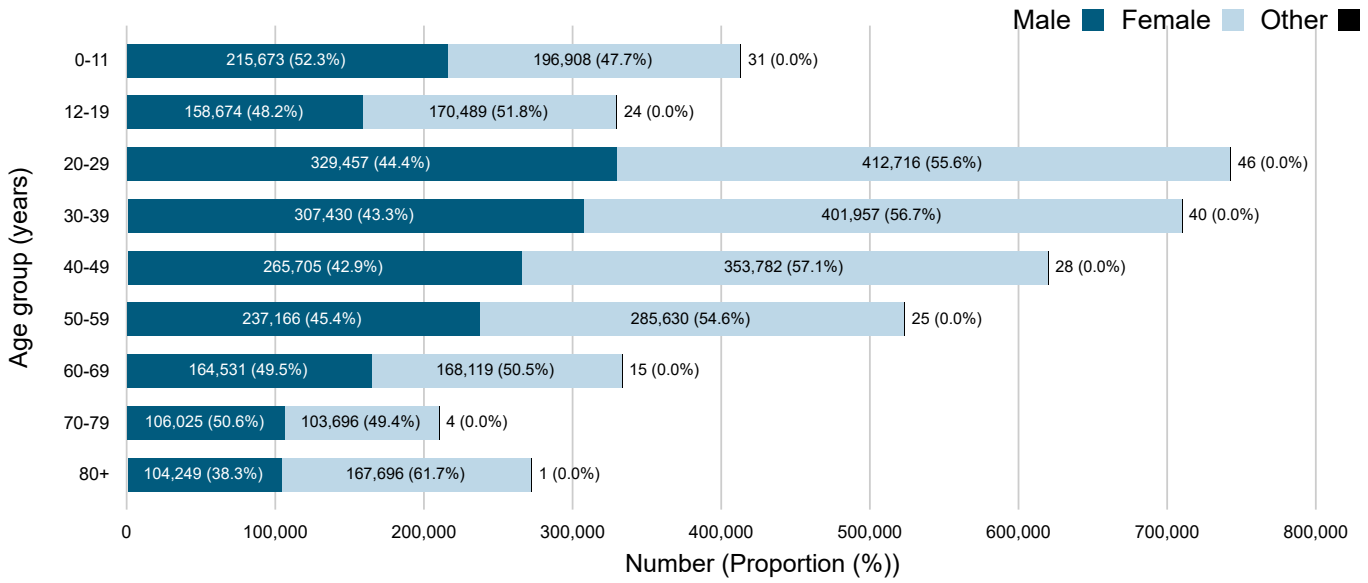


Figure 4b. Age and gender distribution of COVID-19 cases hospitalized in Canada as of November 7, 2022, 9 am ET (n=193,686)

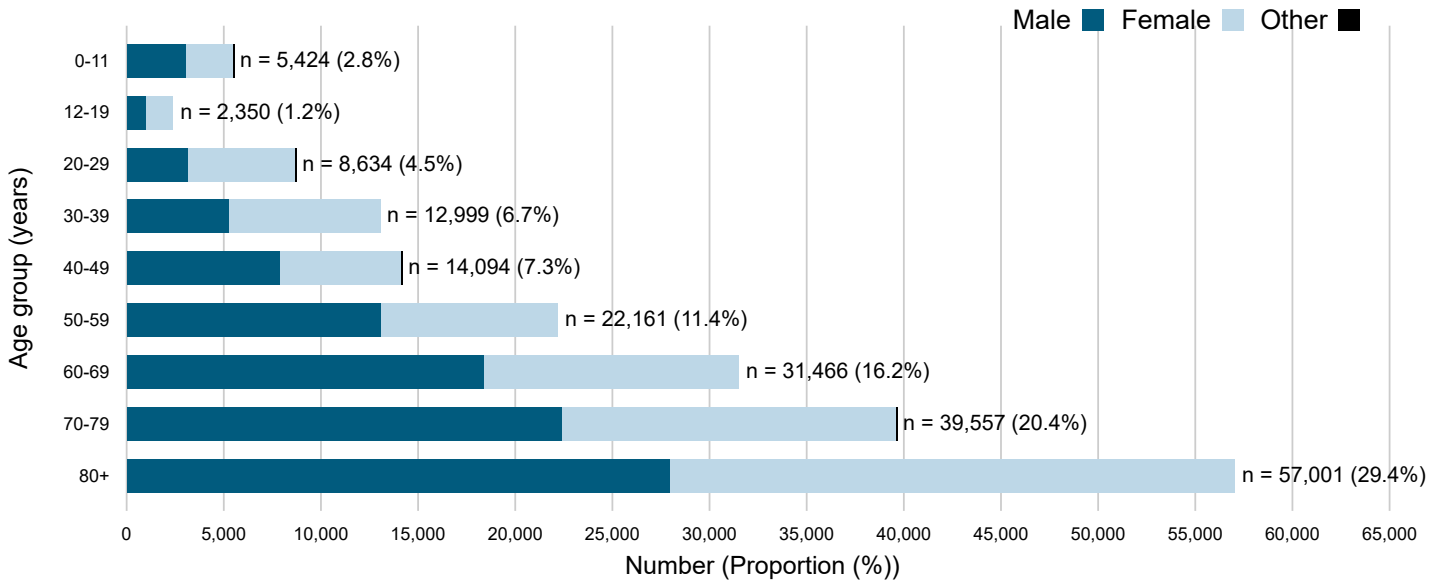


Figure 4c. Age and gender distribution of COVID-19 cases admitted to ICU in Canada as of November 7, 2022, 9 am ET (n=29,844)

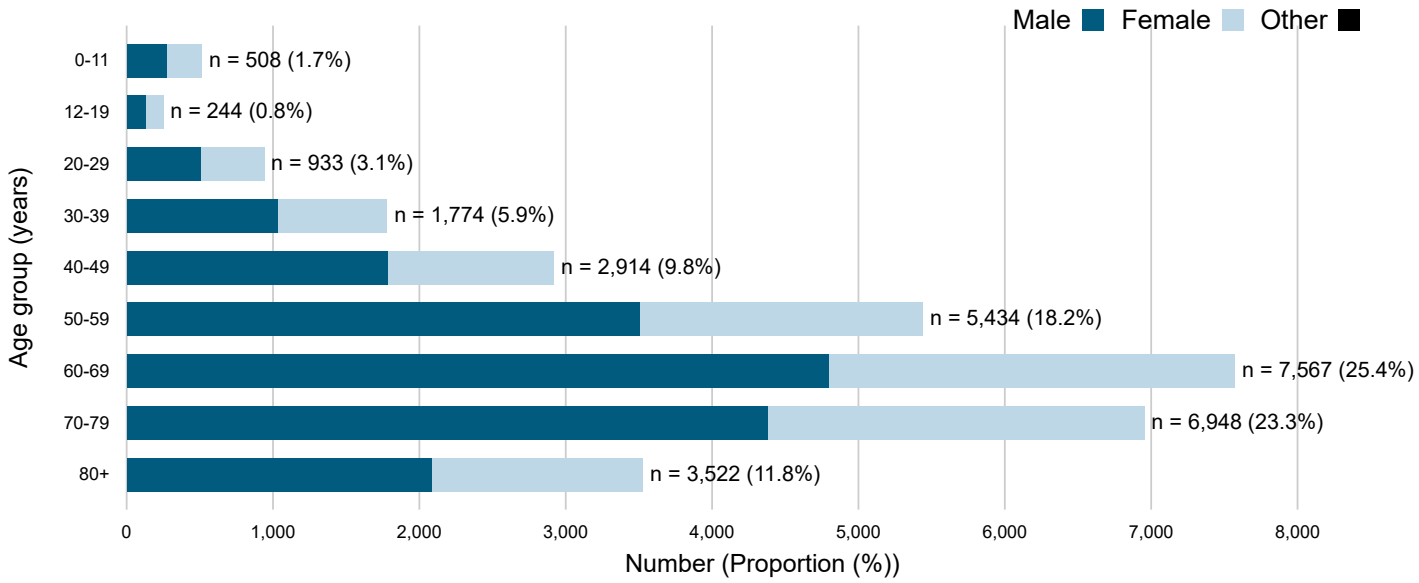
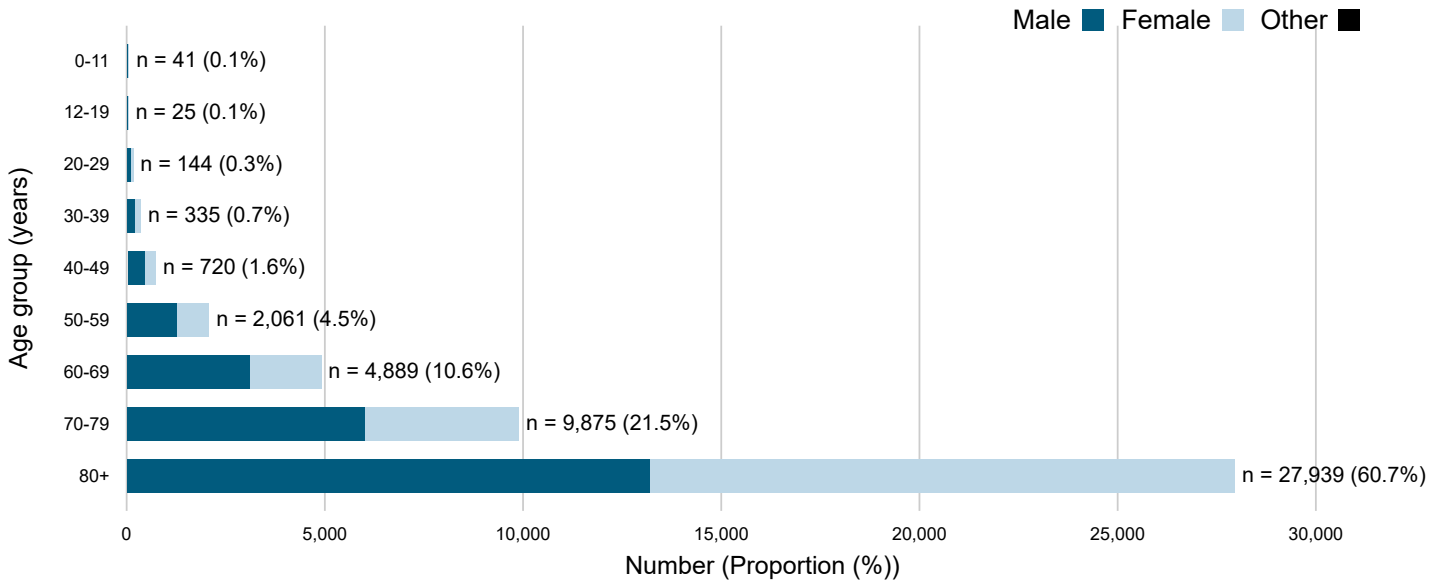


Figure 4d. Age and gender distribution of COVID-19 cases deceased in Canada as of November 7, 2022, 9 am ET (n=46,029)



a. This figure reflects detailed case information provided to the Public Health Agency of Canada (PHAC) by health authorities in the provinces and territories. This data is updated every week. It may change as we get more information about cases.

b. This figure includes COVID-19 cases hospitalized, admitted to ICU, and deceased for which age and gender information were available. Therefore, some COVID-19 hospitalizations, ICU admissions, and deaths may not be included.

Age and gender distribution of COVID-19 cases in Canada as of November 7, 2022, 9 am ET (n=4,093,695)

Age group (years)	Number of cases with case reports (percentage)	Number of male cases (percentage)	Number of female cases (percentage)	Number of other cases (percentage)
0-11	414,244 (10.0%)	215,673 (11.4%)	196,908 (8.7%)	31 (14.5%)
12-19	330,566 (7.9%)	158,674 (8.4%)	170,489 (7.5%)	24 (11.2%)
20-29	745,073 (17.9%)	329,457 (17.4%)	412,716 (18.3%)	46 (21.5%)
30-39	711,355 (17.1%)	307,430 (16.3%)	401,957 (17.8%)	40 (18.7%)
40-49	621,005 (14.9%)	265,705 (14.1%)	353,782 (15.6%)	28 (13.1%)
50-59	524,031 (12.6%)	237,166 (12.6%)	285,630 (12.6%)	25 (11.7%)
60-69	333,394 (8.0%)	164,531 (8.7%)	168,119 (7.4%)	15 (7.0%)
70-79	210,111 (5.0%)	106,025 (5.6%)	103,696 (4.6%)	4 (1.9%)
80+	272,388 (6.5%)	104,249 (5.5%)	167,696 (7.4%)	1 (0.5%)

Age and gender distribution of COVID-19 cases hospitalized in Canada as of November 7, 2022, 9 am ET (n=193,686)

Age group (years)	Number of cases with case reports (percentage)	Number of male cases (percentage)	Number of female cases (percentage)	Number of other cases (percentage)
0-11	5,424 (2.8%)	3,038 (1.6%)	2,385 (1.2%)	1 (0.0%)
12-19	2,350 (1.2%)	988 (0.5%)	1,362 (0.7%)	0 (0.0%)
20-29	8,634 (4.5%)	3,143 (1.6%)	5,490 (2.8%)	1 (0.0%)
30-39	12,999 (6.7%)	5,220 (2.7%)	7,779 (4.0%)	0 (0.0%)
40-49	14,094 (7.3%)	7,832 (4.0%)	6,261 (3.2%)	1 (0.0%)
50-59	22,161 (11.4%)	13,073 (6.7%)	9,088 (4.7%)	0 (0.0%)
60-69	31,466 (16.2%)	18,346 (9.5%)	13,120 (6.8%)	0 (0.0%)
70-79	39,557 (20.4%)	22,398 (11.6%)	17,158 (8.9%)	1 (0.0%)
80+	57,001 (29.4%)	27,929 (14.4%)	29,072 (15.0%)	0 (0.0%)

Age and gender distribution of COVID-19 cases admitted to ICU in Canada as of November 7, 2022, 9 am ET (n=29,844)

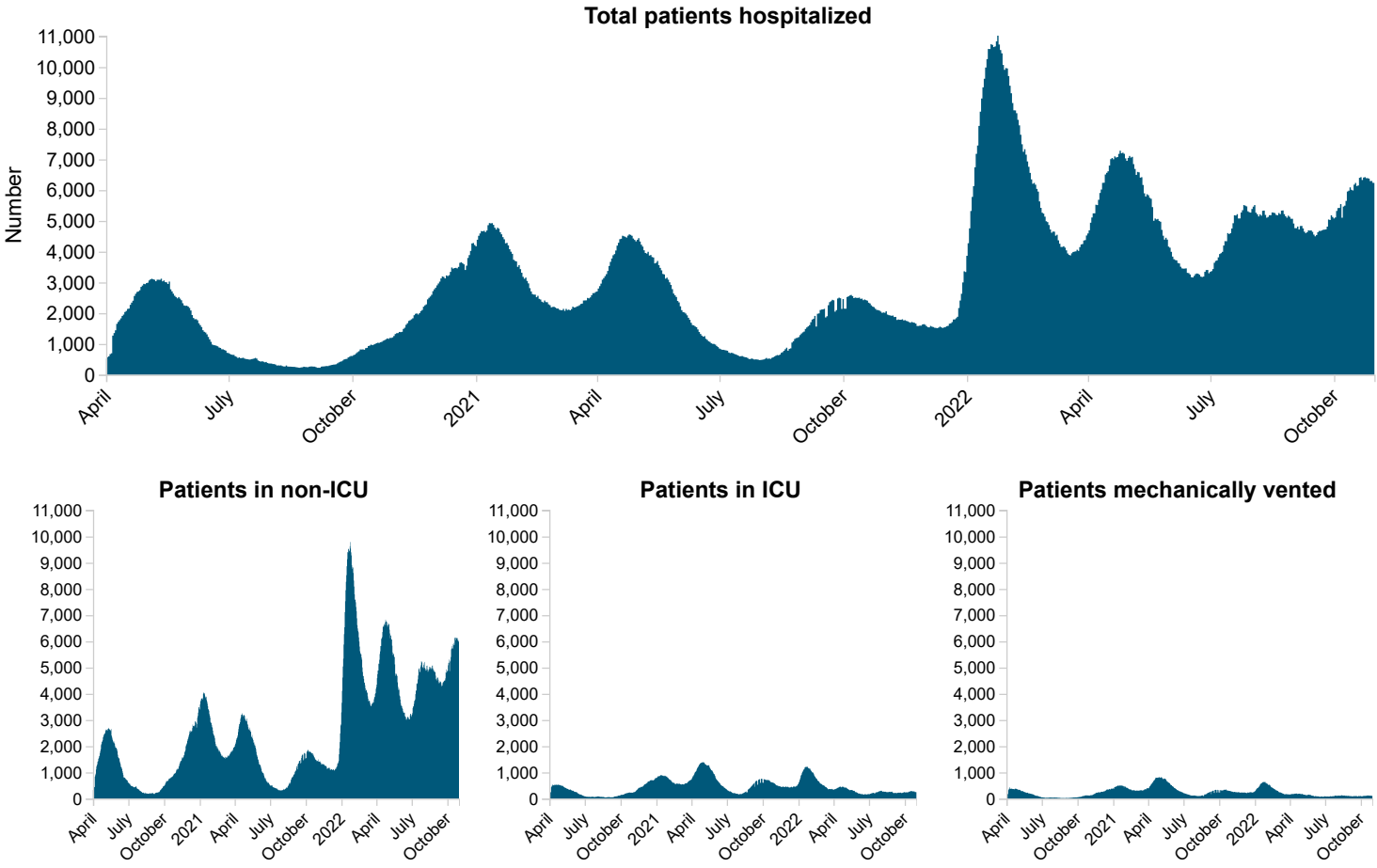
Age group (years)	Number of cases with case reports (percentage)	Number of male cases (percentage)	Number of female cases (percentage)	Number of other cases (percentage)
0-11	508 (1.7%)	274 (0.9%)	234 (0.8%)	0 (0.0%)
12-19	244 (0.8%)	126 (0.4%)	118 (0.4%)	0 (0.0%)
20-29	933 (3.1%)	502 (1.7%)	431 (1.4%)	0 (0.0%)
30-39	1,774 (5.9%)	1,030 (3.5%)	744 (2.5%)	0 (0.0%)
40-49	2,914 (9.8%)	1,784 (6.0%)	1,130 (3.8%)	0 (0.0%)
50-59	5,434 (18.2%)	3,507 (11.8%)	1,927 (6.5%)	0 (0.0%)
60-69	7,567 (25.4%)	4,794 (16.1%)	2,773 (9.3%)	0 (0.0%)
70-79	6,948 (23.3%)	4,375 (14.7%)	2,573 (8.6%)	0 (0.0%)
80+	3,522 (11.8%)	2,083 (7.0%)	1,439 (4.8%)	0 (0.0%)

Age and gender distribution of COVID-19 cases deceased in Canada as of November 7, 2022, 9 am ET (n=46,029)

Age group (years)	Number of cases with case reports (percentage)	Number of male cases (percentage)	Number of female cases (percentage)	Number of other cases (percentage)
0-11	41 (0.1%)	20 (0.0%)	21 (0.0%)	0 (0.0%)
12-19	25 (0.1%)	13 (0.0%)	12 (0.0%)	0 (0.0%)
20-29	144 (0.3%)	89 (0.2%)	55 (0.1%)	0 (0.0%)
30-39	335 (0.7%)	208 (0.5%)	127 (0.3%)	0 (0.0%)
40-49	720 (1.6%)	453 (1.0%)	267 (0.6%)	0 (0.0%)
50-59	2,061 (4.5%)	1,266 (2.8%)	795 (1.7%)	0 (0.0%)
60-69	4,889 (10.6%)	3,095 (6.7%)	1,794 (3.9%)	0 (0.0%)
70-79	9,875 (21.5%)	5,997 (13.0%)	3,878 (8.4%)	0 (0.0%)
80+	27,939 (60.7%)	13,197 (28.7%)	14,742 (32.0%)	0 (0.00%)

Hospital use

Figure 5. Daily number of hospital beds and ICU beds occupied by COVID-19 patients as of October 31, 2022



Between October 24, 2022 and October 31, 2022:

- the total number of **hospital beds** occupied by COVID-19 patients **decreased** from **6,423** to **6,234** beds.
- the number of **non-ICU beds** occupied by COVID-19 patients **decreased** from **6,146** to **5,986** beds.
- the number of **ICU beds** occupied by COVID-19 patients **decreased** from **277** to **248** beds.
- the number of **COVID-19 patients who were mechanically vented decreased** from **118** to **102**.

Provincial, territorial and international reporting

For more information, please refer to provincial or territorial COVID-19 webpages:

- British Columbia
- Alberta
- Saskatchewan
- Manitoba
- Ontario
- Quebec
- Newfoundland and Labrador
- New Brunswick
- Nova Scotia
- Prince Edward Island
- Yukon
- Northwest Territories
- Nunavut

For more information, please refer to international COVID-19 webpages:

- World Health Organization
- US Centers for Disease Control and Prevention
- European Centre for Disease Control and Prevention

COVID-19 epidemiology update

Summary of COVID-19 cases, hospitalizations and deaths, cases following vaccination, testing and variants of concern across Canada and over time. Older versions of this report are available on the archived reports page.

Cases following vaccination

Update Schedule: We update all sections of this page every 4 weeks on Tuesdays. Data extracted on October 14, 2022 for cases between December 14, 2020 and September 25, 2022.

While COVID-19 vaccines are highly effective at preventing severe outcomes such as hospitalization and death, vaccinated people can still get infected if exposed. This means that even with high vaccine effectiveness, some vaccinated people will get sick, be hospitalized or die.

Most people in Canada have been vaccinated. Because they're a larger group, there will naturally be more cases among vaccinated people than among unvaccinated people. However, despite their higher case counts, **vaccinated people are less likely to get very sick or die**.

Case counts underestimate the total number of COVID-19 cases because a rapid increase in cases starting in December 2021 led to changes in COVID-19 testing policies and delays in data entry.

Case counts are likely to over-represent people at risk of severe disease, because they have been prioritized for testing. Data should be interpreted with caution.

Cases reported since the start of the vaccination campaign, as of September 25, 2022

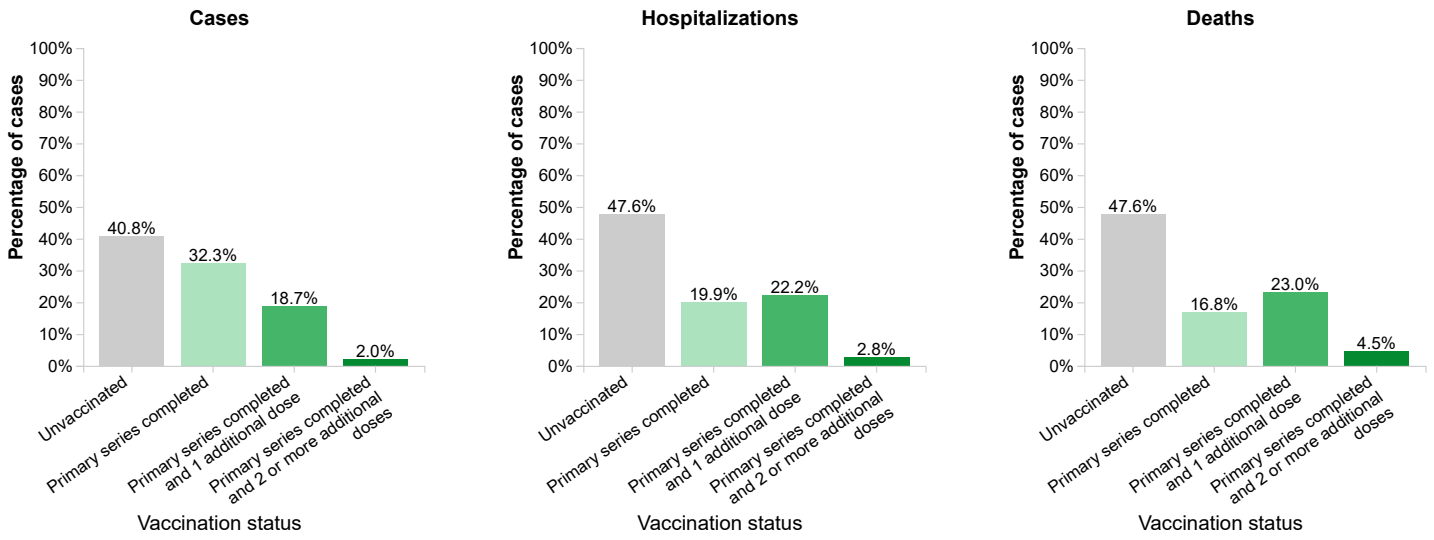
Since the start of the vaccination campaign on December 14, 2020, PHAC received case-level vaccine history data for 73% (n=2,457,576) of COVID-19 cases aged 5 years or older.

Of these cases:

- 1,002,452 (40.8%) were unvaccinated
- 794,145 (32.3%) had completed their primary vaccine series
- 460,280 (18.7%) had completed their primary vaccine series and 1 additional dose
- 49,056 (2.0%) had completed their primary vaccine series and 2 or more additional doses

For definitions of the different vaccination statuses, please refer to the Technical notes and definitions section.

Figure 1. Distribution of outcomes of confirmed COVID-19 cases reported to PHAC by vaccination status as of September 25, 2022



Outcomes of confirmed COVID-19 cases reported to PHAC by vaccination status, as of September 25, 2022

Status	Cases	Hospitalizations	Deaths
Unvaccinated	40.8%	47.6%	47.6%
Primary series completed	32.3%	19.9%	16.8%
Primary series completed and 1 additional dose	18.7%	22.2%	23.0%
Primary series completed and 2 or more additional doses	2.0%	2.8%	4.5%

Among the twelve jurisdictions that have reported case-level vaccine history data to PHAC, a total of 25.2 million people have received at least one dose of the COVID-19 vaccine as of September 25, 2022.

Cases following vaccination were more common among older adults and females (Table 1). This may be due to:

- higher risk of disease among older adults and pregnant people
- longer life expectancy among females, which means more women move into older age groups with a higher risk of disease

Older adults have been prioritized for second booster doses. As a result, older people make up a large proportion of people who had completed their primary vaccine series and 2 or more additional doses. For the same reason, they also make up a large proportion of cases in that group.

Table 1. Characteristics of confirmed cases by vaccination status, as of September 25, 2022

		Unvaccinated (n=1,002,452)	Primary series completed (n=794,145)	Primary series completed and 1 additional dose (n=460,280)	Primary series completed and 2 or more additional doses (n=49,056)	Total cases† (n=2,457,576)
Gender*	Male	505,488 (45.3%)	349,204 (31.3%)	168,004 (15.0%)	19,728 (1.8%)	1,116,527 (100.0%)
	Female	492,450 (36.9%)	442,709 (33.2%)	291,150 (21.8%)	29,222 (2.2%)	1,332,782 (100.0%)
Age group	5-11	124,188 (75.3%)	8,334 (5.1%)	26 (0.0%)	0 (0.0%)	164,844 (100.0%)
	12-17	72,638 (52.9%)	56,193 (40.9%)	2,534 (1.9%)	14 (0.0%)	137,288 (100.0%)
	18-39	422,270 (43.2%)	375,031 (38.4%)	132,168 (13.5%)	1,587 (0.2%)	978,009 (100.0%)
	40-59	251,264 (36.3%)	246,720 (35.6%)	153,871 (22.2%)	4,104 (0.6%)	692,037 (100.0%)
	60-79	103,393 (31.2%)	85,657 (25.8%)	101,450 (30.6%)	18,218 (5.5%)	331,631 (100.0%)
	80+	28,699 (18.7%)	22,210 (14.4%)	70,231 (45.7%)	25,133 (16.3%)	153,767 (100.0%)

Source: Detailed case information received by PHAC from provinces and territories, since December 14, 2020 (see data notes in the Technical notes and definitions section)

People who were diagnosed with COVID-19 after completing their primary vaccine series were significantly less likely to be hospitalized or to die, particularly if they received an additional dose(s).

Between August 29, 2022 and September 25, 2022, unvaccinated cases were 3 times more likely to be hospitalized and 5 times more likely to die from their illness, compared to cases with a completed primary vaccine series. During the same 4-week period, unvaccinated cases were 3 times more likely to be hospitalized and 5 times more likely to die from their illness, compared to cases with a completed primary vaccine series and 1 or more additional doses (see data notes in Technical notes and definitions section).

Technical notes and definitions

Data for this analysis comes from the COVID-19 national data set, which contains detailed case-level information received by PHAC from all provinces and territories.

- 12 of 13 provinces and territories have reported case-level vaccine history data to PHAC as part of the national COVID-19 dataset.
- 12 of these provinces and territories reported data on cases with a completed primary vaccine series and 1 additional dose. 8 of the 12 provinces and territories reported data on cases with a completed primary vaccine series and 2 or more additional doses. In provinces and territories that have not yet reported additional dose data, cases are classified as having completed their primary vaccine series if they have a completed primary series or with or without any more additional doses.
- We used a data cut-off of September 25, 2022 to account for routine reporting delays associated with vaccine history information.
- [†]Counts of cases by vaccination status may not add up to total counts, as data on cases not yet protected and partially vaccinated cases are not presented here.
- Data presented here on cases with a completed primary vaccine series and 1 or more additional dose(s) are limited to individuals aged 5 years or older.
- [*]When available, we used gender data. If unavailable, we used sex data. We excluded cases with missing gender and sex data from the gender analysis. Reliable data on gender diverse respondents are unavailable due to small counts.

- As of October 18, 2022, rate ratios are age-standardized using July 2022 Canadian population estimates for all 2022 report weeks. As a result, there is a decrease in rate ratios compared to previously published reports. For more information on denominators for cases following vaccination, see Vaccination coverage data sources.
- For analyses of rate ratios, cases are classified as having completed their primary series with one or more additional dose(s) if they have received at least 1 additional dose after completing their primary series
- Rate ratio calculations were based on data from 12 provinces and territories that have reported complete case-level vaccine history data to PHAC during the 4-week period of analysis.

Episode date: Refers to symptom onset date. When symptom onset date is unavailable or the case is asymptomatic, episode date refers to either:

- laboratory specimen collection date, or
- laboratory testing date

PHAC monitors cases following vaccination using the following categories:

Unvaccinated cases: those who were unvaccinated at the time of their episode date.
Cases not yet protected from vaccination: those whose episode date occurred less than 14 days after their first dose of the vaccine.
Partially vaccinated cases: those whose episode date occurred:

- 14 days or more after their first vaccine dose in a 2-dose series, or
- less than 14 days after their second dose of the vaccine.

Cases with a completed primary series: those whose episode date occurred:

- 14 days or more after receipt of a second dose in a 2-dose series, or
- 14 days or more after receipt of one dose of a 1-dose vaccine series, and
- if an additional (for example, third dose or booster) dose was received, 0 to <14 days after receipt of the first additional dose.

Cases with a completed primary series and 1 or more additional dose(s): those whose episode date occurred 14 days or more following the receipt of at least 1 additional dose (for example, third dose or booster) of a COVID-19 vaccine product, after completing a primary vaccine series.

- Data on counts and distributions are further categorized into 2 groups:
  - **Cases with a completed primary vaccine series and 1 additional dose**: those whose episode date occurred 14 days or more following receipt of 1 additional dose (for example, third dose or first booster) of a COVID-19 vaccine product and, if a second additional dose was received, 0 to <14 days after receipt of that dose
  - **Cases with a completed primary series and 2 or more additional doses**: those whose episode date occurred 14 days or more following receipt of at least 2 additional doses (for example, fourth dose or second booster)

COVID-19 vaccine product: vaccines that have been:

- authorized by Health Canada or
- accepted by the Government of Canada for the purpose of travel to and within Canada

COVID-19 epidemiology update

Summary of COVID-19 cases, hospitalizations and deaths, cases following vaccination, testing and variants of concern across Canada and over time. Older versions of this report are available on the archived reports page.

Testing and variants

Update schedule: We update 'Key COVID-19 testing updates' and 'Testing in Canada' every Monday. We update 'COVID-19 variants in Canada' every Friday. This page was last updated on November 7, 2022, 10 am ET.

Changes to update schedule

Change in update schedule: We now update the following sections on Mondays, instead of Fridays: Current situation (except for 'Hospital use'), Key COVID-19 testing updates, Testing in Canada, and Outbreaks.

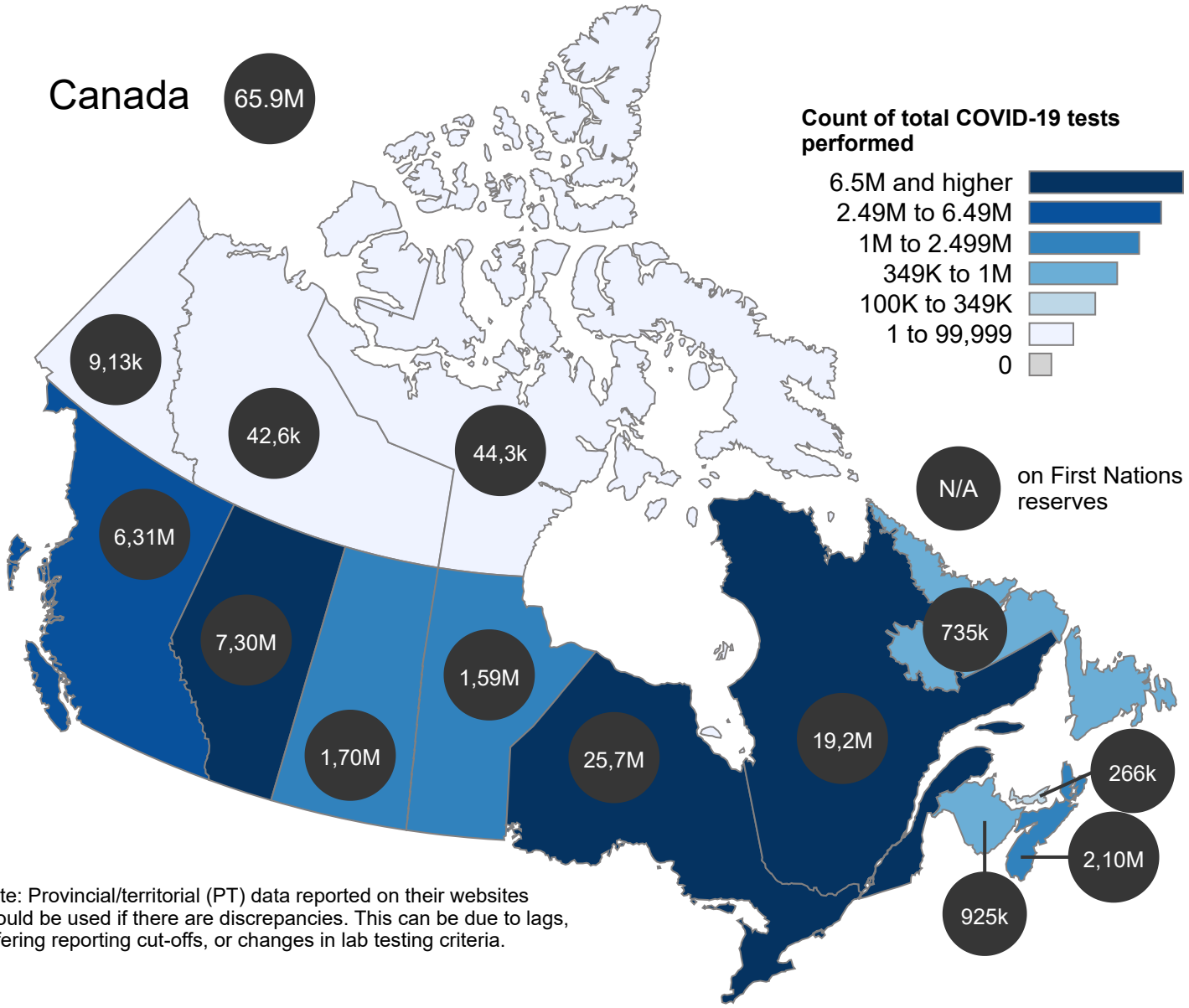
Key COVID-19 testing updates (Last data update November 7, 2022, 10 am ET)

Total tests performed	Daily percent positive (last 7 days)	Daily tests per 100,000 population (last 7 days)
65,873,060	**12.3%**	**54**

- Laboratory data represents specimens received by labs up to November 1, 2022 to allow time to process results.
- The daily percent positive (last 7 days) and Daily tests per 100,000 population (last 7 days) are calculated as the sum of the daily numbers for the previous 7 days from the provinces and territories, (up to and including the day of the last update), divided by the number of days for which data is available.
- As of October 19, 2022, the Statistics Canada population estimates as of July 1, 2022 are being used for denominators in rate calculations.

Testing in Canada

Figure 1. Count of total tests performed for COVID-19, by province/territory up to November 01, 2022 (Last data update November 7, 2022, 10 am ET)



Note: Provincial/territorial (PT) data reported on their websites should be used if there are discrepancies. This can be due to lags, differing reporting cut-offs, or changes in lab testing criteria.

The count of total tests performed of COVID-19 in **Canada** was **65,873,060** up to November 01, 2022.

a. This information is based on testing data provided to the Public Health Agency of Canada (PHAC) by health authorities in the provinces and territories. The numbers provided reflect tests up to November 1, 2022. For the most up to date data for any province, territory or city, please visit their website.

b. The 7-day moving average is the sum of the daily numbers for the previous 7 days (up to and including the day of the last update), divided by the number of days for which data is available. We go back and update the moving averages as provinces and territories submit more data. To calculate

the national 7-day moving average, we sum the number of tests performed during the 7-day period from the provinces and territories, and then divide by 7 the national population to calculate the rate.

c. Due to changes in COVID-19 testing policies in many jurisdictions since December 2021, case counts are under-estimated.

d. Out of all people tested, 76 were repatriated travellers, of whom 13 tested positive.

Areas in Canada with cases of COVID-19

	Total tests performed	Moving average daily tests performed (latest week)		Moving average daily percent positivity (latest week)
Location	**Count**	**Count**	**Rate***	**Percent**
British Columbia	6,308,638	912	17	9.8%
Alberta	7,295,283	N/A	N/A	N/A
Saskatchewan	1,695,344	858	72	10.4%
Manitoba	1,585,783	326	23	26.8%
Ontario	25,716,080	8,505	56	15.8%
Quebec	19,152,762	9,249	106	8.9%
Newfoundland and Labrador	735,090	344	65	9.1%
New Brunswick	925,487	N/A	N/A	N/A
Nova Scotia	2,096,891	655	64	20.9%
Prince Edward Island	265,599	21	13	16.7%
Yukon	9,129	N/A	N/A	N/A
Northwest Territories	42,576	11	23	19.1%
Nunavut	44,322	25	62	7.2%
Canada	**65,873,060**	**20,905**	**54**	**12.3%**

a. * Rate per 100,000 population

b. Out of the total number of people tested, 76 were repatriated travellers, of which 13 were cases.

COVID-19 variants in Canada

All viruses, including COVID-19, change over time. These changes are called mutations, and result in variants of the virus. Not all mutations are of concern. Most do not cause more severe illness. However, some mutations result in variants of concern or variants of interest.

A variant of concern has mutations that are significant to public health. Before a variant of interest is considered one of concern, scientists and public health professionals must determine if the mutations result in an actual change in the behaviour of the virus. For example, it might:

- spread more easily
- cause more severe illness
- require different treatments, or
- reduce vaccine effectiveness

The Public Health Agency of Canada (PHAC) works with provincial and territorial partners and the Canadian COVID-19 Genomics Network (CanCOGeN) to sequence a percentage of all positive COVID-19 test results. Sequencing reveals the genetic code of the virus, which tells us which variant is involved in a specific case of COVID-19. We report the proportion of COVID-19 variants in Canada every week.

We collect evidence to determine if new variants meet the definition for a variant of concern or a variant of interest. Many variants are being tracked across Canada and around the world.

Currently, Omicron and its sub-lineages are the primary variants of COVID-19 circulating in Canada. Evidence demonstrates that Omicron is more transmissible than previous variants of concern.

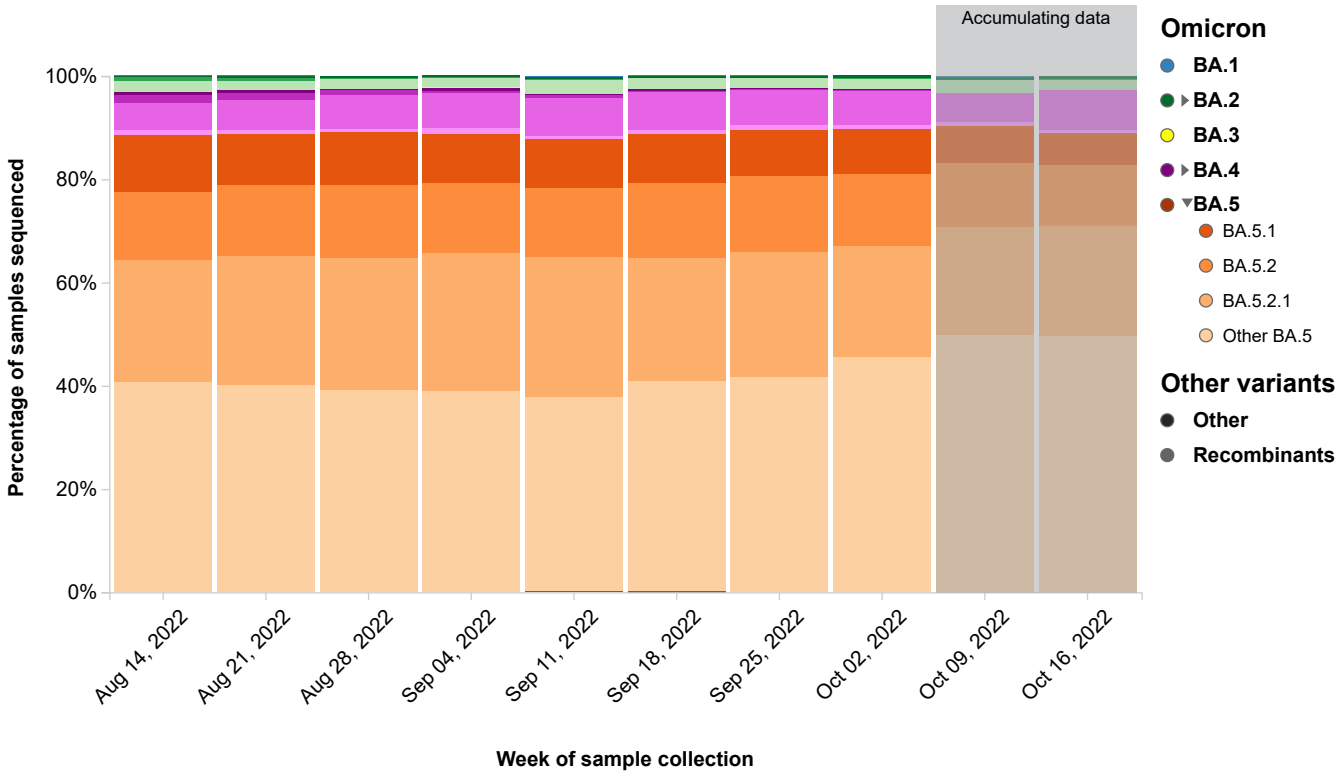
Previous variants of concern in Canada are as follows:

- Alpha
- Beta
- Gamma
- Delta

Staying up to date with COVID-19 vaccination continues to be one of the most effective ways to protect against serious illness, hospitalization, and death from COVID-19. Canada now has access to two updated bivalent vaccines that are expected to provide better protection against the Omicron variant of concern.

Figure 2. Weekly variant breakdown Updated: November 04, 2022, 4 pm EDT

ℹ The graphic shows the percentage mix of COVID-19 variants detected in Canada through whole genome sequencing, by week of sample collection. You can see the numbers for each date by hovering over, tabbing to, or long-pressing any of the bars. To see a specific variant or variant grouping, click or press return. Repeat to restore the complete graph. Sublineages or offshoots for some variants can be revealed or hidden by clicking on the name of the variant in the legend.



This information is based on whole genome sequencing from surveillance testing in all provinces and territories. In addition to sequencing done by the National Microbiology Laboratory in Winnipeg, data is included from provincial and territorial laboratories.

Sequencing takes from 1 to 3 weeks to complete, so the proportions for recent weeks may change as more data are added. Surveillance in each province or territory is organized and prioritized according to local needs and may change from time to time. Because of differences in local sampling and reporting, the percentages illustrate trends rather than precise measurements.

Weekly variant breakdown

Percentage of COVID-19 cases identified through whole genome sequencing, presented by variant and by week of sample collection.

Percentage of COVID-19 cases identified through whole genome sequencing, presented b variant and by week of sample collection.

Variant Grouping	Aug 14, 2022 (n=3,306)	Aug 21, 2022 (n=3,705)	Aug 28, 2022 (n=3,539)	Sep 04, 2022 (n=3,045)	Sep 11, 2022 (n=3,546)	Sep 18, 2022 (n=3,829)	Sep 25, 2022 (n=3,641)	Oct 02, 2022 (n=3,570)	Oct 09, 2022 (n=3,470)	O 20 (n
Omicron	**100.1%**	**100.0%**	**99.8%**	**100.0%**	**99.6%**	**99.9%**	**100.0%**	**99.9%**	**99.8%**	**9**
BA.1	**0.1%**	**0.1%**	**0.0%**	**-**	**0.1%**	**0.1%**	**0.1%**	**0.0%**	**0.1%**	**0.**
BA.2	**3.1%**	**2.6%**	**2.4%**	**2.3%**	**3.3%**	**2.5%**	**2.3%**	**2.6%**	**3.0%**	**2.**
BA.2	0.3%	0.4%	0.2%	0.2%	0.3%	0.4%	0.4%	0.4%	0.5%	0.
BA.2.12.1	0.8%	0.5%	0.3%	0.2%	0.2%	0.0%	0.0%	0.1%	0.1%	0.
BA.2.3	-	0.1%	0.0%	0.0%	-	-	0.0%	-	-	0.
Other BA.2	2.0%	1.6%	1.9%	1.9%	2.8%	2.1%	1.9%	2.1%	2.4%	2.
BA.3	**-**	**-**	**0.0%**	**0.1%**	**-**	**-**	**-**	**-**	**-**	**0.**
BA.4	**8.3%**	**8.5%**	**8.3%**	**8.9%**	**8.6%**	**8.7%**	**8.1%**	**7.6%**	**6.4%**	**8.**
BA.4	0.6%	0.7%	0.2%	0.5%	0.2%	0.4%	0.1%	0.1%	0.0%	-
BA.4.1	1.6%	1.3%	1.0%	0.5%	0.4%	0.2%	0.2%	0.1%	-	0.
BA.4.6	5.3%	5.9%	6.5%	6.8%	7.4%	7.3%	6.9%	6.7%	5.7%	7.
Other BA.4	0.8%	0.6%	0.6%	1.1%	0.6%	0.8%	0.9%	0.7%	0.7%	0.
BA.5	**88.6%**	**88.8%**	**89.1%**	**88.7%**	**87.6%**	**88.6%**	**89.5%**	**89.7%**	**90.3%**	**89**
BA.5.1	11.2%	10.0%	10.4%	9.5%	9.6%	9.5%	9.0%	8.8%	7.3%	6.
BA.5.2	13.0%	13.7%	14.0%	13.5%	13.2%	14.6%	14.6%	13.8%	12.3%	11
BA.5.2.1	23.7%	25.1%	25.7%	26.9%	27.2%	23.7%	24.4%	21.5%	21.0%	21
Other BA.5	40.7%	40.0%	39.0%	38.8%	37.6%	40.8%	41.5%	45.6%	49.7%	49
Other variants	**0.1%**	**0.1%**	**0.1%**	**0.1%**	**0.3%**	**0.2%**	**0.1%**	**0.1%**	**0.1%**	**0.**
Other	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.0%**	**-**	**-**
Recombinants	**0.1%**	**0.1%**	**0.1%**	**0.1%**	**0.3%**	**0.2%**	**0.1%**	**0.1%**	**0.1%**	**0.**

Downloadable data (in .csv format).

Note: The shaded columns on the right represent a period of accumulating data.

Contributing laboratories:

- Saskatchewan - Roy Romanow Provincial Laboratory (RRPL)
- Public Health Ontario (PHO)
- Nova Scotia Health Authority
- Newfoundland and Labrador - Eastern Health
- New Brunswick - Vitalité Health Network
- Manitoba Cadham Provincial Laboratory
- Laboratoire de santé publique du Québec (LSPQ)
- BCCDC Public Health Laboratory
- Alberta Precision Labs (APL)
- National Microbiology Laboratory (NML) - supplemental sequencing for all provinces and territories

National Microbiology Laboratory (NML) - supplimental sequencing for all provinces and territories

COVID-19 epidemiology update

Summary of COVID-19 cases, hospitalizations and deaths, cases following vaccination, testing and variants of concern across Canada and over time. Older versions of this report are available on the archived reports page.

Outbreaks

Update schedule: We update this page every Monday. This page was last updated on November 7, 2022, 10 am ET.

Changes to update schedule

Change in update schedule: We now update the following sections on Mondays, instead of Fridays: Current situation (except for 'Hospital use'), Key COVID-19 testing updates, Testing in Canada, and Outbreaks.

The Public Health Agency of Canada (PHAC) regularly receives COVID-19 outbreak data from health authorities in the provinces and territories. This page summarizes outbreaks in Canada by setting and by size, and is updated weekly. Data may change retroactively if there are changes to:

- provincial or territorial COVID-19 testing strategies
- provincial or territorial reporting of outbreaks
- data collection methods, or
- outbreak management methods

Outbreak definitions vary across the country, but we use a national outbreak definition for all outbreaks. An outbreak is 2 or more confirmed cases of COVID-19 which are epidemiologically linked to a specific setting or location. It does **not** include:

- households (since household cases may not be declared or managed as an outbreak if the risk of transmission is contained)
- cases that are geographically clustered (such as in a region, city, or town) but not epidemiologically linked
- cases attributed to community transmission

In December 2021, the highly contagious Omicron variant caused a rapid increase in cases. This surge affected public health and testing capacity, which led to a change in testing strategies and limited contact tracing. This made it harder for provinces and territories to link cases. As a result, outbreaks were

undercounted. The provinces and territories still consistently report cases of COVID-19 in high-priority settings. However, most no longer report cases in community settings, such as schools, recreational facilities and stores.

- **Acute care**: Hospital or similar setting where patients receive short-term treatment for an injury or severe episode of illness, an urgent medical condition, or during recovery from surgery. Acute care settings include:
  - hospitals
  - emergency departments
  - urgent care
  - transitional care
  - convalescent care
  - short-term inpatient rehabilitation centres
- **Congregate living** includes:
  - retirement residences
  - assisted/supportive living
  - group homes
  - residential treatment centres
  - transition centres
  - shelters
  - student dormitories
- **Correctional facilities** include:
  - provincial jails and prisons
  - federal jails and prisons
  - youth correction centres
- **Long-term care facilities** include both public and private facilities that provide living accommodations for people who require full-time supervised care, including professional health services, personal care, and other services (meals, laundry, cleaning)

Showing outbreaks data from 2021-01-03 to 2022-10-23.

The shaded area on the far right of Figure 1 and Figure 2 represents a period of accumulating data. This is the period of time (1 to 2 weeks) before the latest outbreaks are reported to PHAC. This delay is a result of the time required to identify cases and declare outbreaks. We update this figure as more data becomes available.

Figure 1. Weekly number of outbreaks by setting

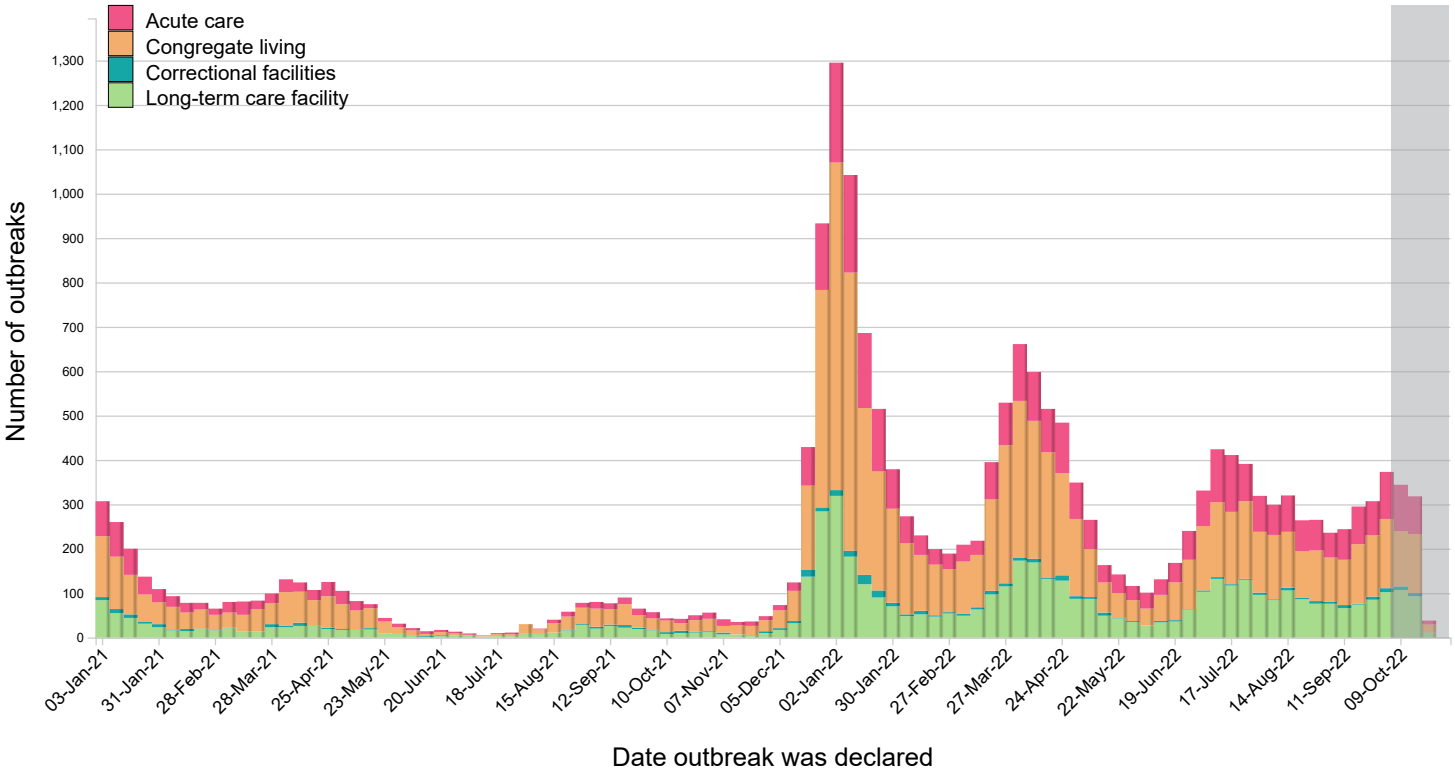
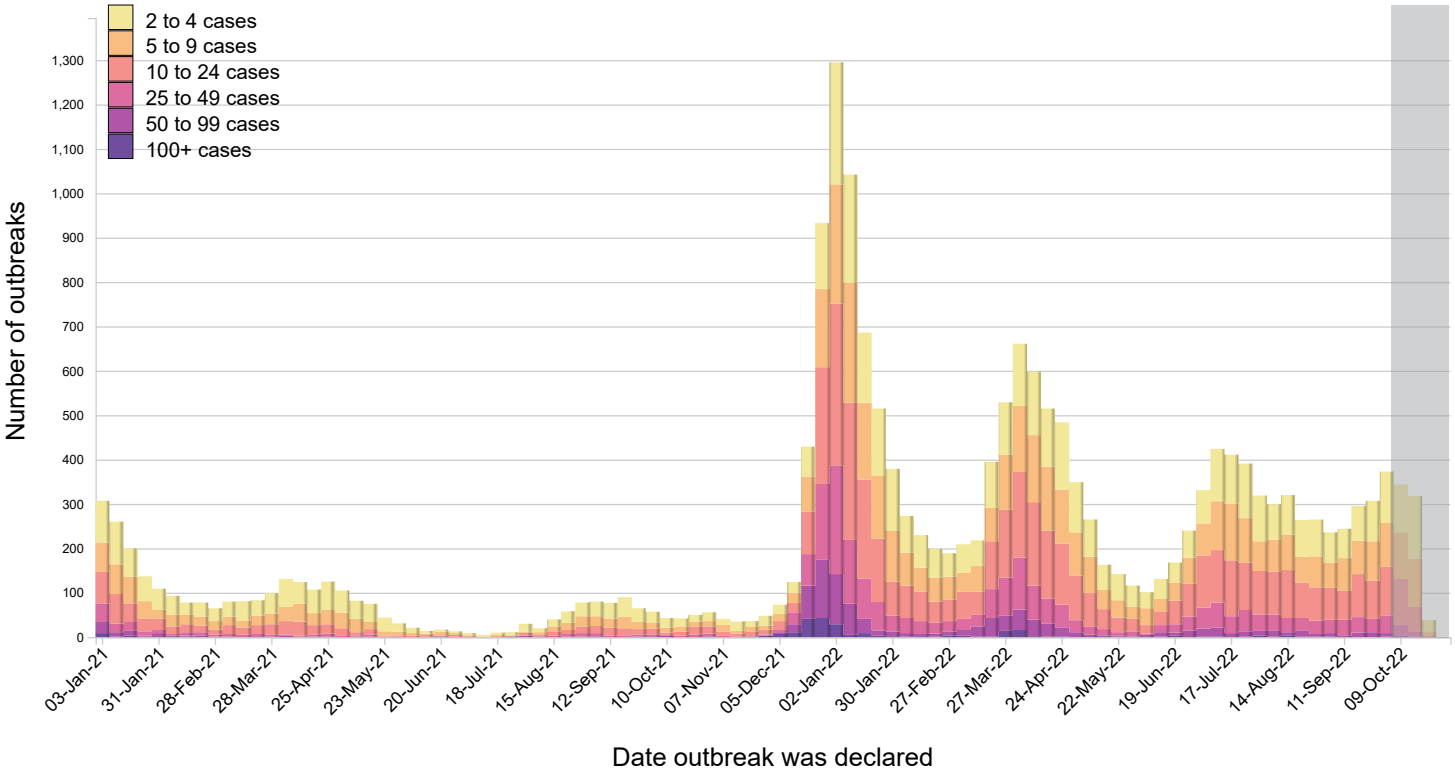


Figure 2. Weekly number of outbreaks by outbreak size for all settings



Between January 2, 2022 and October 22, 2022:

- Acute care accounted for 23% of outbreaks. The median outbreak size was 7 cases/outbreak.

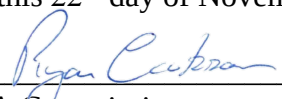
- Congregate living accounted for 50% of outbreaks. The median outbreak size was 7 cases/outbreak.
- Correctional facilities accounted for 2% of outbreaks. Median outbreak size was 12 cases/outbreak.
- Long-term care facilities accounted for 25% of outbreaks. Median outbreak size was 14 cases/outbreak.

Table 1. Summary statistics of COVID-19 outbreak size by setting, all time

Setting	Median case count	Average case count	Number of outbreaks
Acute care	7	10	4,654
Congregate living	7	14	10,130
Correctional facilities	12	37	403
Long-term care facility	14	24	5,183

Date modified:
2022-11-07

This is **“Exhibit B”**
to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022



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Public Health Ontario | Santé publique Ontario

Ontario COVID-19 Data Tool

The Ontario COVID-19 Data Tool provides epidemiological information on COVID-19 activity in Ontario to-date. Explore the most recent COVID-19 data including: daily and weekly case counts by hospitalizations and deaths, vaccine uptake by age, sex and public health unit, outbreaks and laboratory testing.

Changes to the Ontario COVID-19 Data Tool as of September 30, 2022:

- **Summary:** The number of Ontarians who have 'completed their primary vaccine series and 2 booster doses' and corresponding vaccination coverage estimates were added to the Summary tab
- **Summary, Vaccines and Vaccine Map:** Current population projections for Ontario are now being used to calculate vaccination coverage estimates for Ontario and public health units, by age group and sex. This update could result in changes in vaccination coverage estimates. See the **Technical Notes – Vaccines** for more information.

Notes:

- Testing and case, contact, and outbreak management in Ontario was restricted to high-risk populations and settings in January 2022. As such, counts are an underestimate of the extent of COVID-19 activity in Ontario.

The COVID-19 Data Tool is updated Fridays at 11:30 a.m. Vaccine data is updated bi-weekly on Fridays.

For questions about the data, please contact **EPIR@oahpp.ca**.

COVID-19 & Flu Activity | Summary | Case trends | Age and sex | Map | Outbreaks | Lab tests | Vaccines | Technical notes | Glossary

Summary

Confirmed COVID-19 cases in Ontario

Up to October 29, 2022

Cases, rates, hospitalizations and deaths by public health unit can be found in **Case trends**.

Recent cases

9,772

reported in previous week

Recent hospital admissions

473

admissions in previous week

Recent deaths

77

deaths in previous week

Total cases

1,494,422

10,142.7 per 100,000

Total hospital admissions

59,171

401.6 per 100,000

Total deaths

14,799

100.4 per 100,000

Laboratory tests for COVID-19 in Ontario

Up to October 29, 2022

See historical data in **Lab tests**.

New tests in previous week

59,576

404.3 tests per 100,000

Weekly % positive

17.1%

Total tests

25,836,624

175,353.6 tests per 100,000

COVID-19 vaccine uptake in Ontario

Up to October 23, 2022

Vaccine data are updated biweekly. See the **Vaccine** and **Map** tabs for more vaccination data.

At least 1 dose

12,665,041

83.7% of Ontario population

Completed primary series

12,197,929

80.6% of Ontario population

Completed primary series and 1 booster dose

7,580,534

50.1% of Ontario population

Completed primary series and 2 booster doses

2,698,902

17.8% of Ontario population

See metric descriptions in **Glossary**.

« Previous Next »

Related Information

Coronavirus Disease 2019 (COVID-19)

External Resources

COVID-19 case data: All Ontario - Government of Ontario

COVID-19 cases in schools and child care centres - Ministry of Education

COVID-19 Hospitalizations - Government of Ontario

COVID-19 Vaccines Status - Government of Ontario

Updated 4 Nov 2022

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to the Affidavit of David McKeown,
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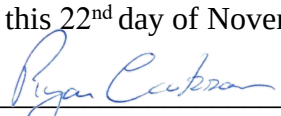

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World Health Organization

< Go back to all Coronavirus disease 2019 Q&As

Coronavirus disease (COVID-19)

13 May 2021 | Q&A

Latest update 13 May 2021 - WHO is continuously monitoring and responding to this pandemic. This Q&A will be updated as more is known about COVID-19, how it spreads and how it is affecting people worldwide. For more information, regularly check the WHO coronavirus pages. https://www.who.int/covid-19

What is COVID-19?

What are the symptoms of COVID-19?

What happens to people who get COVID-19?

Among those who develop symptoms, most (about 80%) recover from the disease without needing hospital treatment. About 15% become seriously ill and require oxygen and 5% become critically ill and need intensive care.

Complications leading to death may include respiratory failure, acute respiratory distress syndrome (ARDS), sepsis and septic shock, thromboembolism, and/or multiorgan failure, including injury of the heart, liver or kidneys.

In rare situations, children can develop a severe inflammatory syndrome a few weeks after infection.

Who is most at risk of severe illness from COVID-19?

Are there long-term effects of COVID-19?

How can we protect others and ourselves if we don't know who is infected?

When should I get a test for COVID-19?

What test should I get to see if I have COVID-19?

What about rapid tests?

I want to find out if I had COVID-19 in the past, what test could I take?

What is the difference between isolation and quarantine?

What should I do if I have been exposed to someone who has COVID-19?

How long does it take to develop symptoms?

How long does it take to develop symptoms?

Is there a vaccine for COVID-19?

What should I do if I have COVID-19 symptoms?

Are there treatments for COVID-19?

Are antibiotics effective in preventing or treating COVID-19?

العربية | 中文 | Français | Русский | Español

WHO TEAM

Emergencies Preparedness

Related

COVID-19 hub

Advice for the public

All COVID-19 Q&As

WHO Information Network on Epidemics (EPI-WIN)

Science in 5 series: WHO experts explain the science related to COVID-19

Start the conversation

More

Subscribe to the WHO newsletter →

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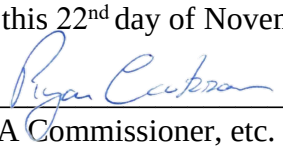

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Centers for Disease Control and Prevention

COVID-19

Long COVID or Post-COVID Conditions

Updated Sept. 1, 2022

DEFINITION

Post-COVID Conditions

Some people who have been infected with the virus that causes COVID-19 can experience long-term effects from their infection, known as post-COVID conditions (PCC) or long COVID.

People call post-COVID conditions by many names, including: long COVID, long-haul COVID, post-acute COVID-19, post-acute sequelae of SARS CoV-2 infection (PASC), long-term effects of COVID, and chronic COVID.

What You Need to Know

- Post-COVID conditions can include a wide range of ongoing health problems; these conditions can last weeks, months, or longer.
- Post-COVID conditions are found more often in people who had severe COVID-19 illness, but anyone who has been infected with the virus that causes COVID-19 can experience post-COVID conditions, even people who had mild illness or no symptoms from COVID-19.
- People who are not vaccinated against COVID-19 and become infected might also be at higher risk of developing post-COVID conditions compared to people who were vaccinated and had breakthrough infections.
- While most people with post-COVID conditions have evidence of infection or COVID-19 illness, in some cases, a person with post-COVID conditions may not have tested positive for the virus or known they were infected.
- CDC and partners are working to understand more about who experiences post-COVID conditions and why, including whether groups disproportionately impacted by COVID-19 are at higher risk.

As of July 2021, “long COVID,” also known as post-COVID conditions, can be considered a disability under the Americans with Disabilities Act (ADA). Learn more: Guidance on “Long COVID” as a Disability Under the ADA, Section

About Long COVID or Post-COVID Conditions

Post-COVID conditions are a wide range of new, returning, or ongoing health problems that people experience after being infected with the virus that causes COVID-19. Most people with COVID-19 get better within a few days to a few weeks after infection, so at least four weeks after infection is the start of when post-COVID conditions could first be identified. Anyone who was infected can experience post-COVID conditions. Most people with post-COVID conditions experienced symptoms days after first learning they had COVID-19, but some people who later experienced post-COVID conditions did not know when they got infected.

There is no test to diagnose post-COVID conditions, and people may have a wide variety of symptoms that could come from other health problems. This can make it difficult for healthcare providers to recognize post-COVID conditions. Your healthcare provider considers a diagnosis of post-COVID conditions based on your health history, including if you had a diagnosis of

COVID-19 either by a positive test or by symptoms or exposure, as well as doing a health examination.

Science at CDC

Scientific evidence and studies behind long COVID

Science behind Long COVID

How to Get Involved in Long COVID Research

The National Institutes of Health (NIH) is conducting a research project, called the RECOVER Initiative, to understand how people recover from a COVID-19 infection and why some people do not fully recover and develop long COVID or post-COVID conditions.

RECOVER: Researching COVID to Enhance Recovery

Symptoms

People with post-COVID conditions (or long COVID) may experience many symptoms.

People with post-COVID conditions can have a wide range of symptoms that can last more than four weeks or even months after infection. Sometimes the symptoms can even go away or come back again.

Post-COVID conditions may not affect everyone the same way. People with post-COVID conditions may experience health problems from different types and combinations of symptoms happening over different lengths of time. Most patients' symptoms slowly improve with time. However, for some people, post-COVID conditions can last weeks, months, or longer after COVID-19 illness and can sometimes result in disability.

People who experience post-COVID conditions most commonly report:

General symptoms

- Tiredness or fatigue that interferes with daily life
- Symptoms that get worse after physical or mental effort (also known as "post-exertional malaise")
- Fever

Respiratory and heart symptoms

- Difficulty breathing or shortness of breath
- Cough
- Chest pain
- Fast-beating or pounding heart (also known as heart palpitations)

Neurological symptoms

- Difficulty thinking or concentrating (sometimes referred to as "brain fog")
- Headache
- Sleep problems
- Dizziness when you stand up (lightheadedness)
- Pins-and-needles feelings
- Change in smell or taste
- Depression or anxiety

Digestive symptoms

- Diarrhea
- Stomach pain

Other symptoms

- Joint or muscle pain
- Rash
- Changes in menstrual cycles

Symptoms that are hard to explain and manage

Some people with post-COVID conditions have symptoms that are not explained by tests.

People with post-COVID conditions may develop or continue to have symptoms that are hard to explain and manage. Clinical evaluations and results of routine blood tests, chest x-rays, and electrocardiograms may be normal. The symptoms are similar to those reported by people with ME/CFS (myalgic encephalomyelitis/chronic fatigue syndrome) and other poorly understood chronic illnesses that may occur after other infections. People with these unexplained symptoms may be misunderstood by their healthcare providers, which can result in a long time for them to get a diagnosis and receive appropriate care or treatment.

Tips for talking to your doctor about post-COVID conditions >

Health conditions

Some people experience new health conditions after COVID-19 illness.

Some people, especially those who had severe COVID-19, experience multiorgan effects or autoimmune conditions with symptoms lasting weeks or months after COVID-19 illness. Multiorgan effects can involve many body systems, including the heart, lung, kidney, skin, and brain. As a result of these effects, people who have had COVID-19 may be more likely to develop new health conditions such as diabetes, heart conditions, or neurological conditions compared with people who have not had COVID-19.

People experiencing any severe illness may develop health problems

People experiencing any severe illness, hospitalization, or treatment may develop problems such as post-intensive care syndrome, or PICS.

PICS refers to the health effects that may begin when a person is in an intensive care unit (ICU), and which may persist after a person returns home. These effects can include muscle weakness, problems with thinking and judgment, and symptoms of post-traumatic stress disorder (PTSD). PTSD involves long-term reactions to a very stressful event. For people who experience PICS following a COVID-19 diagnosis, it is difficult to determine whether these health problems are caused by a severe illness, the virus itself, or a combination of both.

People More Likely to Develop Long COVID

Some people may be more at risk for developing post-COVID conditions (or long COVID).

Researchers are working to understand which people or groups of people are more likely to have post-COVID conditions, and why. Studies have shown that some groups of people may be affected more by post-COVID conditions. These are examples and not a comprehensive list of people or groups who might be more at risk than other groups for developing post-COVID conditions:

conditions.

- People who have experienced more severe COVID-19 illness, especially those who were hospitalized or needed intensive care.
- People who had underlying health conditions prior to COVID-19.
- People who did not get a COVID-19 vaccine.
- People who experience multisystem inflammatory syndrome (MIS) during or after COVID-19 illness.

Health Inequities May Affect Populations at Risk for Long COVID

Some people are at increased risk of getting sick from COVID-19 because of where they live or work, or because they can't get health care. Health inequities may put some people from racial or ethnic minority groups and some people with disabilities at greater risk for developing post-COVID conditions. Scientists are researching some of those factors that may place these communities at higher risk of both getting infected or developing post-COVID conditions.

Preventing Long COVID

The best way to prevent post-COVID conditions is to protect yourself and others from becoming infected. For people who are eligible, getting vaccinated and staying up to date with vaccines against COVID-19 can help prevent COVID-19 infection and protect against severe illness.

Research suggests that people who are vaccinated but experience a breakthrough infection are less likely to report post-COVID conditions, compared to people who are unvaccinated.

Learn more about protecting yourself and others from COVID-19.

Living with Long COVID

Living with a post-COVID condition can be hard, especially when there are no immediate answers or solutions.

However, people experiencing post-COVID conditions can seek care from a healthcare provider to come up with a personal medical management plan that can help improve their symptoms and quality of life. Review these tips to help prepare for a healthcare provider appointment for post-COVID conditions. In addition, there are many support groups being organized that can help patients and their caregivers.

Although post-COVID conditions appear to be less common in children and adolescents than in adults, long-term effects after COVID-19 do occur in children and adolescents.

Talk to your doctor if you think you or your child has long COVID or a post-COVID condition. Learn more: Tips for Talking to Your Healthcare Provider about Post-COVID Conditions

Data for Long COVID

Studies are in progress to better understand post-COVID conditions and how many people experience them.

CDC is using multiple approaches to estimate how many people experience post-COVID conditions. Each approach can provide a piece of the puzzle to give us a better picture of who is experiencing post-COVID conditions. For example, some studies look for the presence of post-COVID conditions based on self-reported symptoms, while others collect symptoms and conditions recorded in medical records. Some studies focus only on people who have been hospitalized, while others include people who were not hospitalized. The estimates for how many people experience post-COVID conditions can be quite different depending on who was included in the study, as well as how and when the study collected information. **Estimates of the proportion of people who had COVID-19 that go on to experience post-COVID conditions can vary**:

- 13.3% at one month or longer after infection
- 2.5% at three months or longer, based on self-reporting
- More than 30% at 6 months among patients who were hospitalized

CDC and other federal agencies, as well as academic institutions and research organizations, are working to learn more about the short- and long-term health effects associated with COVID-19, who gets them and why.

Scientists are also learning more about how new variants could potentially affect post-COVID symptoms. We are still learning to what extent certain groups are at higher risk, and if different groups of people tend to experience different types of post-COVID conditions. These studies, including for example CDC's INSPIRE and NIH's RECOVER, will help us better understand post-COVID conditions and how healthcare providers can treat or support patients with these longer-term effects. CDC will continue to share information with healthcare providers to help them evaluate and manage these conditions.
CDC is working to:

- Better identify the most frequent symptoms and diagnoses experienced by patients with post-COVID conditions.
- Better understand how many people are affected by post-COVID conditions, and how often people who are infected with COVID-19 develop post-COVID conditions afterwards.
- Better understand risk factors, including which groups might be more at risk, and if different groups experience different symptoms.
- Help understand how post-COVID conditions limit or restrict people's daily activity.
- Help identify groups that have been more affected by post-COVID conditions, lack access to care and treatment for post-COVID conditions, or experience stigma.
- Better understand the role vaccination plays in preventing post-COVID conditions.
- Collaborate with professional medical groups to develop and offer clinical guidance and other educational materials for healthcare providers, patients, and the public.

Related Pages

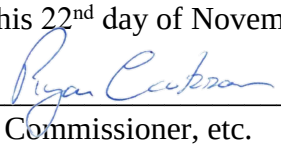
- Caring for People with Post-COVID Conditions
- Preparing for Appointments for Post-COVID Conditions
- Researching COVID to Enhance Recovery
- Guidance on "Long COVID" as a Disability Under the ADA

For Healthcare Professionals

- Post-COVID Conditions: Healthcare Providers

Last Updated Sept. 1, 2022

This is **"Exhibit E"**
to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022



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SYNTHESIS

12/01/2020

COVID-19 Routes of Transmission – What We Know So Far

Introduction

Public Health Ontario (PHO) is actively monitoring, reviewing and assessing relevant information related to Coronavirus Disease 2019 (COVID-19). "What We Know So Far" documents provide a rapid review of the evidence related to a specific aspect or emerging issue related to COVID-19.

The development of these documents includes a systematic search of the published literature as well as scientific grey literature (e.g., ProMED, CIDRAP, Johns Hopkins Situation Reports) and media reports, where appropriate. Relevant results are reviewed and data extracted for synthesis. All "What We Know So Far" documents are reviewed by PHO subject matter experts before posting.

As the COVID-19 outbreak continues to evolve and the scientific evidence rapidly expands, the information provided in these documents is only current as of the date of posting.

See Appendix A for Glossary of Terms for COVID-19 Routes of Transmission.

Updates in Latest Version

Since the last version (July 16, 2020), multiple new studies and systematic reviews have been published with evidence on the potential for transmission via several routes including respiratory droplet and close-contact, vertical, conjunctival and fomite transmission. There was more evidence against several modes of transmission, including sexual and transmission through breast milk.

Importantly, there are now experimental studies and outbreak case studies that support severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission through small particle respiratory droplets or aerosols during prolonged exposure in a poorly ventilated space. The primary mode of SARS-CoV-2 transmission; however, remains through respiratory droplets and unprotected close contact.

New modes of transmission addressed in this update include potential transmission from wastewater, food, urine and zoonotic transmission (through animals).

Key Points

- Overall, the evidence for various transmission routes relies heavily on the detection of viral RNA in clinical and environmental samples, rather than the detection of viable, infectious virus. Further, the quantity of viral RNA that is representative of an infectious dose is unclear.

- Transmission of SARS-CoV-2 occurs predominantly through close (<2 m), unprotected contact with an infected individual(s). Based on the epidemiology of COVID-19, transmission predominantly occurs via respiratory droplets from symptomatic, presymptomatic or less commonly, asymptomatic individuals.
- Transmission over longer distances (>2 m) is less common, but possible under certain conditions such as prolonged exposure in a poorly ventilated space. Under these conditions, inhalation of small particle respiratory droplets and aerosols can occur. SARS-CoV-2 is likely an *opportunistic* airborne pathogen, as non-airborne transmission is most common, but aerosols may result in transmission under favourable conditions.
- Relatively uncommon routes of transmission of SARS-CoV-2 include conjunctival, vertical (intrauterine), fecal-oral, fomite and zoonotic. While these routes of transmission are possible, their contribution to the epidemiology of COVID-19 is unclear.
- Routes of transmission that are theoretically possible due to the detection of viral RNA, but that are very unlikely, are sexual transmission (via semen and vaginal secretions); bloodborne transmission (blood products, organ transplant); transmission through breast milk; transmission through urine; food-borne transmission; and transmission through contaminated wastewater.

Background

The purpose of this document is to outline the evidence for various SARS-CoV-2 transmission routes, based on a review of the scientific literature. SARS-CoV-2 is genetically similar to other coronaviruses and shares a high degree of genetic similarity (79%) with the coronavirus (SARS-CoV-1) responsible for Severe Acute Respiratory Syndrome (SARS).[1] Therefore, in instances of limited evidence for COVID-19, we have extrapolated existing data from other coronaviruses, in particular SARS-CoV-1.

During the COVID-19 pandemic, evidence for and against potential routes of transmission has evolved. In some instances, there is no consensus on the contribution from certain modes of transmission. A number of reports postulate transmission routes; however, in many it is challenging to determine the precise mode of transmission where there are multiple opportunities for transmission to occur (i.e. through direct contact, fomites, or inhalation). In addition, the strength of evidence by transmission route has changed. In contrast to the July 16, 2020 version of this document, there have been several systematic reviews published on the subject that are included. The systematic reviews contribute to bringing the evidence base closer to a consensus. Within this document, we underpin our findings with systematic reviews and meta-analyses where available, supporting findings with case series and cohort studies.

Methods

In considering feasibility, scope and the need for responsiveness, a rapid review was chosen as an appropriate approach to determining the routes of transmission for SARS-CoV-2. A rapid review is a type of knowledge synthesis wherein certain steps of the systematic review process are compromised in order to be timely.[2]

PHO is actively monitoring, reviewing and assessing relevant information related to COVID-19. This document provides a rapid review of the evidence related to transmission routes of SARS-CoV-2.

On October 14, 2020, PHO Library Services developed and conducted a search in MEDLINE (Appendix B). English language peer-reviewed and grey literature records that describe transmission of SARS-CoV-2

were included. We did not restrict year of publication. We reviewed references of included studies for additional articles.

Two reviewers screened titles and abstracts, and the senior author reviewed the application of the eligibility criteria. The senior author synthesized relevant data. We did not perform a critical appraisal of the methodological quality of studies due to time constraints. PHO subject matter experts reviewed this rapid review before posting.

Results

Droplet and Contact Transmission

Current evidence suggests that the primary mode of transmission of COVID-19 is through direct contact from respiratory droplets that have the potential to be propelled for varying distances.[3-5]

Household secondary attack rates are indicative of predominantly droplet and close-contact transmission:

In household settings, people are in close proximity to one another, thereby increasing the risk of infection. The consensus among systematic reviews is that most infections are occurring in household settings where physical distancing is not feasible and household secondary attack rates are higher than in casual-contact settings (e.g., shopping).

In a systematic review and meta-analysis, Lei et al. reported the secondary attack rate in households was 27% (95% confidence interval [CI]: 21−32); the risk of secondary infection was 10 times higher in households compared to non-household settings (odds ration [OR]: 10.72; 95% CI: 5.70–20.17; p<0.001).[7] In another systematic review and meta-analysis by Madewell et al., the household secondary attack rate was 18.8% (95% CI: 15.4–22.2).[8] Koh et al, in a meta-analysis, reported that the household secondary attack rate was 18.1% (95% CI: 15.7–20.6), much higher than the secondary attack rate in health care settings (0.7%; 95% CI: 0.4–1.0).[9] Further, these findings do not support predominant airborne transmission. If SARS-CoV-2 was predominantly and efficiently spread through an airborne route (i.e., through aerosols), household secondary attack rates would be expected to be substantially higher (e.g., >90% in measles).[6]

Contact tracing studies also show higher secondary attack rates in households, compared to other settings. The limited transmission to contacts outside the household setting suggests that the mode of SARS-CoV-2 transmission is predominantly from close contact. Luo et al. studied 3,410 close contacts of 391 index cases in Guangzhou, China and found that the secondary attack rate was lower when people were exposed in health care settings (1.0%; OR: 0.09; 95% CI: 0.04–0.20) and on public transportation (0.1%; OR: 0.01; 95% CI: 0.00–0.08), compared to the household secondary attack rate (10.3%).[10] In a retrospective cohort study in Guangzhou, China, Jing et al. reported the household secondary attack rate (among close relatives) was 12.4% (95% CI: 9.8–15.4).[11] In most studies, non-household close contacts have secondary attack rates less than 1% (Bi et al., Chaw et al., Cheng et al., Li et al.).[12-15]

Evidence for SARS-CoV-2 droplet and contact transmission:

The majority of COVID-19 cases have been linked to person-to-person transmission through close, direct contact with symptomatic patients,[16-18] or through close contact with a pre-symptomatic patient.[19-21] In addition, high viral loads have been identified in individuals who were asymptomatic or pre-

symptomatic .[22-24] In a case-control study of patients 18 years old and older in the United States (US), Fisher et al. reported that close contact with a person with COVID-19 was reported more often among cases (42%) than controls (14%).[25] A study modelling the transmission risk from epidemiological data among train passengers revealed that travellers directly adjacent to the index patient had a much higher infection risk (relative risk [RR]: 18.0; 95% CI: 13.9–23.4), and the attack rate decreased with increasing distance.[26] Furthermore, the attack rate increased by 0.15% (p=0.005) per hour of co-travel time.

Using whole-genome sequencing of SARS-CoV-2 clinical samples during a nosocomial outbreak of COVID-19 in Dublin, Ireland, Lucey et al. reported that the majority of infections were among patients who required extensive and prolonged care by health care providers.[27] The authors concluded that the likely mode of transmission from health care workers to patients was through respiratory droplets and close contact, rather than airborne transmission.

The reproductive number (R_0) is less suggestive of airborne spread, as airborne infections tend to have a higher R_0. For example, in a systematic review by Guerra et al., the R_0 for measles in the pre-vaccine era was 6.1–27.0;[28] compared to the range of R_0 (2–3) reported for COVID-19.[29]

Evidence for distance travelled by respiratory droplets:

Researchers have demonstrated the propulsion of respiratory droplets up to 2 m, and in a study by Guo et al., respiratory droplets were found on the floor up to 4 m away from a patient.[30] A systematic review of studies assessing the horizontal distance travelled by respiratory droplets found that droplets could travel up to 8 m.[31]

Airborne Transmission

Respiratory virus transmission occurs on a spectrum from larger droplets that spread at close range to smaller droplets (or aerosols) that have the potential to be infectious over longer distances (i.e. >2 m) and may be suspended for longer periods of time (typically hours). As summarized above, current evidence supports that SARS-CoV-2 transmission is predominantly through close, unprotected contact, which supports larger droplet spread. However, under conditions of poor ventilation or with recirculation of unfiltered and untreated air, aerosols may accumulate in sufficient quantities to become infectious and transmission via inhalation is plausible based on the emerging literature.[32] Further evidence regarding the quantity of viral particles required to cause infection is needed. There is no evidence at this time of transmission over long distances through the air (such as through air ducts). The term “airborne transmission” has special meaning in public health, for infection prevention and control purposes, and in health care settings. This term is typically reserved to describe infections efficiently transmitted by small droplets and particles suspended in the air over long distances and persisting in the air for long periods (see Appendix for size designations). Airborne pathogens typically require specialized engineering controls to prevent spread (e.g. negative-pressure isolation rooms and specific personal protective equipment (PPE) such as respirators). However, the historical dichotomy of airborne vs non-airborne pathogens used in health care settings is likely imprecise. Infectious pathogens can be considered on a spectrum of efficiency for airborne transmission classified as *obligate* (infection only occurs via aerosols), *preferential* (aerosols predominate), or *opportunistic* (non-airborne transmission is most common but aerosols may transmit under favorable conditions). Current evidence supports SARS-CoV-2 as an *opportunistic* airborne pathogen.[33]

A commentary by Morawska and Milton appealed to the medical community to recognize the potential for airborne transmission, based on experimental evidence that small respiratory droplets (or aerosols)

could be inhaled.[34] Another commentary by Klompas et al. discussed how the balance of currently available evidence does not support long-range aerosol transmission as the dominant mode of COVID-19 transmission. While aerosols are reported by Stadnytskyi et al. to be produced during activities such as speaking, breathing and coughing,[35] it is not clear what role aerosols have in transmission for distances greater than 2 m, as viable SARS-CoV-2 has only once been detected during air sampling. The role of these aerosols has been suggested in a modelling study by Chen et al. to be most important for transmission in close proximity (<2 m).[36]

As discussed in the Droplet and Contact Transmission section, household secondary attack rates are more consistent with primary transmission through respiratory droplets when people are in close contact with one another, rather than airborne transmission. There is emerging evidence that *opportunistic* aerosol transmission occurs under the right combination of conditions (i.e. poorly ventilated space with sufficient quantity of infectious virus produced). However, as discussed above, this appears to be less frequent, and less efficient, when compared with direct close contact.

Environmental exposures, such as sunlight, may have significant effects on viability of SARS-CoV-2. Using a rotating drum experiment similar to other studies for viability of SARS-CoV-2, simulated sunlight (UVA/UVB) was applied to aerosolized virus through a window on the drum.[37] Results indicated 90% inactivation of virus within 20 minutes.

Experimental evidence of aerosol generation of SARS-CoV-2:

In a study comparing SARS-CoV-2 and SARS-CoV-1, van Doremalen et al. reported that SARS-CoV-2 could be artificially aerosolized with a jet nebulizer and detectable for up to 3 h in a rotating metal drum.[38] The half-lives of SARS-CoV-2 and SARS-CoV-1 were similar in aerosols with median estimates of the half-life of 1.1–1.2 h. While the van Doremalen et al. study concluded that aerosol transmission was possible, they did not demonstrate that it occurred (refer to the PHO Synopsis on this study for further details). Fears et al. drew similar conclusions through conducting a similar experiment.[39]

Lee modelled the minimum sizes of aerosols emitted from an infected individual that could be expected to contain viral particles.[40] Under certain assumptions, Lee estimated that the minimum sizes theoretically ranged from 0.4–42 μm; by using experimental data of virus in oral fluid, they estimated a range of 4.7–32 μm. Studies discussed by Lee detected virus by polymerase chain reaction (PCR) in much smaller aerosol sizes (<0.25–4 μm). The author reconciled differences in the modelled sizes and air-sampled sizes by acknowledging that aerosols evaporate to smaller sizes (which may take only seconds) and/or the possible range of virus in oral fluid can be higher than reported by the previous experiment used to inform this model. Lee also noted that the virus particles captured in those experiments may not be viable.

Studies have not consistently detected viable SARS-CoV-2 in air samples:

Multiple air sampling studies performed in proximity to confirmed COVID-19 cases were unable to detect any virus by PCR.[41-47] Santarpia et al. was unable to culture virus from air samples collected outside of patient rooms.[48] Similarly, Binder et al. reported that 3 PCR-positive air samples, collected at distances of 1–3.2 m from patients, were culture negative.[49] Cheng V et al. sampled air at a high flow rate 10 cm from the chin of symptomatic and asymptomatic patients (n=6), with no viable virus detected by culture from collected air samples.[44] One PCR-positive air sample was obtained during an endotracheal intubation within 10 cm of the patient's head in a naturally ventilated room (window open

with fan attached); eleven other air samples near patients and 17 samples outside patient rooms and at nursing stations were PCR-negative.[50]

Lednicky et al. used a prototype and commercial version of an air sampler and custom PCR probes for detection of SARS-CoV-2 in a patient room with two patients. One patient was discharged soon after sampling periods began and after receiving a negative PCR test.[51] The remaining patient began experiencing respiratory illness two days prior to admission to the room. The results of the study include PCR-positive air samples following 3 h of sampling as well attempting viral cultures. Researchers positioned samplers 2–4.8 m from the recently symptomatic patient's head. The ventilation unit provided 6 air changes/h, filtering air and treating air with UV irradiation before recycling the air. Estimates of virus per volume of air ranged from 6–74 tissue culture infective dose $(TCID)_{50}$ units/L of air. More studies quantifying viable virus, with details of the type of ventilation and patient characteristics as reported in this study, are needed to inform the gaps in understanding aerosol transmission.

Another study detected SARS-CoV-2 by PCR in 38.7% (14/31) of air samples from a London hospital in the United Kingdom (UK) during the first peak of their epidemic. However, Zhou et al. did not detect virus by culture, suggesting there may not be adequate virus present in air samples to cause transmission.[52] Another study by Guo et al. detected SARS-CoV-2 by PCR in 35% (14/40) of air samples in an intensive care unit (ICU) and 12.5% (2/16) of air samples in the general ward that manages patients with COVID-19. 15 of 16 PCR-positive air samples were from within 2 m of patients, with 1/8 samples positive at 4 m away.[30] Ben-Shmuel et al. conducted limited sampling (generally one air sample per area) in rooms with ventilated and non-ventilated patients, at a nursing station, and in private and public areas of a quarantine hotel.[53] Positive air samples were detected in a room with a ventilated patient (n=1/1), at a nursing station (n=1/1), and in a quarantine hotel room (n=1/1). However, there were no positive air samples in rooms of non-ventilated patients (n=0/3), a doffing area (n=0/1), and a public area of a quarantine hotel (n=0/1).

Kenarkoohi et al. detected SARS-CoV-2 in 1/5 samples from a ward containing intubated, severely ill patients, but did not find any positive air samples in other areas of the hospital such as wards with suspected, confirmed and mild patients.[54] In a series of distinct room types (two airborne infection isolation rooms [AIIR] with 15+ air changes per hour, an isolation room without negative pressure, and a shared cohort room) for patients admitted within 7 days of symptom onset, Kim et al. reported that 32 air samples were negative and 20 air samples from anterooms were also negative.[55]

Chia et al., in an extended study of Ong et al., detected SARS-CoV-2 RNA by PCR in air samples collected within 1 m of patients in two of three AIIRs.[56] Lei et al. reported limited detection of SARS-CoV-2 virus by air sampling in open wards, private isolation rooms and bathrooms.[57]

Further research is needed to reconcile differences in viral RNA detection and viral viability in air samples, despite positive samples found on the surfaces of ventilation units. Differences may be due to several factors, including: 1) air sampling devices were potentially not capable of maintaining viability of captured virus; 2) timing of air sampling varies by time since onset of symptoms, severity of disease, or viral load; and, 3) the conditions of ventilation (engineering controls) reducing concentrations of viral aerosols to undetectable levels.[49,51,53]

Evidence for long distance spread of SARS-CoV-2 is uncommon:

There were few reports that have identified long distance transmission of SARS-CoV-2. The minimal transmission to fellow passengers seated near individuals with COVID-19 on airplanes does not support an airborne transmission route.[58-60] The airflows in an airplane cabin were modelled in a study

demonstrating how risk of infection may be restricted to certain areas in front and behind an infected passenger.[61]

In one case study, worshippers who were not wearing masks were exposed to a presymptomatic index patient for 100 minutes while on a bus.[62] Twenty-four of 67 worshippers became infected, including several passengers seated beyond 2 m distance. Seven of 172 other worshippers attending the same event were positive for SARS-CoV-2. The bus containing the index patient was heated and air was recirculated without filtration. Infections occurred in individuals at either end of the bus and the index case was located roughly in the middle. Risk of infection was only moderately higher for individuals sitting closer to the index patient. The authors of this study postulate that the poor ventilation in the bus supports aerosols in this large transmission cluster; however, other routes of transmission such as close contact from movement within the bus or fomites could not be excluded.

An investigation by Lu et al. into a COVID-19 outbreak in a restaurant in Guangzhou, China involving three families sitting in close proximity for more than 1 hour concluded that the air conditioning (AC) ventilation likely contributed to transmission.[63] In this scenario, there was between 53–73 min of contact between the presymptomatic index case and secondary cases. The location of a consistently running AC unit (the outlet and exhaust flanked the table of the index case) was in the airflow path of the secondary cases and was in an enclosed environment. No secondary cases occurred at adjacent tables that were outside of the likely "air column." The furthest distance between index and secondary cases was approximately 3 m.

Recent outbreaks with detailed reporting are less likely to be explained completely by droplet or contact routes (Miller et al., Brlek et al.).[64,65] In a choir group, 53 of 60 individuals (excluding the index patient) were confirmed or strongly suspected to have been infected during a 2.5 hour rehearsal in a main hall. Individuals who moved to another area of the building from the index case to practice for 45 min were less likely to have become infected than those who remained in the main hall for the full duration of the rehearsal.[64,65] In another study, infection was documented from exposure in a squash court used by patrons after a recently symptomatic index patient had played for 1 hour. Two sets of patrons using the court after the index patient were also infected (up to 90 min later). Aerosol persistence in a poorly ventilated squash court, re-aerosolization of virus from the squash court floor due to rapid movement of players, or fomite transmission were possible routes of transmission. However, this case investigation strongly supports indirect transmission of SARS-CoV-2, most likely through persistence of aerosols in a poorly ventilated space.

In an outbreak in a nursing home, de Man et al. reported that the outbreak involved 81% (n=17) of residents and 50% (n=17) of health care workers. The authors concluded that AC units and a ventilation system that did not provide adequate air exchanges contributed to the outbreak.[66] However, it should be noted that health care workers did not wear masks during non-patient care activities and the mobility and interaction between residents was not considered.

In a call center in South Korea, half of one floor of the office building experienced an outbreak in 94/216 employees.[67] The outbreak description is limited in providing further detail because the index patient was not known, ventilation parameters were not reported (especially whether air circulation was shared on both sides of the building), and daily mingling habits were not described. A handful of infected individuals were detected on two other floors, but no outbreaks occurred in those areas and the infected individuals could not be linked to the outbreak.

The importance of ventilation is described in a modeling study by Jones, who suggested that exposure to inhalable particles are mostly (80%) experienced within close proximity to the patient.[68] Even in rooms with high air exchanges, Tang et al.'s review of SARS-CoV-2 aerosols indicates that viral RNA copies can still be detected in air samples from patient rooms (1.8–3.4 viral RNA copies/m^3), toilet rooms (19 copies/m^3), and PPE doffing rooms (18–42 copies/m^3).[69]

Airborne Transmission during AGMPs

There were no documented cases of airborne transmission of SARS-CoV-2 during AGMPs in the peer-reviewed literature we examined. We note the lack of transmission in these settings may be due to the appropriate use PPE during AGMPs, with few unprotected close-contact exposures.

Evidence for transmission of SARS-CoV-2 during AGMPs:

There is little evidence demonstrating AGMPs as a contributor to health care worker transmission. In a case-control study involving health care workers, Lentz et al. reported that while AGMPs were not associated with an increased risk of SARS-CoV-2 infection, respirator use during AGMPs lowered the risk of infection (adjusted OR: 0.4; 95% CI: 0.2–0.8; p=0.005).[70]

While airborne transmission does not appear to be the predominant mode of transmission (i.e., such as in households and in routine patient care), medical procedures that generate aerosols may be associated with an increased risk of transmission.[71] During the SARS outbreak in 2003, infections disproportionately occurred among healthcare workers, with those involved in AGMPs and manipulation of the airway (i.e., at the time of intubation) at greatest risk.[72] An investigation into a nosocomial outbreak of SARS in Toronto concluded that the epidemiological links described in their investigation support the hypothesis that SARS-CoV-1 was transmitted primarily through respiratory droplets and direct contact, noting that transmission occurred during high-risk procedures (i.e. intubation) when only a surgical mask was utilized, in the absence of protective eyewear.[73] Infected healthcare workers were no less likely to contract SARS-CoV-1 while wearing an N95 respirator (vs. surgical mask), suggesting that it may have been doffing (taking off) of PPE where transmission occurred.[74] AGMPs do not appear to be a significant risk factor for SARS-CoV-2 transmission among health care workers, potentially related to improved health care worker precautions for AGMPs and/or the lower infectiousness of SARS-CoV-2 in the second week of illness (in contrast to SARS-CoV-1).[70,75-78]

Fecal-oral (Feces, Wastewater) Transmission

While fecal-oral transmission of SARS-CoV-2 is possible, it is unclear the extent to which this transmission route plays in the epidemiology of COVID-19. The evidence supporting fecal-oral transmission was limited.

Researchers have documented angiotensin-converting enzyme 2 (ACE-2; proposed receptor used by SARS-CoV-2 to enter cells) receptor expression in gastrointestinal epithelial cells; SARS-CoV-2 infects these glandular cells, as evidenced by RNA detection and intracellular staining of viral nucleocapsid protein in gastric, duodenal and rectal epithelia.[79] Gastrointestinal symptoms occur in about 9.5% of adults and children with COVID-19.[80] Tissues in the oral cavity express ACE-2 receptors.[81] SARS-CoV-2 RNA and live virus have been detected in the stool of patients with COVID-19. Given detection of infectious virus in stool and that virus can infect via the oral mucosa, fecal-oral transmission is possible.

Evidence for SARS-CoV-2 RNA detection and shedding in feces:

In systematic reviews, the mean prevalence of SARS-CoV-2-RNA-positive stool in patients with COVID-19 ranged from approximately 40% to 50% and viral RNA shedding in stool lasted longer than in nasopharyngeal (NP) swabs. In a systematic review and meta-analysis of 4,243 patients, Cheung et al. reported the prevalence of viral RNA in stool was 48.1% (95% CI: 38.3–57.9).[82] In a meta-analysis by van Doorn et al., the pooled prevalence of viral RNA in stool or anal swabs was 51.8% (95% CI: 43.8%–59.7%); and fecal samples remained positive for a mean duration of 12.5 days after negative NP swabs in 282/433 (64%) of patients who had serial test results for both respiratory and GI specimens.[83] A systematic review by Gupta et al. noted that 53.9% (291/540) of COVID-19 patients had viral RNA-positive fecal samples; duration of fecal shedding ranged from 1 to 33 days after negative NP swabs.[84] Parasa et al. reported on a meta-analysis of 407 patients with COVID-19, where the prevalence of viral RNA-positive stool was 40.5% (95% CI: 27.4–55.1).[85] In a meta-analysis, Wong MC et al. reported a pooled detection rate of viral RNA in fecal samples among patients was 43.7% (95% CI: 32.6–55.0).[86]

In studies detecting viral RNA in various clinical samples other than NP swabs, researchers more commonly detect viral RNA in stool of patients with COVID-19. In a systematic review of 569 patients by Roshandel et al., prevalence of viral RNA was higher in stool (39.5%) than blood (21.3%) and urine (8%).[87] In another systematic review, Morone et al. reported the prevalence of viral RNA-positive stool (48.8%) was higher than positive blood (17.5%) and urine (16.4%) samples; median duration of viral shedding in stool was significantly longer than shedding in respiratory samples (19 days vs. 14 days; $p<0.001$).[88] Comparing viral RNA detection in serum, urine and stool in 74 patients, Kim et al. reported a detection rate of 2.8% (9/323 samples), 0.8% (2/247) and 10.1% (13/129), respectively.[89] The mean viral load was 1,210 ± 1,861, 79 ± 30 and 3,176 ± 7,208 copies/µL, respectively, and no viable virus was detected in cell cultures. In a review, Jones et al. noted that the abundance of viral RNA in urine (10^2–10^5 genome copies [gc]/ml) and feces (10^2–10^7 gc/ml) was lower than in NP swabs (10^5–10^{11} gc/ml).[90]

In a study of 69 children, 86% had viral RNA-positive stool/rectal/anal swabs and the mean duration of viral shedding was 23.6 ± 8.8 days from symptom-onset.[91] In a study of 69 patients with COVID-19, patients with positive fecal samples were significantly younger compared to patients with negative fecal samples (mean age: 43 vs. 52 years; $p=0.003$).[92] Viral shedding in stool persisted for over 3 weeks since symptom-onset and the severity of COVID-19 was not associated with duration of viral shedding in stool.[93,94]

Kang et al. reported on an outbreak of COVID-19 in a high-rise apartment building in Guangzhou, China, where the proposed mode of transmission was through fecal aerosols via the pipes in the building.[95] However, the authors did not demonstrate the exact mode of transmission; i.e., through direct contact or indirectly through inhalation of aerosolized virus or touching contaminated surfaces.

Environmental sampling in health care and non-health care settings detected viral RNA on toilets and other bathroom surfaces.[43,55,96-99] While readily detected, it is not clear if the source of viral RNA in bathrooms was the result of respiratory droplets or from fecal contamination.

Evidence for live SARS-CoV-2 detection in feces:

Live virus has been cultured in stool samples of patients with COVID-19.[100,101] In a systematic review, viable virus was detected in the stool of six out of 17 patients, where culturing of virus was attempted.[83] It is important to note that the authors did not define positive and negative controls in these studies. While researchers detect live virus in feces, the extent of fecal-oral transmission in COVID-19 epidemiology is unclear.

Evidence for SARS-CoV-2 RNA in wastewater:

Viral RNA detection in wastewater systems in areas experiencing outbreaks; however, the risk of transmission through contaminated wastewater is low.[102,103] In a study of treated and raw sewage in Germany, the authors detected viral RNA, but not viable virus.[104] Where wastewater contaminates recreational or drinking water (especially in resource-limited countries), there is a theoretical risk of transmission; however, there is no documented transmission in these settings.[105]

In a study of eight patients with COVID-19 in a densely populated area of Guangzhou, China, the postulated mode of transmission was through the fecal-oral route, initiated from contaminated sewage in street puddles (viral RNA-positive).[106] In this study, there was an increased risk of infection when patients worked as cleaners/waste pickers, wore outdoor shoes inside their homes and cleaned dirty shoes. The authors did not confirm transmission via sewage in this study, as the authors did not detect viable virus from samples and they did not rule out other modes of transmission.

Conjunctival Transmission

To date, there is a low risk of COVID-19 infection through the conjunctiva.

Transmission through the ocular surface is a possible route of transmission of SARS-CoV-2 based on the detection of viral RNA in ocular samples of patients with COVID-19 and indirect evidence that eye protection decreases the risk of infection.[107] The risk of tears or ocular secretions acting as a source of infection is low, given that only one study has successfully cultured viable virus in these samples.

Several studies have demonstrated the expression of ACE-2 and transmembrane serine protease 2 (TMPRSS2) receptors in the eye's surface epithelium (i.e., conjunctiva, limbus and cornea) and corneal endothelium, indicating a potential entry point for SARS-CoV-2.[108-111] The conjunctiva has been proposed as a possible site of initial infection, where it can spread to the upper respiratory tract via the nasolacrimal system.[112] Deng et al. demonstrated that rhesus macaques developed mild disease after inoculation of the conjunctiva, providing further animal-study evidence of conjunctival transmission.[113]

Evidence for conjunctival transmission:

In a case report, Lu et al. described a healthcare worker who became infected after caring for a patient with COVID-19; the health care worker was wearing an N95 respirator, but no eye protection.[114] The health care worker developed eye redness and then pneumonia.

In a study of an ophthalmologist with COVID-19, 142 patients were exposed; however, only a single patient developed symptoms (but PCR negative), indicating the use of face shields, masks and performing hand hygiene prevented infection.[115] In the meta-analysis by Chu et al., eye protection provided significant protection against coronavirus infections (unadjusted RR: 0.34; 95% CI: 0.22–0.52), suggesting that transmission through the conjunctiva was possible.[116]

Fomite (Surfaces, Objects, Food) Transmission

SARS-CoV-2 can survive on a variety of surfaces, potentially leading to transmission via fomites; however, the evidence supporting fomite transmission of COVID-19 was limited and based primarily on studies of virus stability under laboratory-controlled conditions.

Evidence for fomite transmission of SARS-CoV-2:

From a detailed investigation, including whole genome sequencing, into an inter-facility outbreak of up to 135 nosocomial COVID-19 cases (including 88 staff and 47 patients) in South Africa, Lessells et al. concluded that a patient in the emergency department likely spread the infection to at least five hospital units, a local nursing home and an outpatient dialysis unit on campus.[117] Based on the pattern of transmissions, the authors concluded that indirect contact and fomite transmission were the predominant modes of transmission, facilitated by frequent patient movement between wards.

In an epidemiological and environmental study of two family clusters (n=5 patients) of COVID-19 in Guangzhou, China, Xie et al. reported potential transmission via contaminated surfaces.[118] In this case, the proposed link between the two families was through nasal secretions, in which a patient had touched a contaminated elevator button. In this study, other modes of transmission cannot be ruled out and no viable virus was detected on surfaces (only viral RNA detection).

As mentioned previously, transmission in a squash court occurred in players that used the space after it was occupied by the index case for one hour.[65] In this case, there is a possibility of aerosol persistence; however, transmission via fomites is possible (e.g., on high-touch surfaces).

Evidence for SARS-CoV-2 RNA detection on surfaces:

In health care settings, studies documented the presence of viral RNA on high-touch surfaces in the environment of symptomatic and asymptomatic patients with COVID-19 (especially medical equipment, phones, bed rails, door handles and toilets).[41,42,46,47,56,96,119-121] In a hospital in Wuhan, China, Ye et al. reported that the most contaminated surfaces were self-service printers for patient use, keyboards and doorknobs.[122] In Italy, researchers detected viral RNA on the external surface of Continuous Positive Airway Pressure (CPAP) helmets worn by COVID-19 patients; however, samples did not grow in viral culture.[123] A study reported viral RNA on surfaces (keyboards, telephones and scanners) in a clinical microbiology laboratory testing COVID-19-patient respiratory samples.[124] In a multicenter study in South Korea, contamination of surfaces was common, especially in places not adequately sanitized.[55]

Cheng et al. reported that the median load of viral RNA on surfaces was 9.2×10^2 copies/mL (range: 1.1×10^2 to 9.4×10^4 copies/mL) and positivity rates on surfaces increased with increasing viral loads in clinical samples.[96]

In non-healthcare settings (patient homes, work places), viral RNA has also been detected on surfaces (especially in bathrooms and bedrooms).[95,98,125] In a study of 39 patients and 259 environmental samples from their homes (Guangzhou, China), surfaces most commonly contaminated with viral RNA were in the bathroom on high touch surfaces (toilets, door knobs, faucets).[43]

Evidence for the detection of live SARS-CoV-2 on surfaces:

In most of the studies we examined, researchers failed to detect viable virus on surfaces or detection of viable virus was inconsistent.[41,49] Ben-Shmuel et al. investigated the viability of SARS-CoV-2 from 97 samples from surfaces of patients.[53] None of the samples grew in viral culture. In controlled experiments, virus viability on plastic and metal ceased after 4 days at ambient temperature (22°C) and decreases in virus viability negatively correlated with increasing temperature. Nonetheless, some studies indicate that under ideal conditions, SARS-CoV-2 remains viable on surfaces for several days.

Van Doremalen et al. compared surface stability of SARS-CoV-2 and SARS-CoV-1.[38] The authors noted an exponential decay in virus titre for both viruses in all experimental conditions. At 40% relative humidity and 21°C–23°C, both SARS-CoV-2 and SARS-CoV-1 were detectable for up to 24 h on cardboard and up to 2–3 d on plastic and stainless steel. On copper, the authors did not find live SARS-CoV-2 and SARS-CoV-1 after 4 h and 8 h, respectively. The estimated median half-lives for SARS-CoV-2 on these surfaces were 0.7 h for copper, 3.5 h for cardboard, 5.6 h for stainless steel, and 6.8 h for plastic. While the van Doremalen et al. study concluded that fomite transmission is possible given detection of SARS-CoV-2 on a number of surfaces, they did not demonstrate that it occurs.

Riddell et al. tested the stability of SARS-CoV-2 under controlled conditions on seven surface types (stainless steel, plastic, paper bank notes, polymer bank notes, vinyl, cotton and glass).[126] The authors concluded that infectious virus survived on non-porous surfaces for at least 28 d at 20°C and 50% relative humidity in the dark. In addition, virus titres decreased by 90% by 10 d post-inoculation at 20°C on all surfaces.

Chan et al. reported that at room temperature (20°C–25°C), SARS-CoV-2 in dried form or solution remained viable 3–5 d and 7 d, respectively; virus remained viable in solution or dried for 14 d at 4°C and about 1 d at 37°C.[127] SARS-CoV-2 was detected at pH 4 to pH 11 for several days.

Chin et al. investigated the surface stability of SARS-CoV-2 at 22°C and 65% relative humidity.[128] the authors did not detect infectious virus on printing and tissue paper 3 h after inoculation. Infectious virus was no longer present on glass or paper money by day 4 and on day 7 for plastic and stainless steel. The authors state, “The virus is highly stable at 4°C, but sensitive to heat. At 4°C, there was about a 0.7 log-unit reduction of infectious titre on day 14. With the incubation temperature increased to 70°C, the time for virus inactivation was reduced to 5 min. SARS-CoV-2 can be highly stable in favourable environments, but it is also susceptible to standard disinfection methods.”

Evidence for food-borne transmission of SARS-CoV-2:

To date, there is no evidence for food-borne transmission of SARS-CoV-2. No peer-reviewed studies investigated SARS-CoV-2 survival or detection on food and no peer-reviewed studies reported on infection through eating contaminated food. There is likely a risk of transmission from droplet or close contact during eating (from an infectious person); in addition, there is a possibility of fecal-oral transmission during eating with contaminated utensils.

Several studies have identified viral RNA on food preparation surfaces and utensils, which could potentially be a source of infection through the oral mucosa; however, the contribution of this mode of transmission is unknown. In a study of surfaces in health care settings, researchers have detected viral RNA on food preparation areas.[129] Liu et al. reported the detection of viral RNA on wooden chopsticks handled by asymptomatic and presymptomatic patients with COVID-19.[130]

Vertical (Intrauterine) Transmission

To date, there is growing evidence supporting vertical transmission, specifically intrauterine transmission, of SARS-CoV-2; however, the degree to which this mode of transmission occurs is unclear.

In a commentary, Schwartz et al. proposed that confirming vertical, intrauterine transmission requires detection of SARS-CoV-2 in chorionic villous cells using immunohistochemistry or *in situ* hybridization.[131] Early onset of COVID-19 or detection of viral RNA soon after birth in neonates, along with immunological response in neonates and RNA-positive swabs of whole placenta are not sufficient to confirm

intrauterine transmission. In addition, vertical transmission would require the detection of viral RNA in umbilical cord tissue or blood.

Evidence against vertical transmission of SARS-CoV-2:

In five systematic reviews and meta-analyses, ranging from 87 to 1,316 births, there were SARS-CoV-2 RNA-positive newborns but no evidence of vertical transmission.[132-136] In a systematic review of 1,125 mothers and 1,141 newborns, Dhir et al. concluded that the majority of infections in newborns occurred in the post-partum period (41/45; 4 infections were reported as congenital).[137]

In a multicenter observational cohort study of 242 pregnant women in Spain, Marin Gabriel et al. found no evidence of vertical transmission in newborns.[138] Yan et al. reported no vertical transmission in a series of 99 mothers with COVID-19, in which no children (n=100) tested positive.[139] Liu et al. reported no vertical transmission after delivery in 19 mothers with COVID-19; neonates tested negative by PCR (throat swab, urine, feces); amniotic fluid and breast milk also tested negative by PCR.[140]

Evidence for post-partum infection (SARS-CoV-2 RNA not detected in placenta or umbilical cord):

There are several studies where newborns tested positive (viral RNA, antibodies) soon after birth under strict infection control and prevention precautions; however, testing of chorionic villous cells or umbilical cord were negative or not performed.[141-148] In a systematic review of 275 pregnant women with COVID-19 and 246 neonates, the testing of additional samples for viral RNA did not produce positive samples (cord blood, n=30; amniotic fluid, n=24; cervical/vaginal fluids, n=7; placenta, n=6).[149]

Kirtsman et al. reported a case of probable vertical transmission of SARS-CoV-2 in a neonate born to a mother who tested positive for viral RNA by PCR on NP swab and put on airborne, droplet and contact precautions.[150] The baby was born by semi-urgent Caesarean section and placed in a resuscitator 2 m away from the mother. The NP swab was positive for viral RNA at birth and on day 2 and 7. Neonatal plasma was viral RNA-positive on day 4 and on day 7 in stool. However, viral RNA was not detected by PCR on the umbilical cord tissue and cord blood was not available for testing.

Knight et al. report the results from a prospective national population-based cohort study using the UK Obstetric Surveillance System, which included 427 pregnant women admitted to hospital with COVID-19.[151] Twelve (5%) of 265 infants tested positive by PCR for viral RNA, six within 12 h of birth. The authors did not attempt viral detection on the umbilical cord blood, placenta or vaginal secretions and did not describe infection prevention and control practices after birth.

Evidence for vertical transmission of SARS-CoV-2:

Using immunofluorescence, Taglauer et al. examined the location of SARS-CoV-2 spike glycoprotein (CoV2 SP) and two viral entry proteins (ACE-2, TMPRSS2) in placentas of 15 COVID-19-positive mothers and 10 COVID-19-negative mothers.[152] CoV2 SP and ACE-2 were localized in the outer syncytiotrophoblast layer placental villi. However, several other studies report that the expression of ACE-2 and TMPRSSR in the placenta is low.[153,154]

In a systematic review and meta-analysis of 122 neonates, Raschetti et al. reported that 5.7% of infections were confirmed as congenital, 4.9% were probable congenital infections and 1.6% were possible congenital infections.[155]

Patanè et al. found viral RNA on the fetal side of the placenta in two mothers infected with COVID-19.[156] Both children were also positive by PCR from NP swabs taken at birth. Hosier et al. analyzed the

placenta from a woman in her second trimester with symptomatic COVID-19 infection, complicated by preeclampsia and placental abruption.[157] Hosier et al. detected viral RNA predominantly in the syncytiotrophoblast cells at the maternal-fetal interface of the placenta. Additionally, Zhang et al. reported virus in syncytiotrophoblast cells, atrophic endometrial glandular epithelium and subchorionic plate (Langhan's fibrinoid) through *in situ* hybridization (2/53 placentas).[158]

Breastfeeding (Breast Milk) Transmission

Currently, there is no evidence to support mother-to-child transmission of COVID-19 through breast milk. Researchers inconsistently detect SARS-CoV-2 RNA in breast milk, with no evidence of live virus in breast milk. There have been no documented cases where breast milk is the suggested mode of transmission to an infant.

During breastfeeding, an infected mother can transmit COVID-19 to the child through respiratory droplets and close-contact transmission. In a systematic review and meta-analysis, Raschetti et al. reported that close contact of mother and child in the first 72 hours of life increased the risk of infection in the child (aOR: 6.6; 95% CI: 2.6–16.0; p<0.0001), while breastfeeding did not (aOR: 2.2; 95% CI: 0.09–1.18; p=0.15).[155]

In experiments that inoculated breast milk with live SARS-CoV-2, Holder pasteurization inactivated the virus; therefore, suggesting donated breast milk that is pasteurized may be safe for recipient children and care providers.[159]

Evidence for SARS-CoV-2 RNA detection in breast milk:

The majority of the literature agrees that there is no transmission of SARS-CoV-2 through breast milk and the benefits of breastfeeding newborns far outweigh any risks of infection.[160-163] In most studies of mothers with COVID-19, breast milk was negative for viral RNA by PCR.[140,144,164,165] While uncommon, there are case reports of mothers with viral RNA-positive breast milk; however, there were no detections of viable virus from breast milk.[166-168] In a living systematic review, Centeno-Tablante et al. reported that 9 of 68 breast milk samples were viral RNA-positive, but concluded that COVID-19 transmission did not occur through breast milk.[169]

A case report detected viral RNA in the breast milk of a breastfeeding mother with COVID-19.[170] The breastfed child developed symptoms one day after his mother, at which time he tested positive by NP swab. The transmission route in this case could not be established.

Groß et al. report on a study of two women who tested positive for viral RNA by PCR after birth and were breastfeeding.[171] Breast milk was viral RNA-positive in one of the two women at 10–13 days after birth. The authors did not attempt to culture the virus. Both infants tested positive for viral RNA (at day 8 and 11), but it is unknown if breastfeeding led to the infection in one of the infants, as the two women and infants had shared a room for some time after delivery.

Evidence for SARS-CoV-2 antibodies in breast milk:

Antibodies to SARS-CoV-2 have been detected from breast milk. In a study of 14 mothers with COVID-19, Gao et al. did not detect viral RNA in breast milk; however, three out of four mothers had breast milk with IgG and IgM antibodies.[172] In another immunological study of 18 women with COVID-19, both IgG and IgA were detected in all 37 of breast milk samples.[173]

Bloodborne (Blood, Blood Products, Organs) Transmission

While SARS-CoV-2 RNA has been detected in the blood of patients with COVID-19, all systematic reviews and studies indicated that the risk of bloodborne or organ transplant transmission is exceedingly low. Compared to upper respiratory samples, the detection of viral RNA in blood and blood products is relatively uncommon and, to our knowledge, there has been no detection of viable virus from these sources.

Evidence for SARS-CoV-2 RNA detection in blood:

Several studies have reported detection of viral RNA, in either the plasma or serum of patients with COVID-19.[18,93,100,174] In Germany, viral RNA was not detected in whole blood or serum of 18 asymptomatic and symptomatic patients; however, viral RNA (low-level RNA: 179 copies/mL) was detected in the plasma of one patient.[175] In a systematic review including 1,348 recovered patients, 17.5% of blood samples were positive for viral RNA; however, no viable virus was cultured.[88]

Evidence against blood-borne transmission:

Several case reports and case series indicate the risk of SARS-CoV-2 transmission in blood products is exceedingly low.[176,177] In a review, Kiely et al. noted that bloodborne transmission is only a theoretical possibility and that a blood phase for COVID-19 infection is brief, uncommon and usually associated with severe disease.[178] In an immunocompromised child, COVID-19 did not develop after platelet transfusion from an asymptomatic donor with COVID-19.[179] In France, low levels of viral RNA were detected in three blood products (pathogen-reduced platelet concentrate, plasma, red blood cell units) from asymptomatic COVID-19-positive donors; none of the four recipients developed disease even though they all had immune system compromise.[180] In the French study, positive plasma samples did not grow virus in culture attempts. Dres et al. reported no transmission of SARS-CoV-2 through extracorporeal membrane oxygenation and dialysis membranes.[181]

No studies have documented transmission of SARS-CoV-2 through organ transplantation. While research has not demonstrated permanent damage to non-lung organs, the consensus is that active COVID-19 infection in donors (living or deceased) is a contraindication for organ donation.[182,183] Hong et al. reported a possible infection in a liver donor recipient, in which the donor was infected at time of donation; however, transmission may have been through direct close contact.[184]

Sexual (Semen, Vaginal Secretions, Urine) Transmission

Sexual transmission may occur through direct contact and through respiratory droplets. The risk of transmission via semen or vaginal secretions is low and the evidence supporting transmission via semen or vaginal secretions was limited.

Based on viral detection in feces, some have proposed possible transmission of SARS-CoV-2 through certain sexual behaviours involving oral-anal contact.[185] In addition, the detection of viral RNA and live virus detected in the saliva of COVID-19 patients represents a potential mode of transmission during sex or intimate contact.[186,187] Jing et al. reviewed the literature on ACE-2 expression in the female reproductive system and noted expression of ACE-2 receptors in the vagina.[188] ACE-2 receptors are also present in testes (i.e., spermatogonia, Leydig and Sertoli cells).[189] While receptors for SARS-CoV-2 are present in reproductive organs, currently there is no evidence for sexual transmission. There was no evidence for the detection of live virus in semen or vaginal secretions.

Evidence for SARS-CoV-2 RNA detection in semen and vaginal secretions:

To date, most studies have failed to detect viral RNA in semen or vaginal secretions in patients with COVID-19 patients.[166,172,190] In a study of 23 male patients with active infection or recovering from infection, Guo et al. did not detect viral RNA in semen samples.[191] Similarly, a study of nine males recovering from mild COVID-19 infection did not show evidence of viral shedding in semen.[192]

Li et al. reported that 15.8% (6/38) of male COVID-19 patients had viral RNA present in their semen. The authors collected semen samples from two clinically recovered patients and four patients at the acute stage of infection.[193] In the Li et al. study, the authors detected viral RNA up to 16 d after the onset of symptoms. Massarotti et al. hypothesized that viral RNA detections in semen are due to viral RNA-contamination by patient urine.[194]

Evidence for SARS-CoV-2 RNA detection in urine:

Researchers report detection of viral RNA in urine; however, the risk of transmission via urine is low. We are only aware of one instance where infectious virus was isolated from the urine of a patient with COVID-19.[195]

In a systematic review and meta-analysis, Roshandel et al. reported that 8.1% of (46/569; see Table 3 in paper) patients showed viral RNA shedding in urine (compared to 42.1% [210/499] for stool and 21.3% [100/469] for stool; see Figure 2 in paper) and viral RNA shedding in urine increases with disease severity.[87] In a systematic review, 16.4% (60/366) of patients were positive for viral RNA in urine.[88] In another systematic review of 549 patients, 6.9% showed evidence of viral RNA in their urine; however, culturing attempts were not successful.[196] In a study of 74 patients hospitalized with COVID-19, Kim et al. found that 0.8% (2/247) of urine samples were positive for viral RNA (viral load: 79 ± 30 copy/µL; compared to 3,176 ± 7,208 copy/µL in stool); however, no viable virus was cultured.[197]

Zoonotic transmission

Evidence for zoonotic transmission from companion, domestic and wild animals to humans was limited. Most of the evidence to date indicated that non-human animals are more at risk of infection from humans, especially companion and domestic animals.[198] Further research is needed to identify potential reservoirs of SARS-CoV-2 and what risk they pose to humans and animals.

Early research revealed SARS-CoV-2 is a close relative of SARS-CoV-1 and MERS-CoV, and all are βCoVs that originated from bats (*Rhinolophus* species).[199,200] Natural infection of animals with SARS-CoV-2, were all exposed to symptomatic humans. Infected animals include companion animals (domestic dogs [*Canis lupus*], domestic cats [*Felis catus*], farmed animals (American mink [*Neovison vison*], and zoo animals (lions [*Panthera leo*], tigers [*Panthera tigris*]).[201-203]

Evidence for animal-to-human and animal-to-animal transmission:

Currently, the intermediate source of the initial COVID-19 infections in humans is unknown and the risk of transmission from animals to humans is low.

Malayan pangolins (*Manis javanica*) have been postulated as the intermediate host based on the presence of viruses closely related to SARS-CoV-2; however, this hypothesis has not been confirmed.[204-206] Recently, Freuling et al. reported that raccoon dogs (*Nyctereutes procyonoides*) are susceptible to SARS-CoV-2 infection and may represent an important intermediate and reservoir host.[207] Authors in

this study infected raccoon dogs through the intranasal route, which led to animal-to-animal transmission through direct contact, with high-level viral shedding with mild disease. Raccoon dogs are widespread in China and raised for their fur. It is important to note that there are no reports of SARS-CoV-2 natural infection in raccoon dogs.

In the Netherlands, there was evidence that COVID-19 transmission occurred from an infectious American mink to human.[208] It should be noted that in most circumstances, transmission of SARS-CoV-2 involving animals is human-to-animal or animal-to-animal.[203] In a laboratory experiment, ferrets can transmit the virus to other ferrets through respiratory droplets and direct contact,[209] and potentially via small aerosols.[210]

In a laboratory experiment, dogs and cats were susceptible to COVID-19; however, neither developed clinical disease.[203,211] Cats transmitted the virus to other cats through close contact. Cats shed virus for 5 days post infection; however, there was no viral shedding in dogs. Authors noted oral and nasal viral shedding 7 days after exposure in two in-contact cats. Therefore, there is a possibility that transmission could occur from cats to humans. In addition, Shi et al. reported that experimental exposure in cats resulted in subclinical and symptomatic infections, and juvenile cats were at a higher risk of severe infection or death.[212]

Evidence for human-to-animal transmission (reverse zoonosis):

The first documented instance of human-to-animal transmission occurred between an infected person in Hong Kong and their companion dog, soon after there was a report of human-to-cat transmission in Hong Kong.[205] There is evidence that human-to-dog transmission may be limited due to cross-reaction of SARS-CoV-2 and canine respiratory coronavirus (CRCoV), providing some immunological cross-protection.[213] The most commonly reported human-to-animal transmission has involved domestic cats, where most cats have a reported close contact with a confirmed human case of COVID-19.[203,214] In Wuhan, China, 14.7% (15/102) of cats seroconverted to SARS-CoV-2 early during the pandemic.[215]

Several researchers have highlighted the need to monitor wild animals, to ensure that reverse zoonosis does not occur (human-to-animal transmission). Olival et al. reported that there is a risk of immunologically naïve North American bats acquiring SARS-CoV-2.[216] Researchers also demonstrated that deer mice (*Peromyscus maniculatus*) are susceptible to infection and are potential reservoirs of SARS-CoV-2 in North America.[217]

To date, laboratory studies indicate that domestic ducks (*Anas platyrhynchos domesticus*), chickens (*Gallus gallus domesticus*) and pigs (*Sus scrofa*) were not susceptible to SARS-CoV-2.[212,218]

Other susceptible animals, used in laboratory experiments or as animal models, include ferrets (*Mustela putorius*), fruit bats (*Rousettus aegyptiacus*), rhesus monkeys (*Macaca mulatta*) and Syrian hamsters (*Mesocricetus auratus*).[212,219]

Conclusions

Transmission of SARS-CoV-2 occurs predominantly through respiratory droplets during close (<2 m), unprotected contact. Airborne transmission over longer distances (>2 m) through the inhalation of small respiratory droplets or aerosols is less common, but possible under certain conditions such as prolonged exposure in a poorly ventilated space.

Relatively uncommon routes of transmission of SARS-CoV-2 include conjunctival, vertical, fecal-oral, fomite and zoonotic. These routes of transmission are possible; however, their contribution to COVID-19 epidemiology is unclear. While modes of transmission such as through semen, breast milk or urine are theoretically possible, the probability of these occurring is exceedingly low.

PHO will continue to monitor the scientific evidence on transmission routes of COVID-19, updating this document as necessary.

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Appendix A. Glossary of Terms for COVID-19 Routes of Transmission

Advisory

The glossary below contains definitions that may be changing with the understanding of evidence. Definitions may be different from how the same terms are used in other contexts or even seen as controversial due to different use within the same context by different organizations. Therefore, these definitions are provided to support the understanding of the COVID-19 – What We Know So Far About… Routes of Transmission document. This glossary is not exhaustive and may be updated with new terms or revised at any time.

Key Terms

Airborne transmission: Transmission of infection occurring due to the inhalation of aerosols that have remained suspended for a long period of time or have been suspended on air currents over long distances.

Air sampling for virus: Collection of volumes of air by a device to determine if aerosols may contain virus. Collection can vary by aerodynamic size captured, duration of collection, volume per second collected, and media on which samples deposit. Air samples can then be tested by molecular methods and/or viral culture.

Aerosol: Aerosols are defined by National Institute for Occupational Safety and Health (NIOSH) as a suspension of particles (solids) or droplets (liquids) in the air.[1] The diameter of microorganism-containing aerosols relevant to inhalation ranges from 0.01 to 100 µm. Discussion of respiratory infections focus on droplets rather than particles because the sources of infectious aerosols are assumed to be from respiratory mucosa or epithelium, which will be droplets (liquids) that contain infectious biological material. Droplets >100um are too large to be suspended in the air, and are therefore not considered aerosols.[2] Droplets generally lose mass while suspended in air as aerosols due to evaporation of volatile components or water. The droplets that result from the process of evaporation are often referred to as droplet nuclei. The final size of a droplet will depend on a variety of environmental factors.

Aerosol generating medical procedures: Aerosol generating medical procedures (AGMPs) are defined as medical procedures that result in the production of aerosols that create the potential for airborne transmission of infections that may otherwise only be transmissible by the droplet route, and are epidemiologically associated with an increased risk of acquisition of infection.[3]

Contact transmission: Transmission of infection through direct contact.

Direct transmission: Transmission of infection through contact or droplet transmission.

Droplet transmission: Transmission of infection occurring due to impaction of large droplets (usually >100 um) that are too large to be suspended in air for long durations. Infection may follow by direct impaction onto mucosal surfaces (mouth, eyes, nose), or contaminate a person's body/clothing which then makes direct or indirect contact with susceptible surfaces (e.g., mucosal surfaces for COVID-19).

Indirect transmission: Includes any mode of transmission where direct contact or droplet transmission is not involved (e.g., fomite transmission, airborne transmission, and vectors).

Fomite/Fomite transmission: Objects that may become contaminated with microorganisms and serve as vehicles of transmission.[4]

Polymerase Chain Reaction (PCR): A molecular method used to amplify nucleic acids. If nucleic acids of the microorganism of interest is present in a sample, then PCR can be used for the identification of that microorganism. This method cannot determine whether or not the microorganisms detected are viable.

Viral culture: Viral culture is used to determine whether a sample containing virus is capable of replication. Replication is a surrogate measure for inducing infection. Other methods to detect virus in a sample such as PCR cannot determine the viability of the organism in the sample. A sample is applied to a susceptible culture of cells and incubated up to a few weeks to detect morphological changes such as plaques that would indicate the presence of a viable virus.

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Appendix B. MEDLINE Search Strategy

Search results reporting

DATABASES SEARCHED

Database	Date searched	Records	Duplicates removed by database	Remaining
MEDLINE	10/14/2020	2641	330	2311

RECORDS TOTALS

Records source	Records
Records identified through database searching	2641
Duplicates removed by database	330
Duplicates removed by bibliographic management software	11
Total records after duplicates removed	2300

Search strategies

MEDLINE

Ovid MEDLINE(R) ALL <1946 to May 29, 2020>

#	Searches	Results	Concept
1	("2019 corona virus" or "2019 coronavirus" or "2019 ncov" or "corona virus 19" or "corona virus 2019" or "corona virus 2019" or "corona virus disease 19" or "corona virus disease 2019" or "corona virus epidemic*" or "corona virus outbreak*" or "corona virus pandemic*" or "coronavirus 19" or "coronavirus 2019" or "coronavirus 2019" or "coronavirus disease 19" or "coronavirus disease 2019" or "coronavirus epidemic*" or "coronavirus outbreak*" or "coronavirus pandemic*" or "covid 19" or "covid 2019" or "new corona virus" or "new coronavirus" or "novel corona virus" or "novel coronavirus" or "novel human coronavirus" or "sars coronavirus 2" or "sars cov 2" or "sars cov2" or "sars like coronavirus" or "severe acute respiratory syndrome corona virus 2" or "severe acute respiratory syndrome coronavirus 2" or "severe specific contagious pneumonia" or "wuhan corona virus" or "wuhan coronavirus" or 2019ncov or covid19 or covid2019 or ncov or sarscov2 or ((novel or Wuhan or China or Chinese or "seafood	69649	COVID-19

#	Searches	Results	Concept
	market" or "2019" or outbreak* or epidemic* or pandemic*) adj5 (coronavirus* or "corona virus*" or betacoronavirus* or "beta coronavirus*" or "beta corona virus*" or pneumonia* or SARS or "severe acute respiratory syndrome")) or ((coronavirus* or "corona virus*" or betacoronavirus* or "beta coronavirus*" or "beta corona virus*" or SARS or "severe acute respiratory syndrome") adj5 pneumonia*) or "coronavirus response" or "corona virus response").kf,kw,ti.		
2	Disease Transmission, Infectious/ or Virus Shedding/ or tm.fs. or (transmi* or spread* or infectivity or (infect* adj3 route*) or excret* or shed*).kf,kw,ti. or (transmi* or spread* or infectivity or (infect* adj3 route*) or excret* or shed*).ab. /freq=2	493440	Transmission
3	(route* or mode or modes or "non-respiratory" or nonrespiratory or (transmission adj3 (dynamics or risk or potential))).kf,kw,ti.	92893	Route
4	Bodily Secretions/ or Body Fluids/ or Sneezing/ or Cough/ or (droplet* or ((body or bodies or lung* or mouth* or nose*) adj3 (fluid* or secretion* or secrete or discharge*)) or cough* or sneez*).kf,kw,ti.	74516	Droplet
5	exp Parents/ or Family/ or Grandparents/ or Housing/ or Public Housing/ or Siblings/ or Spouses/ or ("close contact*" or "communal living" or "direct contact*" or "flat mate*" or "personal residence*" or "physical contact*" or accommodation* or apartment* or brother* or cohabit* or "co-habit*" or coliving or "co-living" or commune or communes or condo* or contacts or domicile* or dwelling* or familial or family or families or father* or flatmate* or grandparent* or ((home or homes) not "stay at home order*") or hous* or husband* or intrafamilial or mother* or parent or parents or relatives or roommate* or "room mate*" or sibling* or sister* or spouse* or wife or wives).kf,kw,ti.	688458	Contact
6	Conjunctiva/ or Conjunctivitis, Viral/ or Conjunctivitis/ or Eye/ or Tears/ or (conjunctiv* or eye or eyes or ocular or tear or tears).kf,kw,ti.	212437	Conjunctiva
7	Air/ or Air Microbiology/ or Air Pollution, Indoor/ or Inhalation Exposure/ or Exhalation/ or Air Ambulances/ or Aircraft/ or Ventilation/ or (air or airborne* or aircraft* or airplane* or ((building* or room* or office*) adj3 circulat*) or exhal* or flight or flights or HVAC or inhal* or plane or planes or vent or vents or "ventilation system*" or duct*).kf,kw,ti.	282916	Airborne
8	Aerosols/ or ((Disease Transmission, Infectious/ or Coronavirus Infections/tm or Pneumonia, Viral/tm) and (Intubation/ or Intubation, Intratracheal/ or Cardiopulmonary Resuscitation/ or Suction/ or Bronchoscopy/ or exp Surgical Procedures, Operative/ or surgery.fs. or Autopsy/ or Sputum/ or exp Positive-Pressure Respiration/ or Oxygen Inhalation Therapy/)) or aerosol*.kf,kw,ti. or ((transmi* or spread* or infect*) and (nebuliz* or nebulis* or intubat* or ((cardiopulmonary or "cardio-pulmonary") adj3	59726	Aerosol-Generating Procedures

#	Searches	Results	Concept
	resuscitation) or bronchoscopy or surgery or surgical or autops* or (sputum adj3 induc*) or (high adj3 oxygen adj3 therapy) or "positive pressure ventilation" or "positive pressure respiration")).kf,kw,ti.		
9	Fomites/ or Health Facility Environment/ or Patients' Rooms/ or Disease Reservoirs/ or exp Textiles/ or Clothing/ or Glass/ or Plastics/ or Metals/ or Cell Phone/ or Computers, Handheld/ or Smartphone/ or fomite*.kf,kw,ti. or (surface or surfaces).ti. or ((clean* or colonis* or coloniz* or contamina* or decay* or decontaminat* or detect* or disinfect* or distribut* or expos* or grow* or harbor* or harbour* or inactivat* or "infection control" or persist* or sanit* or stabilit* or surviv* or viab*) adj15 (bathroom* or bed* or carpet* or chair* or cloth* or counter or counters or curtain* or "door handle*" or "door knob*" or doorknob* or environment* or equipment or fabric* or faucet* or fixture* or floor* or furnish* or furniture* or glass* or gown* or handrail* or "hand rail*" or ipad* or iphone* or keyboard* or keypad* or "key pad*" or "light switch*" or linen* or material* or mattress* or metal* or phone* or plastic* or railing or railings or reservoir* or sink* or smartphone* or surface or surfaces or telephone* or textile* or tile* or toilet* or "touch screen*" or upholster* or wall* or washroom*)).kf,kw,ti.	400853	Fomites
10	Feces/ or Diarrhea/ or exp Gastrointestinal Diseases/ or (fecal or faecal or feces or stool or stools or diarrhea or diarrhoea or enterocolitis or gastrointestin* or gastroenter*).kf,kw,ti.	1125779	Fecal-Oral
11	Blood-Borne Pathogens/ or Blood Safety/ or bl.fs. or (bloodborne or blood or BBI).kf,kw,ti.	2190148	Bloodborne
12	Sexually Transmitted Diseases/ or Sexually Transmitted Diseases, Viral/ or Semen/ or Semen Analysis/ or Vaginal Discharge/ or Vaginal Smears/ or (sexual* or semen or vagina*).kf,kw,ti.	213704	Sexual Transmission
13	Amniotic Fluid/ or Breast Feeding/ or exp Delivery, Obstetric/ or exp Parturition/ or exp Pregnancy/ or Fetal Blood/ or Fetus/ or Infant, Newborn/ or Infectious Disease Transmission, Vertical/ or Maternal Exposure/ or Maternal-Fetal Exchange/ or Milk, Human/ or Peripartum Period/ or Postpartum Period/ or Pregnancy Complications, Infectious/ or Pregnancy Complications/ or Pregnancy Outcome/ or Pregnancy, High-Risk/ or Pregnant Women/ or ("amniotic fluid" or "breast feeding" or "breast milk" or "cord blood" or "fetal blood" or "human milk" or "in utero" or ((infant* or baby or babies) and mother*) or birth* or breastfeeding or breastmilk or fetal or fetus or foetal or foetus or gestation* or gestation* or infant* or intrapartum or intrauterine or maternal* or mother* or natal* or neonat* or newborn* or obstetric* or parturition or perinatal* or placenta* or placenta* or postnatal* or postpartum* or pregnan* or prenatal* or puerperal*	1928571	Vertical Transmission

#	Searches	Results	Concept
	or reproductive or transplacental or trans-placental or transuterine or trans-uterine or uter* or vertical).kf,kw,ti.		
14	1 and 2 and 3	296	
15	1 and 2 and 4	165	
16	1 and 2 and 5	356	
17	1 and 2 and 6	123	
18	1 and 2 and 7	318	
19	1 and 2 and 8	886	
20	1 and 9	550	
21	1 and 2 and 10	285	
22	1 and 2 and 11	141	
23	1 and 2 and 12	60	
24	1 and 2 and 13	590	
25	14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24	3063	
26	("2019 corona virus" or "2019 coronavirus" or "2019 ncov" or "corona virus 19" or "corona virus 2019" or "corona virus 2019" or "corona virus disease 19" or "corona virus disease 2019" or "corona virus epidemic*" or "corona virus outbreak*" or "corona virus pandemic*" or "coronavirus 19" or "coronavirus 2019" or "coronavirus 2019" or "coronavirus disease 19" or "coronavirus disease 2019" or "coronavirus epidemic*" or "coronavirus outbreak*" or "coronavirus pandemic*" or "covid 19" or "covid 2019" or "new corona virus" or "new coronavirus" or "novel corona virus" or "novel coronavirus" or "novel human coronavirus" or "sars coronavirus 2" or "sars cov 2" or "sars cov2" or "sars like coronavirus" or "severe acute respiratory syndrome corona virus 2" or "severe acute respiratory syndrome coronavirus 2" or "severe specific contagious pneumonia" or "wuhan corona virus" or "wuhan coronavirus" or 2019ncov or covid19 or covid2019 or ncov or sarscov2 or ((novel or Wuhan or China or Chinese or "seafood market" or "2019" or outbreak* or epidemic* or pandemic*) adj5 (coronavirus* or "corona virus*" or betacoronavirus* or "beta coronavirus*" or "beta corona virus*" or pneumonia* or SARS or "severe acute respiratory syndrome")) or ((coronavirus* or "corona virus*" or betacoronavirus* or "beta coronavirus*" or "beta corona virus*" or SARS or "severe acute respiratory syndrome") adj5 pneumonia*) or "coronavirus response" or "corona virus response").ti.	66947	COVID-19 (focused, title only)
27	*Disease Transmission, Infectious/ or *Virus Shedding/ or *Coronavirus Infections/tm or *Pneumonia, Viral/tm or (transmi* or spread* or (infect* and route*) or excret* or shed*).ti.	183017	Transmission (focused, title only)
28	26 and 27	2994	
29	25 or 28	4832	
30	limit 29 to yr="2020 -Current"	4642	
31	limit 30 to English	4539	
32	(202006* or 202007* or 202008* or 202009* or 202010*).ez.	585088	

#	Searches	Results	Concept
33	31 and 32	2802	
34	limit 33 to (comment or editorial or news)	161	
35	33 not 34	2641	
36	remove duplicates from 35	2311	

Citation

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Ontario

This is **"Exhibit F"**
to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022

A Commissioner, etc.

Public Health Ontario | Santé publique Ontario

SYNTHESIS

20/05/21

COVID-19 Transmission Through Large Respiratory Droplets and Aerosols… What We Know So Far

Introduction

Public Health Ontario (PHO) is actively monitoring, reviewing and assessing relevant information related to Coronavirus Disease 2019 (COVID-19). "What We Know So Far" documents provide a rapid review of the evidence on a specific aspect or emerging issue related to COVID-19. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is transmitted in different ways; however, this document will focus on transmission by respiratory droplets and aerosols.

Key Findings

- The historical dichotomy of droplet versus airborne transmission, while useful in implementing infection prevention and control (IPAC) strategies, does not accurately recognize the complexity of viral respiratory transmission, including for SARS-CoV-2.
- SARS-CoV-2 is transmitted most frequently and easily at short range through exposure to respiratory particles that range in size from large droplets which fall quickly to the ground to smaller droplets, known as aerosols, which can remain suspended in the air.
- There is evidence to suggest long-range transmission can occur under the right set of favourable conditions, implicating aerosols in transmission.
- The relative role of large respiratory droplets versus smaller droplet particles in short-range transmission is challenging to quantify. Their contributions to a specific case-contact interaction vary based on contextual factors including source/receptor characteristics (e.g., forceful expulsions such as singing, coughing, sneezing; viral load) and pathway characteristics (e.g., duration of exposure; environmental conditions such as ventilation, temperature, humidity, ultraviolet light; source control; and use of personal protective equipment).
- Translation of this summary into control measures needs to take into consideration other information, such as evidence around the effectiveness of control measures to date. Several control measures applied together in a layered approach are likely to be effective irrespective of the relative contribution of droplets or aerosols, including achieving high vaccination coverage and avoiding the "3 C's" (closed spaces, crowded places and close contact).

Background

The diameter of microorganism-containing respiratory particles relevant for respiratory infections ranges from approximately 0.01 micrometres (µm) to greater than 100 µm.[1] Particles larger than about 100 µm play a role in respiratory infection transmission by impacting on mucosal surfaces, such as the nostrils, mouth and eyes. Particles smaller than 100 µm can be inhaled or impact on mucosal surfaces. Some particles are small enough that they can be suspended in the air for various periods of time (known as aerosols).[2] Environmental factors such as local air currents and humidity affect these particles, e.g., how they move, evaporate, and how long they remain in air.[3] Therefore, the mode of transmission is influenced by three key elements: the source, the pathway, and the receptor. Depending on the unique characteristics of each element, certain modes may be more likely than others.

Traditionally, respiratory particles >5 or 10 µm have been termed droplets and were thought to impact directly on mucous membranes, while smaller particles were thought to be inhaled. This dichotomy of transmission routes has been applied to infection prevention controls within health care settings worldwide. However, these transmission routes are not mutually exclusive as droplets well over 5 µm are capable of remaining suspended in air for some time and can be inhaled. At short range within about 2 metres (m), infection can occur from inhaled aerosols as well as droplets landing on mucous membranes (short-range transmission). Herein, we refer to what was traditionally called airborne transmission via inhalation of aerosols that have remained suspended over long distances and periods of time[4,5] as long-range transmission.

We describe transmission through epidemiological studies, experimental or simulation of transmission studies, and statistical or mathematical modelling. Modelling shows what is possible, experimental studies what is plausible, and epidemiologic studies observe what is actually occurring, and each type of evidence is subject to limitations. However, exact routes of SARS-CoV-2 transmission in real-life scenarios can only be inferred based on the available data.

The purpose of this rapid review is to outline the evidence for droplets and aerosols in SARS-CoV-2 transmission. We have summarized the evidence as either short-range transmission from large respiratory droplets and small droplets or aerosols, or long-range transmission from aerosols.

Methods and Scope

In considering feasibility, scope and timelines, we undertook a rapid review to update our summary of SARS-CoV-2 transmission from large respiratory droplets and aerosols. A rapid review is a knowledge synthesis where certain steps of the systematic review process are omitted in order to be timely (e.g., duplicate screening).[6]

We conducted literature searches in MEDLINE (April 22, 2021) and National Institutes of Health COVID-19 Portfolio (Preprints) (April 27, 2021), search strategies are available upon request. We searched PubMed and Google Scholar on April 28, 2021 for additional articles of interest.

English-language peer-reviewed and non-peer-reviewed records that described large respiratory droplet and aerosol routes of transmission of COVID-19 were included. We restricted the search to articles published after January 1, 2020. This rapid review concentrated on evidence from systematic reviews and meta-analyses, supplemented by primary literature where appropriate. We reviewed citations from included articles to identify additional research.

Prior to publishing, PHO subject-matter experts review all What We Know So Far documents. As the scientific evidence is expanding rapidly, the information provided in this document is only current as of the date of respective literature searches.

Out-of-scope for this document was a review of IPAC practices appropriate for individual transmission scenarios and settings. Application of a hierarchy of control measures for non-health care settings is briefly discussed in the conclusions. For additional information related to IPAC in health care settings, please see PHO's technical briefing *IPAC Recommendations for Use of Personal Protective Equipment for Care of Individuals with Suspect or Confirmed COVID-19* and *Interim Guidance for Infection Prevention and Control of SARS-CoV-2 Variants of Concern for Health Care Settings*.[7,8] Please note that the *Ministry of Health's Directive 1* is the provincial baseline standard for provision of personal protective equipment for hospitals, long-term care homes and retirement homes and that the *Ministry of Health's Directive 5* provides agency to health care workers to make professional decisions regarding the appropriate personal protective equipment when dealing with suspected, probable or confirmed COVID-19 patients or residents.[9,10] Evidence for contact/fomite transmission, and virus and host (source/receptor) factors were not reviewed in this document, but are acknowledged as contributors to short- and long-range transmission. Other routes of transmission are reviewed in PHO's synthesis *COVID-19 Routes of Transmission – What We Know So Far*.[11]

Short-range Transmission

Main Findings

SARS-CoV-2 is transmitted most frequently and easily at short range. Short-range transmission generally occurs within 2 m of an infectious individual (e.g., during a conversation with inadequate distancing, no barriers, no personal protective equipment). Theoretically, short-range transmission may occur due to droplets or aerosols, but the relative contribution of either is specific to each case-contact interaction which varies based on contextual factors including source/receptor and pathway characteristics.

Environmental Factors Affecting Short-range Droplets and Aerosols

In addition to virus and host factors, environmental factors are associated with short-range viral transmission. The distance travelled by large respiratory droplets is generally <2 m, although it can reach up to 8 m in certain circumstances. In a study by Guo et al. (2020), SARS-CoV-2 virus was detected on the floor up to 4 m away from a patient.[12] In a systematic review of studies assessing the horizontal distance travelled by respiratory droplets, Bahl et al. (2020) reported that droplets could travel up to 8 m.[13] In a mathematical model, Chen et al. (2021) reported that respiratory droplets >100 µm in diameter are only important in transmission at a distance of less than 0.2 m when the infector is talking, or within 0.5 m when the infector is coughing.[14] Modelling by Wang et al. (2021) (preprint) suggested droplets >100 µm would most often not travel past 1.75 m (most droplets >100 µm diameter settle before 1.25 m).[15]

In a review of respiratory virus transmission, Leung (2021) reported that environmental factors affecting transmission include temperature, relative humidity, ventilation, airflow and ultraviolet (UV) light.[16] Ventilation, airflow and forceful expulsion (sneezing or coughing) can make respiratory particles travel further than 2 m through momentum.[14,17] High temperature and low humidity contributes to shrinking of droplets such that they may remain suspended in air for longer periods of time.[18]

Even at short-range distances, ventilation may affect transmission. De Oliveira et al. (2021) modelled infection risk in ventilated (10 air changes per hour [ACH]) and unventilated spaces without respiratory protection during a 1-hour exposure at 2-m distance.[19] The impact of decreasing concentration of virus in the air through ventilation was notable. Estimates of infection risk were reduced by at least three times based on the parameters and assumptions of their model. The authors also commented that the direction of airflow can have a significant impact – upward air streams can maintain aerosols at face height significantly increasing infectious risk.

Indoor settings are a predominant risk factor for transmission. In a systematic review of 5 studies, Bulfone et al. (2020) reported that the odds of indoor transmission were 18.7 times (95% confidence interval [CI]: 6.0–57.9) higher than outdoor settings, and less than 10% of infections occurred outdoors.[20] Very few superspreading events have been described from exclusively outdoor exposures. The explanation for this observation is likely multifactorial which includes important differences in ventilation, UV light, humidity, as well as possible differences in behaviour.

Epidemiological and Modelling Studies Describing Short-range Transmission

The following section reviews the epidemiologic and modelling evidence supporting short-range transmission of COVID-19. It reviews the reproductive number and summarizes the epidemiological and modelling studies by setting, including transportation, health care and sports.

The reproductive number (R_0) of SARS-CoV-2 is less suggestive of long-range transmission commonly occurring, as viruses where long-range transmission commonly occurs tend to have a higher R_0.[16] For example, in a systematic review by Guerra et al. (2017), the R_0 for the measles virus in the pre-vaccine era was 6.1–27.0,[21] compared to the median range of R_0 (2.7–3.3) reported for SARS-CoV-2.[22] It is important to note that R_0 is not a direct measure or indication of transmission route, as R_0 can be setting and population-specific, and be impacted by factors such human behaviours. The R_0 for SARS-CoV-2 also displays overdispersion, where the overall R_0 is lower than pathogens that commonly transmit through aerosols at long-range, but a small proportion of cases are associated with reproductive numbers in the range typical of viruses that commonly transmit through aerosols at long-range (i.e., superspreader events).[23] Such cases illustrate the potential variability in COVID-19 transmission, depending on differences in source/receptor characteristics and environment.

Short-range transmission was favoured in a retrospective cohort study of 18 short-to-medium haul flights (median flight time 115 minutes) to England from the beginning of the pandemic.[24] The attack rate was 0.2% (95% confidence interval [CI]: 0.1–0.5) for all aircraft-acquired cases, and was higher at 3.8% (95% CI: 1.3–10.6) if a subgroup analysis was performed only on contacts within a two-seat radius. It was assumed that no masks were worn given that it was early in the pandemic.

Family gatherings for meals are high-risk scenarios for transmission. Lo Menzo et al. (2021) reported transmission of lineage B.1.1.7 variant of concern to 8 of 9 family members during a dinner gathering.[25] The only uninfected family member was presumed to have immunity acquired from a previous infection (high antibody titres and polymerase chain reaction (PCR) negative result). Contact and fomite transmission cannot be excluded from this type of event.

In a case-control study of 154 patients 18 years and older in the United States (US), Fisher et al. (2020) reported that close contact with a person with COVID-19 was reported more often among cases (42.2%) than controls (14.5%) ($p<0.01$).[26]

Short-range transmission has been documented in school settings. Four student-to-student and one student-to-teacher transmission events were reported in Salt Lake County, Utah.[27] For four transmission events, unprotected, short-range exposures were noted. There was a lack of transmission to other students that were a median of 1 m away during class, but adhered to control measures implemented in the school. However, when household transmission associated with the secondary cases was evaluated, transmission was high for 3 of the 5 households of secondary patients. In these three households, 6 of 8 household members were also infected and may be related to challenges with physical distancing, masking, and shared surfaces in the household.

Using whole genome sequencing of SARS-CoV-2 clinical samples (n=50) in Dublin, Ireland, Lucey et al. (2020) investigated cases of hospital-acquired COVID-19 and reported that the majority of infections were among patients who required extensive and prolonged care by health care providers.[28] The authors concluded that the likely mode of transmission from health care workers to patients was through short-range transmission and close contact, rather than long-range transmission. Notably, the use of masks by health care providers was not universal and patients were not wearing masks either.

Three short-range health care-associated transmission events have been reported where large respiratory droplet transmission was less likely because masks were worn by either the source or the contact and in two of three events, the contact was also wearing eye protection.[29] In case 1, an asymptomatic, unmasked patient transmitted infection to two health care workers who wore medical masks and face shields, following multiple hours of exposure in a room with 6 ACH. A second case occurred where a presymptomatic masked health care worker transmitted infection to an unmasked patient in a room with 6 ACH. A third case involved a presymptomatic masked patient transmitting infection to a health care worker who was wearing a mask and goggles during a 45 minute face-to-face discussion at 1 m. Notably in the third case, the patient's mask was removed temporarily for oropharynx inspection. While each case was verified by whole genome sequencing, there was a lack of detail about the specific encounters (e.g., distance, duration, if direct contact occurred, if doffing errors occurred), and no airflow studies were conducted.

An analysis of SARS-CoV-2 infections in an outdoor rugby league, including video evaluation of close contact due to tackling inherent in the game, indicated that no cases among players in the league could be linked to close-contact during the outdoor rugby games.[30] Instead, transmissions were linked to other indoor short-range transmission events. While this study demonstrates examples where outdoor close-contact transmission did not occur, there were not enough close-contacts documented to provide evidence that close-contact transmission could not have occurred in the context of outdoor rugby.

In a modelling study, Zhang and Wang (2020) reported that the median infection risk via long-range aerosol transmission (10^{-6}–10^{-4}) was significantly lower than the risk via close contact (10^{-1}).[31] The model was based on a 1-hour exposure in a room with an area of 10–400 m^2, with one infected individual and a ventilation rate of 0.1–2.0 ACH. In a modelling study by Hu et al. (2020), the transmission risk from epidemiological data among train passengers as 0%–10.3% (95% CI: 5.3%–19.0%).[32] Travellers directly adjacent to the index patient had a much higher infection risk (relative risk [RR]: 18.0; 95% CI: 13.9–23.4), and the attack rate decreased with increasing distance.

Household and Non-Household Secondary Attack Rates

The consensus among systematic reviews is that household settings, where physical distancing, consistent source control mask-wearing, and disinfection of shared surfaces are potentially not feasible, are associated with a higher risk of infection compared to casual-contact settings (17%–27% compared

to 0%–7%). However, the secondary household attack rates are not as high as would be expected if SARS-CoV-2 easily spread through long-range transmission (e.g., >90% in measles).[16,33]

In a systematic review and meta-analysis of 54 studies and 77,758 patients, Madewell et al. (2020) reported that the household secondary attack rate was 16.6% (95% CI: 14.0–19.3).[34] In a systematic review and meta-analysis of 45 studies, Thompson et al. (2021) estimated the household secondary attack rate as 21.1% (95% CI: 17.4–24.8; 29 studies).[35] Non-household settings had lower secondary attack rates: 1) social settings with family and friends (5.9%; 95% CI: 0.3–9.8; 7 studies); 2) travel (5.0%; 95% CI: 0.3–9.8; 5 studies); 3) health care facilities (3.6%; 95% CI: 1.0–6.9; 10 studies); workplaces (1.9%; 95% CI: 0.0–3.9; 7 studies); and casual social contacts with strangers (1.2%; 95% CI: 0.3–2.1; 7 studies). Koh et al. (2020), in a meta-analysis of 43 studies, reported that the household secondary attack rate was 18.1% (95% CI: 15.7–20.6; 43 studies), much higher than the secondary attack rate in health care settings (0.7%; 95% CI: 0.4–1.0; 18 studies).[36] In a systematic review and meta-analysis of 24 studies, Lei et al. (2020) reported that the secondary attack rate in households was 27% (95% CI: 21−32); the risk of secondary infection was 10 times higher in households compared to non-household settings (odds ratio [OR]: 10.7; 95% CI: 5.7–20.2; p<0.001).[37] Tian and Huo (2020), in a meta-analysis of 18 studies, reported that the household secondary attack rate was 20% (95% CI: 15–28; 15 studies; n=3,861 patients), followed by social gatherings at 6% (95% CI: 3–10; 5 studies; n=2,154 patients) and health care settings at 1% (95% CI: 1–2; 4 studies; n=1,320 patients).[38]

Long-range Transmission

Main Findings

Transmission of SARS-CoV-2 over longer distances (generally >2 m) and time occurs through inhalation of aerosols under favourable circumstances, such as prolonged exposure in an inadequately ventilated space. Current evidence supports long-range transmission of SARS-CoV-2 occurring “opportunistically”, in that long-range transmission can occur under some circumstances, but inconsistently, and is not the predominant situation in which transmission occurs. Epidemiological and modelling studies support that long-range transmission via aerosols occurs. All of these examples include combinations of favourable source/receptor and pathway conditions such as inadequate ventilation, prolonged exposure time, high viral load, with certain activities (singing, exercising, yelling, etc.), and lack of masking for source control by the index case.

Environmental Factors Affecting Long-range Aerosols

In experimental models, researchers have demonstrated the potential for long-range transmission. In a series of experiments, simulations and modelling, Wang et al. (2021) (preprint) reported that aerosols could remain suspended for a longer period than historically predicted.[15] In general, viral copies/millilitre (ml) or concentration decreased as distance from source increased. The work showed that the evaporation time for large respiratory droplets is longer than predicted, especially at higher relative humidity (90%). In a sneeze plume, the largest respiratory droplets (>100 µm) are centrally located within the plume, with smaller respiratory droplets and aerosols at the periphery. The largest droplets contain more virus copies but are less abundant as they settle quickly to the ground, while smaller droplets carry fewer virus copies but are more abundant and remain in the air. The authors conclude that while aerosol transmission is important past 1 m from the source, aerosol transmission is likely even more important at shorter ranges.

Modelling studies have also highlighted the potential for aerosol transmission at varying distances. Xu et al. (2021) analysed the data of 197 symptomatic COVID-19 cases in the Diamond Princess cruise ship outbreak and concluded that long-range transmission did not occur between cabins based on the random distribution of symptomatic cases on all decks and the lack of spatial clusters of close contact (within cabin) infection.[39] The authors inferred that most transmission had occurred in public areas before the quarantine, possibly due to crowding and insufficient ventilation in those spaces. The authors also inferred that there was no transmission between passenger rooms during the quarantine period, and suggested that the ship's central heating, ventilation, and air conditioning (HVAC) system did not play a role in SARS-CoV-2 transmission. However, the authors noted that the lack of data on 109 of the 306 symptomatic individuals and on the 328 asymptomatic individuals may alter their estimation. In addition, their estimation did not take into consideration possible transmission between crew and passengers. Another model of the same outbreak estimated that the contribution of short-range transmission (from large droplets or aerosols) accounted for a median of 36% (mean: 35%) of transmission events, fomite (median: 21%; mean: 30%) and long-range (median: 41%; mean: 35%) contributing to the remainder.[40]

A study of aerosol particles (<5 μm diameter) by Dobramysl et al. (2021) (preprint) reported that time to infection increases approximately linearly as distance from source increases, the most important parameter for time to infection.[41] Exposure to a person breathing normally (simulating an asymptomatic individual) at a distance of 1 m led to infection after 90 minutes; however, coughing every 5 minutes led to infection in 15 minutes. Mask use and even minimal ventilation increased time to infection at a given distance. The importance of ventilation is also described in a modelling study by Jones (2020) which suggested that exposure to inhalable particles mostly (80%) occurs within close proximity to the patient.[42] In still air, aerosols will rise above head-level; however, turbulent air can change the trajectory of virus-laden aerosols, bringing aerosols closer to the head.[43-45] A modelling study by Sen (2021) found that when the ceiling-mounted elevator fan was off, about 11% of the droplets expelled by coughing fell to the ground while 89% evaporated and became smaller.[46] After travelling downward in cough-induced turbulence for approximately 6 seconds, droplets about 50 μm tended to move up and spread in the upper part of the elevator. If the cough happened at 30° to another rider, up to 40% of the droplets may fall on the face of another elevator rider. However, when the fan is operating, up to 50% of the droplets were dragged down to the floor in less than 3 seconds.

The basement of a large wholesale market was investigated as the source of a major outbreak in Beijing, China.[47] Many factors contributed to spread across multiple possible modes of transmission including long-range transmission. A field study of the area using fluorescent powders and microspheres as tracers allowed authors to conclude that while air was circulated, the air was unfiltered and there was very little fresh air, there was high humidity, low temperature, inadequate hand sanitization supplies in washrooms, and significant contamination of surfaces possibly due in part to resuspension of droplets from wet floors.

Given that persistence of aerosols over time is a factor in long-range transmission, the viability of SARS-CoV-2 in aerosols is important to consider. The half-life of SARS-CoV-2 in aerosols is approximately 1 hour.[48,49] Humidity seems to have less of an effect on SARS-CoV-2 viability in aerosols compared to the effect of sunlight or temperature.[50,51] Increasing temperature is associated with a reduction in the half-life of SARS-CoV-2 in aerosols.[52-54] Using a rotating drum experiment similar to other studies for viability of SARS-CoV-2, simulated sunlight (UVA/UVB) was applied to aerosolized virus through a window on the drum.[51] Results indicated 90% inactivation of virus within 20 minutes.

Inadequate ventilation can contribute to spread of aerosols, where the buildup of infectious aerosols is inversely proportional to the number of air exchanges.[55-57] In a modelling study, Schijven et al. (2021) assessed the risk of aerosol transmission of SARS-CoV-2 at a distance beyond 1.5 m from continuous breathing, speaking, or singing, or from one cough or one sneeze, in an indoor environment of 100 m^3.[58] Where there was no ventilation, the mean risk of transmission (derived from dose-response data for human coronavirus 229E) after 20 minutes of exposure to a person with 10^7 RNA copies/ml of mucous was estimated at 0.1%, except for sneezing with high aerosol volume (40,000 picolitres/sneeze). The mean risk of transmission increased to above 30% for sneezing with high aerosol volume and above 10% for singing after an exposure of 2 hours to a person with mucous RNA concentration above 10^8 copies/ml. Ventilation at 1 ACH reduced the risk by approximately half and at 6 ACH, the risk of transmission was reduced by a factor of 8–13 for sneezing and coughing, and by a factor of 4–9 for singing, speaking and breathing.

Estimates for minimum infectious dose, amount of viable virus in aerosols and quantified exposure rates are lacking. One preprint study assessed superspreading events related to long-range transmission in order to determine a minimum infectious dose for transmission.[59] The model used rate of aerosolized virion shedding based on data from other coronaviruses and a destabilization rate measured for SARS-CoV-2. They reported a critical exposure threshold for aerosol transmission of 50 virions. A computational characterization of inhaled droplets by Basu (2021) reported an estimated inhaled infectious dose around 300 virions, which was similar to estimates of 500 virions for ferrets.[60] The author acknowledged that this estimate could vary widely depending on environmental and individual biological factors.

Epidemiological and Modelling Studies Describing Long-range Transmission

Epidemiological case studies have reported long-range transmission of SARS-CoV-2, exclusively in indoor settings (e.g., bus, church, restaurant, concert halls, apartment building, office building).[61-67] In most of these case studies, long-range transmission was inferred as the dominant route of transmission, given that infectees were usually further than 2 m away from index cases. In addition, in these case studies, susceptible people were exposed to index cases for prolonged periods (>50 minutes) in indoor environments with inadequate ventilation and, in some instances, with increased respirations (e.g., singing, yelling, or exercising) and/or no face mask use (by case and/or contact). As with most epidemiological studies on transmission events, it was difficult to exclude other contributing routes of transmission. We summarize a few of these case studies, highlighting settings and contributing contextual factors to long-range transmission.

Stagnant indoor conditions can contribute to aerosol transmission. One example is a series of transmissions linked to an individual who developed symptoms around the time they were playing squash in an unventilated squash court.[68] Players who arrived hours after the index case and played in the same squash court were later identified as positive cases, though the role of other potential routes (e.g. unidentified staff contacts, shared surfaces) may have contributed as well and the source of transmission could not be confirmed. In contrast, a post-operative analysis of susceptible patients (no previous SARS-CoV-2 infection or vaccination) in a surgical suite within 48 hours following the use of the suite by SARS-CoV-2 positive patients indicated that there were no transmission events. The event rate was lower than the number of events in a control group (0% vs. 1.9%).[69] Ventilation was likely a significant factor that prevented transmission in the surgical suite.

In a study of six indoor singing events (five with transmission) in the Netherlands, Shah et al. (2021) (preprint) reported that long-range transmission was the likely route of transmission (short-range transmission possibly contributing to transmission at three of these events and indirect contact transmission possibly contributing to transmission at one of the events).[62] The authors assigned transmission likelihood as either less likely or possible; however, the authors do not state how these were defined. Attack rates at these events ranged from 25%–74% (9–21 people aged 20–79 years attended the events) and authors hypothesize that singing led to transmission. The authors note that they cannot quantify the contribution of each route of transmission. Genomic sequencing was not performed to help rule out other sources of SARS-CoV-2.

In a choir group (Washington, US), 53 of 60 individuals (excluding the index patient) were confirmed or strongly suspected to have been infected during a 2.5 hour rehearsal in a main hall.[64] Individuals who moved to another area of the building from the index case to practice for 45 minutes were less likely to become infected than those who remained in the main hall for the full duration of the rehearsal.

Twelve secondary cases of SARS-CoV-2 were linked to an index case, an 18-year-old chorister with high viral load who sang at four 1-hour services.[70] The index case was seated at a piano raised approximately 3 m from the ground floor and facing away from the secondary cases. Secondary cases sat between 1–15 m (horizontal distance) from the index case. Use of masks was not in place and there was minimal ventilation during the service (ventilation system was off, fans were off and doors and windows were largely closed). Interestingly, no new cases were linked to exposure that occurred the day of respiratory symptom-onset, and no explanation could be provided for why only a certain section near the chorister was affected and other sections (including those directly in front of the index case) were not.

In a case study by Shen et al. (2020), passengers who were not wearing masks were exposed to a presymptomatic index patient for 100 minutes while on a bus in eastern China.[61] Twenty-four of 67 passengers became infected, including several passengers seated beyond 2 m distance. The bus containing the index patient was heated and air was recirculated without filtration. Infections occurred in individuals at either end of the bus and the index case was located roughly in the middle. Risk of infection was only moderately higher for individuals sitting closer to the index patient. In contrast, seven of 172 other people attending the same religious event were positive for SARS-CoV-2. Some of the cases became positive after 14 days from exposure; thus, transmission likely did not occur on the bus for these case. The authors of this study postulate that the poor ventilation in the bus supports aerosol transmission in this cluster; however, other routes of transmission such as close contact from movement within the bus or fomites could not be excluded.

Vehicles are also potential environments for short-range and long-range transmission. A patient transport van was implicated in long-range aerosol transmission despite physical distancing observed by the infected drivers in two distinct transmission events.[71] One driver did not wear a mask, but all passengers wore a single-layer mask. The passengers were exposed for 2 hours during both events. Transmission was confirmed by whole genome sequencing. Fans were on medium speed and windows were closed. Airflow experiments were conducted with different size aerosols demonstrating plausibility of spread from the driver.

An epidemiological investigation of a chain of transmissions was reported beginning with a flight from India to New Zealand, a bus ride to a quarantine facility, a stay at a quarantine facility, a bus ride to the airport, and subsequent household transmissions.[72] Based on positivity test dates, genome sequencing, flight positions and hotel room placement the transmission events were ascribed to both short-range and long-range transmission on flights, within the quarantine facility, and within households. Masks

were required on flights and bus rides. One of the transmission events occurred between two adjacent hotel rooms in the quarantine facility. The authors used recorded video and observed >20 hours between any shared items and no direct contact. The authors concluded that fomite transmission was unlikely and attributed transmission to aerosols in the corridor outside of the hotel rooms wherein the space was enclosed and unventilated. Notably, the hotel rooms themselves, based on a review of the ventilation system, exerted positive pressure relative to the corridor.

An investigation by Lin et al. (2021) into an outbreak of nine COVID-19 cases from three families living in vertically-aligned units of an apartment building in Wuhan, China supported the possibility of long-range transmission.[66] Phylogenetic analysis of respiratory samples showed that all cases were infected by the same strain of SARS-CoV-2. Epidemiological investigation revealed that 4/5 cases of the index family in apartment 15-b had a travelling history to Wuhan, while the other four cases in apartments 25-b and 27-b had neither a travelling history to Wuhan nor close contact with any COVID-19 cases prior to their infection. Transmission through close contact in the elevators was considered unlikely as video records in the elevator did not show any close contact between the index family and the cases from units 25-b and 27-b. However, there was an incident where one unmasked occupant of unit 27-b took the elevator 8 minutes after two unmasked occupants from the index family had left the elevator. Epidemiologically, the infection rate for residents in units b was significantly higher ($p<0.05$) than that in units a and c. Testing of wind speed at the bathtub drain and floor drain found that the airflow produced by toilet flushing on one storey can influence the entire building as the drain pipes for toilets and the sewage pipes connected with floor drains were connected with the exhaust pipe. An experiment with a tracer gas indicated that gas could spread from one storey to another via the drainage and vent systems, especially as the seals in U-shaped traps in the floor drains were dried out in some units and the use of exhaust fans could create a negative pressure in the pipeline system. A similar situation was reported involving air ducts in a naturally ventilated apartment complex in Seoul, South Korea.[67] There were no valves blocking air from entering the bathrooms from the shared natural ventilation shafts (not for building or apartment unit ventilation). Limitations of this outbreak investigation included no genome sequencing or air sampling. Direct applicability to Canadian contexts may be limited by different building construction standards and practices.

Independent of ventilation, movement of air from an infected individual to others nearby can be an important factor in long-range transmission. Direct airflow was deemed responsible for a long-range transmission event in a restaurant in Korea.[73] The suspected index case sat 4.8 m and 6.5 m away and directly upwind of the airflow from two secondary cases at different tables. Nine other visitors in the restaurant did not test positive for SARS-CoV-2 even though at least two were closer to the index case for longer but not in the direct path of airflow originating from the index case. Notably the transmission in one case was suspected to have occurred from an exposure as short as five minutes, and three patrons sitting with the secondary cases but facing away from the index cases were not infected.

An investigation by Lu et al. (2020) into a COVID-19 outbreak in a restaurant in Guangzhou, China involving three families sitting at three tables in close proximity for about 1 hour concluded that the air conditioning (AC) system likely contributed to transmission.[63] In this scenario, a presymptomatic index case and secondary cases were present in the same area for 53–73 minutes. The location of a consistently running AC unit was in the airflow path of the secondary cases and was in an enclosed environment. No secondary cases occurred in staff or at adjacent tables that were outside of the likely "air column". The furthest distance between index and secondary cases was approximately 3 m. Additional investigation indicated that the exhaust fans had been closed due to cold outside temperatures.[74] The airflow assessment indicated that air was recirculating in a defined area, which exposed the three families.

A report involving group exercise at three facilities in Hawaii, US calculated attack rates of 25%–100%.[75] There was no fresh air ventilation and exposure occurred over a duration of 1 hour. Extended close contact and lack of masks in some cases were concluded as contributing to the transmission.

An outbreak in a multi-bed hospital room occurred wherein three patients and six health care workers became infected despite the use of masks and presence of ventilation of 3–4 ACH.[76] The presymptomatic index case was a parent located in a chair beside their child's bed who constantly wore a surgical mask, near the entrance to the room. Notably the air conditioning unit appeared to be located on the ceiling and no details were given about how it operated (e.g., constant versus timed/triggered) and what amount of fresh air circulation it provided. There were no exhaust vents indicated on the room diagram. Exposures for health care workers were in the range of 10–15 minutes, most at distances further than 2 m from the index patient. The report noted that masks were worn as personal protective equipment by health care workers. Transmission was based on the epidemiology of the outbreak without corroboration by genomic analysis of infections.

Detection of SARS-CoV-2 in Air Samples

Air sampling for virus refers to the process of collecting volumes of air by a device to determine if aerosols may contain virus. Collection can vary by aerodynamic size captured, duration of collection, volume per second collected, and media on which samples deposit. Air samples can then be tested by molecular methods such as reverse transcription PCR (RT-PCR) to amplify viral nucleic acids and/or viral culture. RT-PCR cannot determine whether the microorganisms detected are viable. Viral culture is used to determine whether a sample containing the virus is capable of replication. While there are several factors that contribute to the probability of infection, replication is a surrogate measure for inducing infection. To detect viability, researchers apply a sample to a susceptible cell culture and incubate up to a few weeks to detect morphological changes.

Detection of SARS-CoV-2 RNA in air samples has been inconsistent.[77] Multiple air sampling studies performed in proximity to confirmed COVID-19 cases were unable to detect any virus by RT-PCR.[78-86] Kenarkoohi et al. detected SARS-CoV-2 RNA by RT-PCR in 1/5 samples from a ward containing intubated, severely ill patients, but did not find any positive air samples in other areas of the hospital such as wards with suspected, confirmed and mild patients (culturing of virus was not attempted in this study).[87] Chia et al. (2020), in an extended study of Ong et al. (2020), detected SARS-CoV-2 RNA by RT-PCR in air samples collected within 1 m of patients in two of three airborne infection isolation rooms (AIIRs) (no culture of virus attempted).[88] Lei et al. (2020) reported limited detection of SARS-CoV-2 RNA virus by air sampling in open wards, private isolation rooms and bathrooms.[85] One PCR-positive air sample was obtained during an endotracheal intubation within 10 cm of the patient's head in a naturally ventilated room (window open with fan attached), eleven other air samples near patients and 17 samples outside patient rooms and at nursing stations were PCR-negative.[89] The stage of infection and level of infectiousness of the patient populations sampled were not reported.

In a study of SARS-CoV-2 RNA in air samples collected from a variety of settings, Liu et al. (2020) reported that the highest concentration of viral RNA was reported from patient and staff areas of hospitals, compared to public areas.[90] Gharehchahi et al. (2021) (preprint) found SARS-CoV-2 RNA in 7/17 (41.2%) of air samples in a hospital for COVID-19 patients, including a mechanically-ventilated temporary waste storage area, two naturally-ventilated offices (one in the admission and discharge area, the other in an administrative department), and within 2 m of patients' beds in two intensive care units (ICUs), a negative pressure room, and an accident and emergency ward that are mechanically-ventilated with or without natural ventilation.[91] SARS-CoV-2 RNA was not detected from the four

samples at nursing stations 2–5 m from patients' beds. The authors speculated that the detection of RNA in non-clinical areas could be due to inadequate ventilation and the occasional presence of infected health care workers.

Stern et al. (2021) sampled air in locations outside of patient care areas in an acute care hospital and found 8/90 (9%) of the samples positive for SARS-CoV-2 RNA, with concentrations ranging from 5–51 copies/m^3.[92] The size of the RNA-positive samples ranged from ≤2.5 to ≥10 μm. Locations adjacent to negative-pressured wards designated for COVID-19 patients did not appear to increase the likelihood of detecting viral RNA, having higher viral concentration, or finding particles of specific sizes in air samples. However, a significant positive association was observed between the average number of COVID-19 patients staying in the hospital during each sampling period, and the likelihood of an air sample testing positive for SARS-CoV-2 RNA. Furthermore, areas where staff congregated during times of high community rates of COVID-19 were associated with positive air samples. Of note, one RNA-positive air sample was taken when the unit was closed for cleaning and not under negative pressure, and the unit doors were left open for cleaning staff who had to pass by the air sampler to access the area for cleaning.

When air samples were RT-PCR-positive, culturing attempts were infrequently successful. In a systematic review and meta-analysis of 24 studies, Birgand et al. (2020) reported that 17.4% (82/471) of air samples from patient environments were RNA-positive (there was no difference in positivity at ≤1 m [2.5%] or 1–5 m [5.5%]; p=0.22), while culturing produced viable virus in 8.6% (7/81; 2 out of 5 studies) of samples.[93] A study by Guo et al. (2020) detected SARS-CoV-2 by RT-PCR in 35% (14/40) of air samples in an ICU and 12.5% (2/16) of air samples in the general ward that managed patients with COVID-19. Fifteen of 16 RT-PCR-positive air samples were from within 2 m of patients, with 1/8 samples positive at 4 m away.[12] Ben-Shmuel et al. (2020) conducted limited sampling (generally one air sample per area) in rooms with ventilated and non-ventilated patients, at a nursing station, and in private and public areas of a quarantine hotel.[94] RT-PCR-positive air samples were detected in a room with a ventilated patient (distance from patient was not reported) (n=1/1), at a nursing station (n=1/1), and in a quarantine hotel room (n=1/1). However, there were no positive air samples in rooms of non-ventilated patients (n=0/3), a doffing area (n=0/1), and a public area of a quarantine hotel (n=0/1). The authors attempted viral culturing; however, no samples were positive.

At this time, only three studies, two from the same research group and one preprint from July 2020, have successfully cultured viable virus from the air. The preprint and one published study were already referred to above in the summary of Birgand et al. (2020). Sampling techniques and equipment may have caused the lack of culture viability despite RT-PCR detection in other studies. Future studies should aim to replicate the use of equipment and culture methods as these studies.

Lednicky et al. (2021) used a prototype and commercial version of an air sampler and custom RT-PCR probes for detection of SARS-CoV-2 in a patient room with two patients. One patient was discharged soon after sampling periods began and after receiving a negative RT-PCR test.[95] The remaining patient began experiencing respiratory illness two days prior to admission to the room. The study detected RT-PCR-positive air samples following 3 hours of sampling as well as positive viral cultures. Researchers positioned samplers 2–4.8 m from the recently symptomatic patient's head. The ventilation unit provided 6 ACH, filtering air and treating air with UV irradiation before recycling the air. Estimates of virus per volume of air ranged from 6–74 tissue culture infective dose $(TCID)_{50}$ units/L of air. Recently, a second study by Lednicky et al. was performed to detect viable SARS-CoV-2 virus from the front passenger seat area of a car driven by a SARS-CoV-2-positive patient without cough symptoms.[96] This study involved a sampler affixed to the sun visor in the passenger seat collecting particles sizes in ranges

of <0.25 µm, 0.25–0.50 µm, 0.50–1.0 µm, 1.0–2.5 µm and >2.5 µm. The patient drove for 15 minutes with the windows up and air conditioner on. The sampler was turned off 2 hour after the patient completed the 15 minute drive. Viable virus was cultured only from the 0.25–0.5 µm fraction, which also had the highest quantity of detectable copies of viral RNA.

Further research is needed to reconcile differences in viral RNA detection and virus viability in air samples, despite RT-PCR-positive samples found on the surfaces of ventilation units.[97] Differences may be due to several factors, including: 1) air sampling devices are potentially not capable of maintaining viability of captured virus; 2) timing of air sampling varies by time since onset of symptoms, severity of disease or viral load; and 3) the conditions of ventilation (engineering controls) reducing concentrations of viral aerosols to undetectable levels. Even in rooms with high air exchanges, Tang et al.'s review of SARS-CoV-2 aerosols indicates that viral RNA copies can still be detected in air samples from patient rooms (1.8–3.4 viral RNA copies/m^3), toilet rooms (19 copies/m^3), and personal protective equipment doffing rooms (18–42 copies/m^3).[98] In a series of distinct room types (two AIIR with 15+ ACH, an isolation room without negative pressure and a shared cohort room) for patients admitted within 7 days of symptom-onset, Kim et al. reported that 32 air samples were negative and 20 air samples from anterooms were also negative.[86] Culturing viruses is technically challenging; therefore, the lack of positive cultures does not necessarily indicate an absence of infectious virus. On the other hand, the detection of SARS-CoV-2 viral RNA on surfaces that are rarely touched suggests that the virus may be transported through the air to those no-touch surfaces.[99]

Conclusions

Respiratory virus transmission occurs on a spectrum, from larger droplets that spread at short range, to aerosols that are present at short ranges but may also contribute to long-range transmission. As a result, categorizing SARS-CoV-2 transmission as either droplet or airborne does not accurately reflect this spectrum. Other respiratory viruses, like influenza, have similarly been described to demonstrate a spectrum of droplet sizes contributing to transmission.[100,101]

The highest risk of SARS-CoV-2 transmission likely occurs via close (<2 m), unprotected exposure (lacking multiple prevention measures) to an infectious individual. While there is a lower risk of transmission at longer distances with unprotected exposure, this kind of transmission has only been documented to occur under certain conditions, usually involving inadequate ventilation or with recirculation of unfiltered or untreated air in combination with activities involving increased exhalation/expulsion (e.g., shouting, singing, exercising), and often with a lack of source control masking.[102] Defining measures or cutoffs for inadequate ventilation was not possible based on the available descriptions of the contexts in which inadequate ventilation was reported to contribute to transmission. However, they included situations where air is circulated without filtration or exchange with fresh air, where there is no ventilation (e.g., windowless rooms without a ventilation system), and where the size of the room and ventilation rate relative to the quantity of infectious aerosols generated exceeds an unknown threshold of risk for infection. VOCs may be more effectively transmitted across all modes of transmission; however, there is no evidence that any VOCs transmit by fundamentally different routes.[103-105]

The delineation of relative contributions of short-range large respiratory droplets and aerosols and long-range aerosols to overall transmission patterns is complicated by the variable confluence of dynamic source/receptor factors and pathway factors. For example, each infector/infectee interaction is affected by source activities and amount of source viral load (e.g., forceful expulsion of droplets during coughing or singing, and timing in the course of illness), source/receptor adherence to preventative measures in place (e.g., hand hygiene, physical distancing, surface disinfection, mask-wearing and ventilation), and

pathway factors that include airflow, UV, temperature, and humidity in indoor or outdoor environments.[16] It is likely that the relative contribution of respiratory particle size to transmission will depend on these combination of factors.

A large body of evidence is emerging related to SARS-CoV-2. Studies related to identification of a specific mode of transmission are generally low quality. Moreover, data from different fields (e.g., epidemiology versus modelling) can be at odds with respect to conclusions drawn about the role of different sized droplets in short-range transmission and relative importance of long-range transmission events. Ongoing study is needed for further evidence regarding the quantity of viral particles required to cause infection. Additional assessment of SARS-CoV-2 viability in aerosols is needed. Lastly, elucidation of setting-specific risk factors for transmission (e.g., differences between source/receptor and pathway factors in health care settings, residential buildings, schools, warehouses, transportation) may provide further insight into mechanisms for transmission.

The COVID-19 pandemic has identified the importance of interdisciplinary collaboration towards understanding and having a common lexicon for describing virus transmission. When the analysis and interpretation of data is challenged by variable terminology used between and within public health, clinicians, aerosol scientists and the public, this can limit progress towards identification and application of appropriate mitigation measures.[106]

Implications for Practice

This document summarizes the evolving evidence on transmission through respiratory particles and acknowledges the role for both larger droplets and aerosols in transmission. While our understanding of how transmission occurs has evolved and the relative contribution of droplets and aerosols continues to be studied, this may not necessitate a change in infection control measures, but highlights the importance of incorporating multiple infection control layers to mitigate transmission. Translation of this information into recommendations for control measures also needs to take into consideration evidence not reviewed in this document on the overall effectiveness of control measures to date: 1) effectiveness of measures in isolation and in combination as layered mitigation; 2) effectiveness in the community vs. health care settings; and 3) effectiveness and the impact of implementation fidelity.

A detailed assessment of the evidence for infection prevention and control measures was out of scope for this document and thus limits discussion of recommendations for specific measures in different contexts. Of note, vaccination against SARS-CoV-2 is a relatively recent measure that is very effective at reducing transmission regardless of the mode of transmission and should be the priority control measure both in health care and community settings.[107]

In health care settings, recommendations for IPAC measures are described in *IPAC Recommendations for Use of Personal Protective Equipment for Care of Individuals with Suspect or Confirmed COVID-19* and *Interim Guidance for Infection Prevention and Control of SARS-CoV-2 Variants of Concern for Health Care Settings*.[7,8] These documents integrate the existing evidence around droplet, aerosol and contact transmission with jurisdictional experience with control measures and outbreak management to date, and recommends the use of the hierarchy of hazard controls to reduce the risk of transmission.

The bulk of disease transmission occurs in the community and in workplaces, not in health care settings. As SARS-CoV-2 transmits early in the course of infection, most commonly in the asymptomatic or presymptomatic period[108-111] and within the first two days of symptom-onset, cases may not seek health care during their most transmissible phase. In all settings it is necessary to utilize multiple control

measures to mitigate the dynamic transmission factors and address potential routes of transmission. Infection prevention controls should also be context-dependent and take into account vaccination status/coverage, the ability to physically distance and avoid crowding, the feasibility of proper wearing of appropriate personal protective and source control equipment, training and education on the appropriate use of personal protective equipment, hand hygiene, surface disinfection, indoor ventilation, and early identification and isolation of infectious persons. Finally, application of measures should also be in the context of overall rates of community transmission and risk of exposure.

Several resources exist for community guidance (e.g., non-health care workplaces, public and private spaces) on how to reduce the risk of SARS-CoV-2 transmission through a layered approach of multiple public health measures designed to mitigate short-range and long-range transmission.[112-114] In general these involve avoiding the "3 C's": closed spaces, crowded places, and close contact. The degree to which various mitigation layers are necessary or possible will depend on the setting and risk context. Transmission can be mitigated through:

- Getting vaccinated[115,116] (higher vaccine coverage in the population can reduce risk for individuals unable to receive a vaccine)
- Staying home when sick[117,118] (e.g., active and passive screening prior to entry into public settings)
- Limiting the number and duration of contacts with individuals outside your household
- Physical distancing[114] and avoiding crowded spaces
- Consistently and appropriately using a well-fitted, well-constructed (2-3-layer) mask for source control and personal protective equipment.[119-122]
- Ensuring that ventilation systems[123] are well-maintained and optimized with the support of professionals according to relevant recommendations (e.g., from American Society of Heating, Refrigerating and Air-Conditioning Engineers) and/or using outdoor environments whenever possible.
- Performing hand hygiene, respiratory etiquette, and environmental cleaning[124]

The above measures are effective means of reducing risk of transmission irrespective of the relative contribution of larger droplets or aerosols to transmission. Some controls will be more effective than others and it is the combination and consistent application of these controls that is most effective for reducing disease spread.

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Ontario

This is **“Exhibit G”**
to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022

A Commissioner, etc.

Public Health Ontario | Santé publique Ontario

SYNOPSIS

05/22/2020

COVID-19 – What We Know So Far About… Asymptomatic Infection and Asymptomatic Transmission

Introduction

PHO is actively monitoring, reviewing and assessing relevant information related to Coronavirus Disease 2019 (COVID-19). "What We Know So Far" documents are intended to provide a rapid review of the evidence related to a specific aspect or emerging issue related to COVID-19.

The development of these documents includes a systematic search of the published literature as well as scientific grey literature (e.g., ProMED, CIDRAP, Johns Hopkins Situation Reports) and media reports, where appropriate. Relevant results are reviewed and data extracted for synthesis. All "What We Know So Far" documents are reviewed by PHO subject-matter experts before posting.

As the COVID-19 outbreak continues to evolve and the scientific evidence rapidly expands, the information provided in these documents is only current as of the date of posting.

Key Points

This document summarizes the evidence regarding asymptomatic infection and transmission of SARS-CoV-2, the virus that causes COVID-19, by individuals who are asymptomatic. For clarity, in this document we will use the term COVID-19 to refer to both the virus and the disease.

Asymptomatic infection:

- **There is clear evidence of asymptomatic infection with COVID-19**. Estimates of the proportion of laboratory-confirmed cases who are asymptomatic may vary by age group, study setting and study methodology, ranging from 8.2% (infants under 1 year of age),[1] 18.2% (contact tracing in a conference outbreak),[2] 36.7% (travellers),[3] 43.2% (universal screening in a town),[4] up to 87.8% (outbreak investigation in a homeless shelter)[5] (see Asymptomatic Infection). The method of detection of asymptomatic cases (i.e., mass screening or testing contacts of cases), and the duration of follow-up to ensure asymptomatic individuals do not subsequently develop symptoms may influence the proportion of cases who are reported to be asymptomatic.

Asymptomatic transmission:

- There is some epidemiological and virological evidence of transmission from people who are asymptomatic and never develop symptoms. On the other hand, there is **more epidemiological and virological evidence as well as inferences from modelling and statistically analyses, that**

transmission can occur from presymptomatic COVID-19 patients (where transmission takes place during their incubation period). In particular, epidemiological investigations and virological findings have suggested that **transmission can occur as early as six days before symptom onset** and possibly even earlier, although alternative unrecognized sources of infection cannot be ruled out. Other studies have estimated the serial interval (time from onset of symptoms in one case to the onset of symptoms in the person they infect) and found that it is shorter than the length of the incubation period, suggesting transmission during the incubation period (see Modelling and Statistical Analysis below).

Background

Asymptomatic infection occurs when an individual is infected but experiences no symptoms, while asymptomatic transmission occurs when an infected individual without symptoms transmits the virus to another person. There are two mechanisms by which asymptomatic transmission can potentially occur:

1. Transmission from an individual who never develops symptoms—if the infected person is asymptomatic throughout his/her infection but nevertheless is infectious.

2. Transmission from an individual during their incubation period—if the infected person is infectious before he/she develops symptoms.

Asymptomatic Infection

Evidence of asymptomatic COVID-19 infection has been reported in studies that report on contact tracing activities, as well as in outbreak investigations and surveillance data. Asymptomatic infections have been reported in all age groups, occurring in various proportions of confirmed cases in different settings. Several studies reported that a substantial portion of COVID-19 patients remained asymptomatic at the end of their isolation period.

Asymptomatic Infections by Settings

The following highlights the proportion of asymptomatic COVID-19 cases from contact tracing activities, outbreak investigations and surveillance activities in various settings.

HEALTH CARE SETTING

A number of studies reported rates of asymptomatic infections after a period of isolation:

- Among the 138 cases detected in Brunei from March 5 to April 24, 2020, all were hospitalized and followed until viral clearance; 42 (30%) were presymptomatic at the time of diagnosis but later developed symptoms and **16/138 (12%) remained asymptomatic until viral clearance**.[3]

- 13/23 (57%) resident cases identified at a point-prevalence screening in a long-term care skilled nursing facility in Washington, United States with a COVID-19 outbreak were asymptomatic; only **3/23 (13.0%) remained asymptomatic at rescreening one week later**.[6]

- 14/19 (74%) resident cases and 4/8 (50%) staff cases identified at multiple point-prevalence screenings in a long-term care skilled nursing facility in California, United States with a COVID-19 outbreak were asymptomatic; **6/19 (31.6%) resident cases remained asymptomatic after at least 17 days of observation**.[7]

- 29/33 (87.9%) pregnant women who tested positive for SARS-CoV-2 at two New York obstetric centres were asymptomatic when screened at delivery; **26/33 (78.8%) remained asymptomatic until discharge**.[8] In another report from about a week before to a week after universal screening was started at these same two centres, 14/43 (32.6%) SARS-CoV-2–positive pregnant women were found to be asymptomatic on admission (two because they later developed symptoms and 12 by screening); 4/43 (9.3%) were asymptomatic throughout their postpartum courses.[9]

- **28/131 (21.4%)** COVID-19 confirmed hemodialysis patients from 65 centres in Wuhan, China remained **asymptomatic throughout** the course of their infection.[10]

- 30/1,012 (3%) patients admitted during February 7-12 to a make-shift hospital for non-critically ill COVID-19 patients in Wuhan, China were asymptomatic on admission. **14/1,012 (1.4%) patients remained asymptomatic after a median duration of 24 days** from exposure (interquartile range: IQR: 22-27).[11]

- Of 31 patients who were asymptomatic on admission to a hospital in Guangzhou, China, **9/31 (29.0%) remained symptom-free during hospitalization**. The viral load was higher in those who subsequently developed symptoms than in those who remained symptom-free.[12]

- 13/328 (4.0%) adult **patients admitted** to a public health centre in Shanghai, China were asymptomatic; **10/328 (3.0%) remained asymptomatic from 5 to 21 days after admission**, although all but one patient had radiologic abnormalities on chest CT.[13]

- **13/71 (18.3%) admitted patients** at a hospital in South Korea were **asymptomatic on admission. 10/71 (14.1%) remained asymptomatic for the entire quarantine period**, and the other 3 cases developed symptoms within 2 days of admission.[14]

CONGREGATE LIVING SETTINGS

High prevalence of asymptomatic infections at the time of testing have been reported in a few congregate settings:

- 87.8% of 147 adult COVID-19 cases identified through screening at a homeless shelter in Boston.[5]

- More than 350 of 615 (>57%) COVID-19 cases on the Theodore Roosevelt aircraft carrier.[15]

- 3 of the 4 resident cases identified at a senior independent and assisted living community in Seattle, Washington reported feeling well between the 14 days prior to and 14-21 days after testing.[16]

- 410/696 (58.9%) confirmed passenger and crew COVID-19 cases in the Diamond Princess cruise ship outbreak.[17] Adjusting for the possible future development of symptoms (right censoring) using a statistical model, Mizumoto et al. estimated the asymptomatic proportion to be 17.9% (95% credible interval (CrI): 15.5 to 20.2%).[18]

COMMERCIAL PREMISES

Two outbreak reports identified cases that remained asymptomatic through the follow-up period:

- In a call centre outbreak in Seoul, 4/97 (4.1%) confirmed COVID-19 cases were presymptomatic and another **4/97 (4.1%) remained asymptomatic throughout a 14-day isolation period**.[19]

- In a conference outbreak in Munich, Germany, **2/12 (17%)** infected attendees **remained asymptomatic after weeks of follow-up**.[2]

COMMUNITY

There are regional and national surveillance reports on the presence of asymptomatic infection in the community:

- A national surveillance report by the Chinese Center for Disease Control and Prevention reported 889/45,561 (2%) of laboratory-confirmed cases as asymptomatic at the time testing as of February 11.[20]

- 94/728 (12.9%) laboratory-confirmed children reported to the Chinese Center for Disease Control and Prevention during January 16-February 8, 2020 were asymptomatic (from 8.2% in children <1 year of age [7/85] to 17.6% for those 6-10 years of age [30/170]).[1]

- Integrated surveillance of COVID-19 in Italy reported 28.6% of the 33,189 cases with clinical data were asymptomatic as of May 20.[21]

- Analysis of regional surveillance data from one day in Lombardy, Italy found 17/380 (4.5%) cases as asymptomatic.[22]

- 35/81 (43.2%) cases identified in two point-prevalence surveys of all inhabitants of the municipality of Vò, Italy were asymptomatic at the time of testing.[4]

- 30/112 (26.8%) cases in a cluster of fitness dance classes in South Korea were asymptomatic at the time of testing.[23]

There are also studies reporting community-based infections that remained asymptomatic after a period of time:

- **50/1,015 (4.9%) confirmed cases** (41 adults and 9 children) in Huangshi, China were **asymptomatic throughout a quarantine period of at least 14 days**, according to publicly available disease databases of Hubei Provincial Health Committee up to March 27, 2020.[24]

- **5/48 (10.4%) secondary cases** among close contacts in Zhuhai, China **remained asymptomatic through a 21-day follow-up**.[25]

- Wan R et al. described 2 close contacts of confirmed patients. Case 1 was exposed at work to a COVID-19 patient and diagnosed 16 days later by reverse transcription polymerase chain reaction (RT-PCR). He **remained asymptomatic up to the end of the isolation period 25 days after exposure**; two chest radiographs taken during his isolation period were negative. Case 2 was the adult son of a COVID-19 patient. Case 2 was isolated the day after the parent's diagnosis and he **remained asymptomatic throughout 26 days of isolation**. Two chest radiographs taken during his isolation were also negative.[26]

TRAVELLERS

A few countries that tested their repatriated passengers or travellers from countries at high-risk of COVID-19 also reported asymptomatic infections:

- 40/783 (5.1%) repatriated passengers to Greece during March 20-25, 2020 who tested positive for SARS-CoV-2 reported no general or respiratory symptoms.[27]
- 2/114 (1.8%) repatriated passengers to Germany on February 1 were asymptomatically infected and remained afebrile 7 days after diagnosis, although one patient developed a faint rash and minimal pharyngitis.[28]
- Out of the 30 arrivals to Brunei who tested positive for SARS-CoV-2 between March 21 and April 24, 11 (36.7%) were presymptomatic and 3 (10%) were asymptomatic.[3]
- In a cluster of 6 travellers and 6 secondary cases in Vietnam, 1/12 cases (8.3%) remained asymptomatic but viral RNA was detected by RT-PCR throughout the 9-day follow-up period.[29]

Abnormal Chest Imaging

Asymptomatically infected individuals can have abnormal chest imaging.

- Hu Z et al. showed that 12/19 asymptomatic adults and children had abnormal chest CT scans.[30]
- Chan JF et al. described an abnormal chest CT in a 10-year old asymptomatic child.[31]
- Wang Y et al. noted pneumonia in CT findings in 37/55 of asymptomatic cases on admission. Note that all 55 cases developed symptoms during hospitalization: 14 had mild infection, 39 had ordinary symptoms and 2 had severe COVID-19.[32]
- Zhou X et al. reported that 9/10 asymptomatic patients hospitalized at a public health centre had signs of pneumonia on their chest CT scans.[13]
- Zhou R et al. noted bilateral abnormalities in chest CT scans typical of pneumonia in 4/9 patients who remained asymptomatic throughout hospitalization.[12]
- Inui S et al. reported that chest CT findings consistent with pneumonia were seen in 41/76 (54%) asymptomatic passengers on Diamond Princess cruise ship.[33]

Asymptomatic Transmission

There is some **evidence of transmission from people who are asymptomatic and never develop symptoms**, and **more evidence of transmission from people who are in their incubation period** (i.e. people who transmit infection while asymptomatic, but prior to their development of symptoms).

Transmission From People who Never Developed Symptoms

Findings from epidemiological and virological investigation have been published to support the observation that transmission can occur from people who never developed symptoms after their infection.

EPIDEMIOLOGICAL EVIDENCE FOR ASYMPTOMATIC TRANSMISSION

Several authors reported clusters of infections in China where epidemiological findings suggest the possibility of transmission by asymptomatic patients.

- Zhou J et al. reported two transmission events by asymptomatic patients in ZhuZhou, China.[34]
    - A 37-year-old woman was isolated for observation after returning from Wuhan on January 22, 2020. Viral RNA was only detected in the 5th specimen taken on February 15, and she remained asymptomatic up to March 2 when her test turned negative and showed no pulmonary imaging changes. Meanwhile, her father was diagnosed of COVID-19 on February 12, 3 days before viral RNA was detected in the woman's specimen.
    - An asymptomatic patient who returned from Wuhan appears to have infected her mother-in-law and father-in-law.

    Zhou et al. conclude that asymptomatic SARS-CoV-2 carriers can spread the virus before viral RNA was detected. It should be noted that they did not provide any information on potential alternate sources of infection or on the reliability of the testing done.

- Zhang J et al. reported a family cluster of 5 in Beijing. The index case was the only one in the cluster who had been to Wuhan; he returned to Beijing in January and invited his nephew (M/32) for dinner that day. This nephew became ill 3 days later and was diagnosed 2 days after symptom onset. Around that time, the index patient's wife (F/45) had a fever and they heard of a relative in Wuhan having COVID-19. As a result, the index patient and family visited a hospital to be assessed and the index and 4 family members (including the nephew and wife) were diagnosed with COVID-19. Both the index patient and a family member remained asymptomatic throughout the observation up to the end of February. The index patient's chest radiograph showed ground glass opacities but that of the other asymptomatic family member was normal. The authors believe the index patient passed the infection on to his family despite having no symptoms himself. However, details of other family members' contact history were not given to rule out potential alternate sources of infection.[35]

- A study by Bai Y et al. reported on an asymptomatic individual who transmitted COVID-19 to five family members in Anyang. She tested positive 18 days after her presumed exposure, with a negative test on day 16 and two negative tests on days 26 and 29. Although the authors argue that the asymptomatic individual was the source of infection for the family members, the family visited a hospital as well. Although the hospital reported no COVID-19 cases at that time, this is a potential alternative source of exposure.[36]

- Hu Z et al. reported on an asymptomatic case who appears to have acquired his infection in Hubei province and transmitted his infection to his wife, son and daughter-in-law who lived with him in Nanjing. His family members denied any other known exposures to confirmed or suspect COVID-19 patients.[30]

- Lavezzo E et al. reported on 3 cases who appeared to have acquired their infection based on contact with asymptomatic individuals. The cases were identified on the second of two point-prevalence surveys that took place at the end of a two-week lockdown of the municipality of Vò, Italy: case 1 had exposure to 4 infected relatives who did not have any symptoms at the time of contact; case 2 had a meeting with an asymptomatic case before the lockdown; case 3 shared

the same flat with two asymptomatic relatives. The authors noted that all the asymptomatic individuals never developed symptoms during the two-week lockdown.[4]

VIROLOGICAL EVIDENCE FOR ASYMPTOMATIC TRANSMISSION

Several studies reported high viral loads in asymptomatic individuals as measured by real-time RT-PCR.

- Arons MM et al.[37] cultured the real time RT-PCR-positive specimens from two point-prevalence surveys in a skilled nursing facility as part of an outbreak investigation, as described in Kimball A et al.[6] above. Viral growth was observed for 13/20 symptomatic residents, 17/24 presymptomatic residents, 1/3 asymptomatic residents. **Viable virus was isolated from 6 days before to 9 days after symptom onset**. In addition, **high viral RNA loads were detected in all groups with median cycle threshold values at 24.8 in those with typical symptoms and 25.5 for those who were asymptomatic**. This suggests the potential for substantial viral shedding in asymptomatic cases. No correlation was observed between cycle threshold values and time from symptom onset.[37]

- Zou L et al. noted that an asymptomatic individual had similar viral loads from nasal and throat swabs compared to 17 symptomatic individuals.[38]

- Roxby AC et al. noted that the viral load in 3 generally asymptomatic residents (one developed a mild cough) of an independent living community were similar to those reported among ill hospitalized patients.[16]

- Kam K et al. noted a high viral load in a nasopharyngeal specimen from a generally well baby. Nasopharyngeal specimens were positive for 16 days and one stool specimen was also positive.[39]

- Hoehl S et al. observed COVID-19 virus in cell culture in throat specimens from two repatriated passengers who tested positive by RT-PCR. One patient developed slight rash and minimal pharyngitis the day after testing but both persons remained well and afebrile during the 7 days after hospital isolation.[28]

- Cereda D et al. noted that the median viral RNA levels in nasal swabs were not statistically different between 295 symptomatic and 17 asymptomatic obstetric cases:
5.0 $\log_{10}$ RNA copies/mL (range 1.7-10.1) vs 4.7 $\log_{10}$ copies/mL (range 2.1-7.1), (P=.51).[22]

Transmission During the Incubation Period

There is both epidemiological and virological evidence, as well as inferences from modelling and statistical analysis, that point to transmission from people prior to their symptom onset.

EPIDEMIOLOGICAL EVIDENCE FOR PRESYMPTOMATIC TRANSMISSION

Several studies describe potential transmission prior to symptom onset, i.e., in the incubation period. In most instances, the contacts who acquired the infection reported no other known sources of exposure other than a case who was in their incubation or early symptomatic period.

- Hijnen D et al. reported an outbreak amongst at least 11/13 attendees (one attendee was not tested) from seven countries at a 2-day conference in Munich, Germany in February, when under 20 cases of COVID-19 had been diagnosed in the country. The **index patient** (a physician

was believed to have been infected when examining a patient in Italy two days before the start of the conference) **developed symptoms only after he had left the conference**.[2]

- Rothe C et al. reported an outbreak in Germany resulting from a business meeting in late January.[40] Böhmer MM et al. reconstructed the transmission events with epidemiological findings and whole genome sequencing of 13 of the 16 subsequent cases.[41] The index case was a Chinese resident from Shanghai who had had contact with her parents from Wuhan before visiting Germany in January for work reasons. Presymptomatic transmission likely occurred from patient 4 (symptom onset on January 24) to patient 5, as patient 5 did not meet the index case but had encounters with patient 4 on January 22 when they sat back to back in the canteen and patient 5 turned to ask patient 4 to borrow the salt shaker from their table. Böhmer MM et al. noted that **presymptomatic transmission is strongly supported by virus sequence analysis**. In addition, presymptomatic transmission could possibly have occurred for 5 more cases.[41]

- Jang S et al. reported on the active surveillance results of a COVID-19 cluster associated with fitness dance classes. On February 15, 2020, a 4-hour workshop for 27 fitness instructors took place in Cheonan, South Korea (approximately 200 km from Daegu where an outbreak was emerging). After discovering cases in Cheonan linked to fitness dance classes, the workshop was investigated. Eight of the 27 instructors at the workshop were found to be infected with SARS-CoV-2. One of these instructors was from Daegu, and therefore was the presumed source case for the outbreak, and developed symptoms on February 18, 2020, three days after the workshop.[23]

- Cheng HY et al. conducted a prospective study that enrolled all the initial 100 confirmed cases in Taiwan from January 15 to March 18, 2020 and their 2,761 close contacts. All close contacts were quarantined at home for 14 days after their last exposure to the index case, and any typical symptoms triggered testing. High-risk contacts (e.g., household and hospital contacts) were tested regardless of symptoms. No secondary clinical cases were detected from all 91 close contacts of the 9 asymptomatic patients. Cheng et al. identified 22 secondary cases, 18 of whom had symptoms. They determined a secondary clinical infection risk of 0.7% (95% confidence interval (CI): 0.4% - 1.0%) among 2,761 close contacts. **For the 299 contacts with exclusive presymptomatic exposures to the index case, the secondary clinical attack rate was 0.7% (95% CI, 0.2%-2.4%)**. The authors noted that the actual contribution of early transmission could be greater as they did not completely identify contacts before symptom onset of the index cases.[42]

- Wei WE et al. reviewed the clinical and epidemiological records of all 243 cases in Singapore to determine whether presymptomatic transmission might have occurred. Of these cases, **157 were locally acquired with 10 (6.4%) attributed to presymptomatic transmission within 7 clusters**, where investigation did not identify any other potential sources of infection. The authors noted that although an unknown source might have caused some of these infections, given that COVID-19 prevalence was very low during the period under investigation and strong surveillance systems were in place, presymptomatic transmission was deemed the most likely mode of transmission. The authors also note that recall bias related the onset date of symptoms might add uncertainty to the duration of the presymptomatic period.[43]

Multiple authors also reported clusters of infections in China where the transmission histories suggest the occurrence of presymptomatic transmission. It should be noted that due to circulation of COVID-19 in China during that time, it is possible that there was another unrecognized source of infection, in addition to the cases reported.

- Gao Y et al. reported a 15-person cluster with 4 generations of transmission and 6 asymptomatic cases in Wuxi. Except the index case, none of the other 14 cases had any history of suspicious exposure except for contact with the previous generation case(s). In this cluster, infections are believed to have spread to the next generation before onset in the previous generation as follows: 2-7 days before onset (1st to 2nd generation), 6-7 days before onset (2nd to 3rd generation), and 3-8 days and 9 days before onset (3rd to 4th generation). The authors noted that generation 2 might also have been infected from other sources while touring in Japan. However, the transmission history of the other generations support the idea of presymptomatic transmission.[44]

- Luo SH et al. reported a cluster of 4 adults in Anqing. Epidemiological evidence suggests that one patient was infected by her husband during the presymptomatic stage of his infection. Neither the wife nor husband had travelled to Wuhan or adjacent areas or had recent exposure to wild animals. However, the husband likely acquired his infection from a relative while the relative was symptomatic.[45]

- Huang L et al. reported a cluster of 8 teenagers and young adults aged 16-23 years in Hefei, originating from a 22-year-old male returning from Wuhan. Six secondary cases became infected after contact of several hours duration with the index case one day before his symptom onset; another secondary case was likely exposed 3 days before the index case's symptom onset. None of the secondary cases had visited Wuhan or had any exposure to wet markets, wild animals, or medical institutes within the previous 3 months.[46]

- Li C et al. described transmission in a familial and hospital settings in Xuzhou. The source case is believed to have acquired his infection on January 14, 2020 during a 6-hour transfer in a train station in Wuhan when travelling to Xuzhou and developed symptoms on January 19, 2020. While caring for his son-in-law in hospital he interacted with another patient and that patient's son from January 15 to 18 (1 to 4 days before the source patient's onset of symptoms); both the other patient and his son became infected. The source case also infected several members of his family whom he was with both before and after the onset of symptoms. Other source(s) of infection, particularly in the hospital setting may also be possible, although were not mentioned by the authors.[47]

- Li P et al. describe a familial cluster of 4 in Zhoushan, who had close contact with a presymptomatic family member 4 to 7 days before the index case's symptom onset. Other than the index case, the family reported no contact with people with fever or respiratory symptoms in Wuhan or other areas with persistent local COVID-19 transmission in the 14 days prior to their symptom onset, and no history of contact with wild animals or poultry.[48]

- Ye F et al. reported a cluster of 5 people from 2 families in Luzhou. The three members of Family 1 traveled from Wuhan to Luzhou on January 22, and met with the two members of Family 2 between January 23 and 25 and on January 30. Family 2 had not left Luzhou and their only contact with anyone from Wuhan was Family 1. The first and last contact between Family 1 and 2 was 13 and 6 days before the first case in Family 1 developed symptoms on February 5. All five family members developed symptoms and the symptoms in the first case in Family 2 started on February 1, 2020, 4 day before the symptoms in Family 1.[49]

- Yu P et al. described an 88-year-old man from Shanghai who developed symptoms 5 days after the arrival of two visitors from Wuhan. The two visitors developed symptoms after the man,

with the earliest symptom onset among the two visitors occurring 11 hours after the man's first symptoms. This suggests that at least one of the visitors had spread infection in their incubation period. Assuming the visitor with the earliest symptom onset transmitted infection to the man, **the earliest the infection could have occurred is from 5 days before onset of illness in that visitor**, based on the date of the visitors' arrival.[50]

- Huang R et al. described a patient from near Wuhan who visited her family in Nanjing and did not develop symptoms until 4 days after leaving Nanjing. She infected six family members, some of whom she lived with and some with whom she attended one or more dinners with, including one on the day before her departure. Two family members, who appear to have been infected at the family dinner with the visiting woman the day before her departure, attended another family dinner with three different relatives. This occurred on the day after the dinner with the visiting woman, and 3 and 4 days before the onset of symptoms. The three relatives subsequently developed symptoms and were found to be infected with COVID-19. **This suggests that transmission can occur at least 5 days before symptom onset and that transmission may occur as early as 1 day following exposure**.[51]

- Tong ZD et al. reported a case of COVID-19 from Wuhan who attended a conference in Zhoushan three days before illness onset. Two colleagues from Zhoushan also attended the conference and dined with the case the following day (2 days before illness onset), sharing the same serving plates. The two colleagues were subsequently confirmed to be infected. **This suggests that the source patient likely infected his two colleagues at least 2 days prior to symptom onset**.[52]

VIROLOGICAL EVIDENCE FOR PRESYMPTOMATIC TRANSMISSION

In addition to epidemiological reports that attribute the source of infection to presymptomatic COVID-19 patients, we found an article that reports on finding viable COVID-19 virus in specimens from patients prior to their symptom onset. Another two studies reported high viral loads in presymptomatic individuals as measured by real-time RT-PCR.

- Arons MM et al. cultured the real time RT-PCR-positive specimens from two point-prevalence surveys in a skilled nursing facility as part of an outbreak investigation (see also Virological Evidence for Asymptomatic Transmission). **Viable virus was isolated from 6 days before to 9 days after symptom onset**. In addition, **high viral RNA loads were detected in all groups with median cycle threshold values at 24.8 in those with typical symptoms and 23.1 for the presymptomatic**. This suggests the potential for substantial viral shedding in presymptomatic cases. No correlation was observed between cycle threshold values and time from symptom onset.[37]

- Kim SE et al. noted very high viral loads (cycle threshold values <20) in specimens from 2 presymptomatic patients two days before symptom onset.[14]

- Zhou R et al. noted significantly higher viral load in nasopharyngeal specimens from presymptomatic patients (median cycle threshold value: 34.5 [IQR 32.2-37.0]) than those from asymptomatic patients (median cycle threshold value: 39.0 [IQR 37.5-39.5]).[12]

MODELLING AND STATISTICAL ANALYSIS

We found a modelling study which estimated that **infectiousness started from 2.3 days (95% CI: 0.8-3.0 days) before symptom onset and peaked at 0.7 days** (95% CI: 2.0 days before symptom onset to 0.2 days after onset). In addition, a number of authors have compared the incubation period with the serial interval of COVID-19. The serial interval is the time from onset of symptoms in one case to the time of symptom onset in the case(s) they infect. When the serial interval is shorter than the incubation period, some transmission is likely to have occurred in the incubation period.

- He X et al. assessed viral RNA load from 414 throat swabs of 94 patients from symptom onset up to 32 days after onset. Viral load based on RT-PCR was observed to be high soon after symptom onset and then declined. The authors then identified 77 transmission pairs from publicly available international sources. Using a mean incubation period of 5.2 days, the serial interval was estimated to have a median of 5.2 days (95% CI: 4.1-6.4 days), with 7.6% having negative serial intervals (which occur when the secondary case's symptom onset precedes that of the primary case). The estimated proportion of presymptomatic transmission was 44% (95% CI: 25-69%).[53]

- From 22 transmission pairs out of 100 confirmed cases in Taiwan, Cheng HY et al. estimated a median incubation period of 4.1 days (95% credible interval, 0.4-15.8) and a median serial interval of 4.1 days (95% credible interval, 0.1-27.8).[42]

- Analyzing published data of 18 transmission pairs with onset dates clearly defined in published articles, Nishiura H et al. estimated a median serial interval of 4.6 days (95% CrI: 3.5-5.9), which was shorter than a mean incubation of approximately 5 days from other published sources.[54]

- Analyzing 16 cases in four transmission generations, Böhmer MM et al. estimated a median incubation period of 4.0 days (IQR 2.3-4.3) and a median serial interval of 4.0 days (IQR 3.0-5.0).[41]

- Assuming a single source of infection for each household, Wu J et al. analyzed 48 secondary cases from index cases in 35 households in Zhuhai, China and estimated a median incubation period of 4.3 days (95% CI: 3.4-5.3) and a serial interval of 5.1 days (95% CI: 4.3-6.2).[25]

- From a cluster of seven people (1 teenager, 6 young adults) infected by a 22 year-old in Hefei, China, Huang L et al. estimated a median incubation period of 2 days (range 1-4) and a median serial interval of 1 day (range 0-4).[46]

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Ontario

This is **“Exhibit H”**
to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022

A Commissioner, etc.

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SYNTHESIS

09/14/2020

Wearing Masks in Public and COVID-19 – What We Know So Far

Introduction

"What We Know So Far" documents are intended to provide an overview of some of the published and unpublished reports related to emerging issues with respect to Coronavirus Disease 2019 (COVID-19). The reports are found through ongoing scanning of the published literature and scientific grey literature (e.g., ProMed, CIDRAP, Johns Hopkins Situation Reports), as well as media reports. For this report, library information specialists at Public Health Ontario searched Ovid MEDLINE, Embase, PsycINFO, EBSCOhost, CINAHL, and Scopus from January 1, 2000 to August 31, 2020 (search strategy available upon request). It is recognized that there may be additional information not captured in this document. As this is a rapidly evolving outbreak, the information will only be current as of the date the document was written.

Key Points

- Public mask-wearing is **likely beneficial as source control** when worn by persons shedding infectious SARS-CoV-2 virus.
- **Mandatory public mask policies** have been associated with a decrease in new COVID-19 cases compared to regions without such policies.
- **Studies evaluating masking in children are limited and have demonstrated variable results** with respect to their effectiveness for source control. However, studies have consistently shown lower adherence, especially in younger children.
- Masking to **protect the wearer is unlikely to be effective in non-healthcare settings**. Existing evidence demonstrates that wearing a mask within households after an illness begins is not effective at preventing secondary respiratory infections.
- There is variability in the effectiveness of homemade and cloth masks. Some materials adequately filter the expulsion of viral droplets from the wearer making them theoretically suitable for **source control**.
- There are theoretical risks of harms from public mask use including self-contamination from improper use and facial dermatitis or discomfort. Children may experience more discomfort from wearing a mask compared to adults. Though there are studies that observe subtle physiologic changes caused by N95 use, there is currently **no evidence that surgical or cloth masks exacerbate respiratory diseases**.

Background

Masks have two potential functions. They may protect the wearer of the mask from exposure (personal protective equipment), or protect individuals from exposure to respiratory aerosols/droplets from the mask wearer, referred to as source control. The use of masks for the general public has been recommended as one of several COVID-19 pandemic mitigation strategies. The Canadian and Ontario governments are currently recommending non-medical face masks or homemade face coverings to be worn by the public when physical distancing cannot be maintained.[1,2] The World Health Organization revised their guidance on June 5, 2020 that "governments should encourage the general public to wear masks in specific situations and settings as part of a comprehensive approach to suppress SARS-CoV-2 transmission".[3,4] These recommendations have been made largely due to the increasing recognition of the importance of pre-symptomatic and asymptomatic transmission and the potential benefit for source control.[5,6] As part of Ontario's school re-opening plans, masks are recommended for children in junior kindergarten (JK) to grade 3 and mandatory for grades 4-12.[7] This *What We Know So Far* was updated on September 8, 2020 and reviews the available evidence for wearing a mask to prevent respiratory viral infections in non-healthcare settings including evidence surrounding homemade masks and evidence specific to children.

Mask-wearing in Non-Healthcare Settings - COVID-19 Studies

No randomized trials have been published so far on mask use by the public during the COVID-19 pandemic. However, observational and ecological studies suggest that mask-wearing provides source control and public mask-wearing mandates have led to reduced daily COVID-19 growth rates.[8-11]

- An ecological report from Germany released in June 2020 utilized Synthetic Control Methodology (SCM) to evaluate the impact of mandatory mask use on public transportation and in sales shops in the city of Jena.[10] On March 30th, the local government in Jena announced that masks would be mandatory starting April 6th, 2020. Masks became mandatory in the rest of Germany between April 20 and 29th, 2020. SCM involves identifying synthetic control groups which were following the same COVID-19 trend as Jena prior to April 6th. The weighted average of this synthetic control group of regions where masks did not become mandatory on April 6th were used as a counterfactual to evaluate the causal effect of mandatory masking. The authors concluded that mandatory masking reduced the daily growth rate of COVID-19 in Jena by 40%. It is not known from this ecological analysis the extent and quality of uptake of mask wearing, the type of masks worn, and if the demonstrated benefit is related to source control, protecting the wearer, or a combination thereof. It is possible there were other public health measures taken in Jena at this time that confound this finding (i.e. physical distancing), and the impact of behavioural change due to mandatory masking was not addressed. However, the authors do note that the timing of the introduction of face masks was not affected by other overlapping public health measures as a general "lock down" had been in place for two weeks. This report has not been peer-reviewed.[10]
- Lyu et al. 2020 performed an observational event analysis, similar to a difference-in-differences design, which provides evidence that states in the United States (US) mandating face mask use in public had a greater decline in daily COVID-19 cases compared to states that did not issue mandates.[11] Sixteen regions issued mask mandates between April 8th and May 15th. Compared to states without mandates, daily COVID-19 growth rates significantly declined by 0.9%, 1.1%,

1.4%, 1.7%, and 2.0% at 1-5, 6-10, 11-15, 16-20, and 21 or more days following the state mandate, respectively. In another analysis, the authors evaluated the impact of employee-only mandates (no public community requirement) and did not find a significant impact from those more targeted mask mandates. While the authors attempted to adjust for other public health measures in their models, residual confounding is possible. This study was unable to assess masking adherence by the public, but provides supporting evidence that state-level mask mandates may have been effective in reducing COVID-19 case numbers.[11]

- Xu et al. 2020 conducted an interrupted time series evaluating trends in new COVID-19 cases and deaths in the US.[12] The authors report slope changes which they attribute to stay-at-home orders on March 23rd (slope change: -0.18, 95% CI: -0.22 to -0.14) and face mask recommendations by the US Centers for Disease Control and Prevention (CDC) on April 3rd (slope change: -0.10, 95% CI: -0.18 to -0.08). Two delayed slope changes were also identified in new deaths on April 9th (slope change: -0.17, 95% CI: -0.21 to -0.14) and April 19th (slope change: -0.13, 95% CI: -0.25 to -0.07). There is a high risk of residual confounding in this study. The attribution of the initial slope change to these two policy interventions is very close together and it is unlikely that the CDC recommendation on April 3rd would result in an immediate change in incidence of new cases. Furthermore, this observational study was unable to account for the multiple simultaneous public health interventions occurring.[12]
- Cheng et al. 2020 report COVID-19 data from Hong Kong with 11 clusters (113 cases) from "mask-off" settings (dining, karaoke, fitness clubs) compared to 3 clusters (11 cases) from "mask-on" settings in workplaces (p=0.036).[13] However, this study cannot differentiate if the differences are related to masks versus physical distancing and increased expulsion of droplets (i.e., singing, exercising) in these settings. They also describe COVID-19 epidemiology in Hong Kong, which had a daily mask compliance of >95%, compared to representative countries in North America, Europe, and Asia and describe significantly lower COVID-19 incidence in Hong Kong. These findings also have potential confounding from broad public health measures of strict quarantine and physical distancing guidance early on in the pandemic in Hong Kong.[13]
- Wang et al. 2020 conducted a retrospective cohort study of household contacts of COVID-19 cases for predictors of secondary transmission in Beijing, China.[9] The overall secondary attack rate was 23% and they found that if it was reported that one or more family members (primary case or family contacts) wore face masks **prior to the development of symptoms**, then there was a 79% reduction in transmission (OR=0.21, 95%CI: 0.06-0.79). Of note in this study was no protective effect of mask-wearing by household contacts if initiated after symptom-onset in the primary case. The findings are associated with the inherent limitations with telephone interview including recall bias.[9]
- Hong et al. 2020 conducted contact tracing of 197 residents in Taizhou, China exposed to 41 presymptomatic COVID-19 positive cases who returned from Wuhan in January 2020.[8] The secondary attack rates from 28 mask-wearing presymptomatic cases was 8.1% (10/123) compared to 19.0% (14/74) from 13 non-mask-wearing presymptomatic cases (p<0.001).[8]
- A contact investigation of two hairstylists with respiratory symptoms and confirmed COVID-19 who wore cloth face masks during close contact with 139 clients did not result in any secondary transmissions (67 of whom tested negative for SARS-CoV-2 by RT-PCR).[14]
- Two case reports describe no in-flight transmission aboard an airplane with symptomatic COVID-19 cases who wore masks during the flight.[15,16]
- Chou et al. 2020 are conducting a living rapid systematic review on the effectiveness of mask use in both healthcare and community settings.[17] As of their most recent update on September

1st, 2020, they have identified one study by Wang et al., discussed above. Updates are expected every 1-2 months.[17]

Mask-wearing as Source Control – Non-COVID-19 Studies

Studies to date have found that the use of medical masks may reduce the amount of aerosol/droplet shedding of some bacteria and viruses from symptomatic individuals, but have inconsistently demonstrated a reduction in secondary cases in household or other close contact studies.

- MacIntyre et al. 2020 re-analyzed data from a previous clinical trial using only seasonal coronavirus data.[18] They identified 10 index cases in the mask group and 9 controls. There was no secondary transmission in either group, although 5/9 control index cases reported wearing a mask.[18]
- Barasheed et al. 2014 conducted a pilot study randomizing tents at the Hajj to 'supervised mask use' (mask use 76%) or 'no supervised mask use' (mask use 12%) for both individuals with influenza-like illness (ILI) and their contacts who slept within 2 meters.[19] They found less ILI among contacts in the mask group (31% versus 53%, p=0.04); however, there were no differences in laboratory-confirmed respiratory virus detections.[19]
- MacIntyre et al. 2016 performed a cluster randomized controlled trial (RCT) of surgical masks for patients with ILI (n=123) compared to controls (n=122) evaluating the risk of secondary cases in household contacts.[20] There were no statistically significant differences in clinical respiratory illness (relative risk (RR) 0.61, 95% CI 0.18 to 2.13), ILI (RR 0.32, 95% CI 0.03 to 3.13) or laboratory-confirmed viral infections (RR 0.97, 95% CI 0.06 to 15.54). As one third of controls wore masks, the authors conducted a post-hoc per protocol analysis and there was a statistically significant protective effect in clinical respiratory infections (RR 0.22, 95% CI 0.06 to 0.86), but not laboratory-confirmed respiratory infections.[20]
- Stockwell et al. 2018 found that mask-wearing significantly reduced the release of *Pseudomonas aeruginosa* aerosols during coughing in people with cystic fibrosis compared to uncovered coughing.[21] The results were similar for surgical masks and N95 respirators.[21]
- Milton et al. 2013 examined exhaled breath samples from symptomatic people infected with seasonal influenza viruses and found that surgical masks reduced the amount of viral aerosol shedding by 3.4 fold overall, ranging from 2.8 to 25 fold depending on particle size.[22]
- Dharmadhikari et al. 2012 studied patients with multidrug-resistant tuberculosis and demonstrated that surgical mask-wearing significantly reduced transmission in experimental conditions.[23]
- Leung et al. 2020 studied surgical mask-wearing in 246 symptomatic individuals with influenza, rhinovirus, and seasonal coronaviruses.[24] They found a significant reduction in virus by polymerase chain reaction testing of exhaled breath droplets and aerosols in the 124 individuals randomized to wearing masks (4/10 versus 0/11, p=0.04). This study did not confirm if the quantity of virus was infectious.[24]

Evidence for Mask Use in Children

There have been no studies evaluating mask use for COVID-19 source control in children. However, there have been 4 cluster RCTs evaluating mask use for influenza prevention in the community that included children as the index cases. Two studies found a possible protective effect for masking and hand hygiene (HH) together, particularly if the intervention was implemented within 36 hours of symptom-onset in the index case,[25,26] while two studies found no apparent protective effect.[27,28]

However, in all studies, mask-adherence when reported was generally poor and the effects may have been related to adults in the study wearing masks, children wearing masks for source control, or a combination thereof. The one study which evaluated masking alone for source control (33% of the index cases were children) did not demonstrate any benefit.[27] One observational study in Japan found a small reduction in influenza infections from self-reported mask-wearing in schools.[29]

- Canini et al. 2010 performed a cluster RCT of masking the index patient for five days after testing positive for influenza on a rapid test to prevent secondary household transmission. ILI was reported in 16.2% of contacts where the index case was masked, and 15.8% when the index case was not masked; there were no significant differences between surgical mask and control groups. This study included 35 (33%) children <15 years as the index case. The analysis was not stratified by age; however, children were significantly more likely to report mask discomfort (i.e., reported feeling pain), compared to adults (3/12 [25%] vs. 1/39 [2.6%], p=0.036).[27]
- Suess et al. 2012 conducted a cluster RCT comparing masking, masking + HH, or control in 84 households, including index cases, with influenza infection in the 2009/10 and 2010/11 seasons.[25] There was no significant effect from either intervention in the primary analysis. Almost all index cases were children <14 years (81/84 [96%]). The average daily adherence to masking by index patients ranged from 40-60% and decreased over time. There was a potential effect observed in the subgroup that implemented masking + HH within 36 hours of symptom-onset of the index case (adjusted odds ratio (OR): 0.16, 95% CI: 0.03-0.92).[25]
- Simmerman et al. 2011 performed a cluster RCT of 442 households in Thailand during the influenza H1N1 pandemic comparing HH, HH + masking with surgical masks, or control to prevent influenza transmission in households with an influenza-positive child.[28] 50% (221/442) of the index patients were <6 years of age. There were no differences in clinical or laboratory-confirmed influenza in either intervention arm (HH + mask compared to control; OR: 1.16; 95% CI: 0.74-1.82). Adults wore their masks for a median of 153 (IQR: 40-411) minutes per day compared to 35 (IQR: 4-197) minutes in the child index cases.[28]
- Larson et al. 2010 conducted a cluster RCT in 509 households and 2,788 individuals (47.3% children ≤ 17 years) comparing health education (HE), HE + HH, or HE + HH + masking with surgical masks on incidence and secondary transmission of upper respiratory tract infections and influenza.[26] There was a significant decrease in secondary respiratory infections in the HE + HH + mask group compared to HE alone (OR: 0.82, 95% CI: 0.70-0.97). This study did not evaluate a masking-only group and while index cases were encouraged to wear masks in the masking group, adherence to mask use was reported as poor by the authors.[26]
- Uchida et al. 2017 conducted an observational questionnaire-based study with 10,524 school-aged children in Japan, of whom 5,474 (52.0%) reported wearing masks.[29] In the multivariable logistic regression model, wearing a mask was associated with reduced risk of influenza infection (OR: 0.86; 95% CI: 0.78-0.95). 21.5% of non-mask-wearing children in grades 4-6 were diagnosed with influenza compared to 18.9% of mask-wearing children (relative effectiveness 12.0%, absolute risk reduction 2.6%). 21.3% of non-mask-wearing children in grades 1-3 were diagnosed with influenza, compared to 20.2% of mask-wearing children (relative effectiveness 5.3%, absolute risk reduction 1.1%). No statistical analysis was performed on the subgroups by age.[29]
- Chen et al. 2020 conducted a survey of 3,649 school-aged children 6-13 years of age about mask use.[30] 51.6% reported good mask-wearing behaviour, with older children (grades 5-6 compared to grades 1-2; OR 1.21, 95% CI; 1.03-1.43), and parental educational level, being associated with better reported mask-wearing behaviour.[30]

- Allison et al. 2010 conducted a survey of teachers after distributing masks to both teachers and students for 4 weeks.[31] Teachers reported that 39% of them thought mask use was not disruptive and 35% reported they would use masks again the following winter. However, 97% reported they would use masks during a pandemic. By direct observation only 30% of students wore masks in week 1 of the study, which decreased to 15% in week 2.[31]
- Stebbins et al. 2009 conducted a parent and teacher survey on nonpharmaceutical interventions to prevent influenza in schools.[32] Student mask-wearing was among the lowest acceptable interventions by both parents and teachers.[32]
- Van der Sande et al. 2008, discussed further in the next section, compared homemade tea cloth masks, surgical masks, and FFP-2 (European equivalent of N95 respirators) in 28 healthy adult volunteers and 11 children between the ages of 5-11 years performing various physical maneuvers and measured quantitative differences in particles with a Portacount®.[33] There were no differences in median protection factors between adults and children.[33]

Protective Effects to the Mask-wearer in Non-Healthcare Settings - Non-COVID-19 Viral Respiratory Infections

Randomized Trials

There have been several cluster randomized studies on the use of medical masks outside of the hospital setting. These studies have evaluated the effectiveness of masking household members and individuals in other confined spaces (e.g. university residences, airplanes) to prevent acquisition of respiratory infections. In the majority of studies, no significant benefit from wearing masks was identified. Studies that demonstrated a benefit were associated with enhanced hand hygiene measures. No RCTs evaluating the effectiveness of mask use by the public to decrease COVID-19 infections have been completed, however there is a trial in Denmark under way (NCT04337541).[34]

- Dugre et al. 2020 performed an umbrella systematic review of masks in healthcare workers and the public.[35] They identified 11 systematic reviews, with 18 RCTs, of which 12 were in the community. In their meta-analysis, mask-wearing by the public did not reduce clinical respiratory infection (RR=1.06, 95% CI; 0.82-1.36; I^2=0%) or confirmed influenza or other viral respiratory infection.[35] The authors pooled the two studies below by Aiello from 2010 and 2012 and identified a significant protective effect on mask-wearing in university dormitories for ILI (RR=0.83, 95% CI; 0.69-0.99; I^2=0%; NNT=24).[36,37]
- Aggarwal et al. 2020 pooled controlled trials and did not identify a significant effect for either mask use alone versus control (5 studies, pooled effect size (pES) -0.17, 95%CI -0.43 to 0.10) or mask use with HH versus control (6 studies, pES -0.09, 95%CI -0.58 to 0.40), in reducing ILI in household and university settings.[38]
- Aiello et al. 2012 conducted a cluster RCT in university residents comparing three arms: HH + masking, masking alone, or control. They found no effect in the primary analysis of ILI or laboratory-confirmed respiratory infections. However, there was a significant effect on ILI in weeks 3-6 of the study in the mask + HH arm (RR = 0.25, 95% CI, 0.07 to 0.87), but not in the mask-only arm, suggesting the effect may have been due to HH.[37]
- Aiello et al. 2010 performed a cluster RCT in university residence halls with 3 arms; masking with surgical masks, masking + HH, or no intervention. In the primary adjusted analysis there were no

significant differences in the mask only group (relative risk (RR) 0.90, 95% confidence interval (CI) 0.77-1.05) or mask + HH group (RR 0.87, 95% CI 0.73-1.02).[36]

- Cowling et al. 2009 performed a cluster RCT of 259 households with confirmed influenza patients.[39] Households (≥3 people) were randomized to either HE (control), HH, or HH + masking with surgical masks. The study included 189 (73%) index cases <16 years. There was no statistically significant difference in either laboratory-confirmed or clinical influenza infection between the 3 groups. In a post-hoc analysis limited to those that applied the intervention within 36 hours of symptom-onset in the index case, mask + HH reduced laboratory-confirmed influenza infections (OR: 0.33, 95% CI; 0.13-0.87), but not clinically-defined influenza. Self-reported mask adherence + HH for index cases and contacts was 49% and 26%, respectively. The authors conclude that if applied early, masks + HH for household contacts of influenza-infected individuals may be effective.[39]
- MacIntyre et al. 2009 performed a cluster RCT of adult household members masking after a child was diagnosed with a respiratory illness. They compared surgical mask, N95 respirator, or control. There were no significant differences between either type of mask and control; however, mask adherence was low.[40]

Non-randomized Studies

Systematic reviews and meta-analyses of observational studies for non-COVID infections have found protective effects from mask-wearing. In contrast to the largely negative randomized trials above, the results of these studies should be interpreted cautiously considering the substantial biases present from the original studies used in these meta-analyses.

- Liang et al. 2020 performed a systematic review and meta-analysis of mask effectiveness. Of the 21 identified studies for inclusion, 8 were in non-healthcare workers.[41] The pooled results of these 8 studies published from 2004-2014 showed a significant protective effect from mask-wearing (OR: 0.53; 95% CI; 0.36-0.79, I^2=45%). However, a number of trials were not included and the observed effect was predominately driven by observational studies (not RCTs).[41]
- Chu et al performed a systematic review and meta-analysis utilizing observational data from Severe Acute Respiratory Syndrome (SARS), Middle East Respiratory Syndrome (MERS), and COVID-19 health-care and non-health care studies to evaluate the protective effects of physical distancing, mask use, and eye protection.[42] Overall, mask use (non-medical, medical or respirator) was effective (unadjusted studies OR 0.34, 95%CI 0.26-0.45; adjusted studies OR 0.15, 95%CI 0.07-0.34); however, from the three included non-healthcare settings (all patients with SARS) masks were significantly less protective compared to healthcare settings (OR 0.56, 95%CI 0.40-0.79, $p_{intereraction}$=0.049). The applicability of these studies to non-healthcare transmission of COVID-19 are questionable.[42]
- Saunders-Hastings et al. 2017 conducted a systematic review and meta-analysis on the effect of personal protective measures on pandemic influenza transmission.[43] The meta-analysis found regular HH provided a significant protective effect against pandemic viral transmission (OR = 0.62; 95% CI 0.52–0.73), but the effect of facemask use was not statistically significant (OR = 0.53; 95% CI 0.16–1.71).[43]
- There is a body of literature on wearing masks at mass gatherings (e.g. Hajj). Barasheed et al. 2016 performed a systematic review of 25 studies.[44] The studies were heterogeneous and generally of poor quality; however, the authors pooled results from 13 studies of masking involving 7,652 participants and found a small but significant protective effect against respiratory infections (RR 0.89 95% CI 0.84-0.94).[44]

- Zhang et al. 2013 conducted an observational study that evaluated the risk of influenza pH1N1 on two flights, after several passengers developed infections.[45] They found that on one flight from New York to Hong Kong there were 9 infections in passengers compared to 32 asymptomatic controls. None of the infected passengers wore masks compared to 15 (47%) of the controls who did wear masks. The index case was never identified. The authors concluded that wearing a mask on this flight was potentially protective.[45]

Homemade and Cloth Masks

Given the challenges in maintaining personal protective equipment supply during the COVID-19 pandemic, the use of homemade and/or cloth masks is the recommended mask type for use in non-healthcare settings. Broadly speaking, there are two types of studies on the effectiveness of cloth masks: studies that evaluate filter efficiency in a laboratory setting, and studies that evaluate infection risk to the wearer and those around them. There are more of the former studies which generally agree that at least some filtration occurs under certain conditions; the latter have observed some evidence for reduction of viral respiratory transmission at the population level, although have not proven such masks effective at an individual level. Overall, the evidence suggests there is variability in the effectiveness of cloth masks and that they are generally inferior to medical masks. One study in a healthcare setting demonstrated that cloth masks were associated with an increased risk of infection and they should not be used to protect healthcare workers.[46] However, the body of evidence supports that certain cloth materials provide sufficient filtration to be a suitable option for source control in non-healthcare settings. With respect to the materials used in cloth masks, a few studies looked at filtration efficiency in a lab setting, and generally agreed that cotton materials with high thread count were more efficient than other materials. There was some variability in findings of filtration efficiency with respect to layered designs and combining materials. Adding electrostatic charge was also noted to improve filtration efficiency.

- Ho et al. 2020 compared a 3-layer 100% cotton mask versus surgical mask and found 86.4% and 99.9% filtration efficiency, respectively.[47] They recruited 211 infected adult volunteers (205 influenza, 6 suspected COVID-19) and compared particle concentrations without masks, with medical masks, and with cotton masks. Both surgical and cotton masks significantly reduced ($p=0.03$) filtered particles, compared to no mask, with no significant differences between mask types.[47]
- Ma et al. 2020 conducted an experiment, using an avian influenza virus, on the comparable efficiency between N95, surgical masks, and homemade masks (made from 4 layers of “kitchen paper” plus 1 layer of polyester cloth) to block nebulizer-produced aerosols.[48] They found that the masks blocked 99.9%, 97.1%, and 95.2% of aerosols, respectively.[48]
- Davies et al. 2013 in an experimental study found that masks made from 100% cotton t-shirts had about 50% the median-fit factor of surgical masks.[49] Both masks blocked microorganisms expelled; however, surgical masks were three times more effective.[49]
- Dato et al. 2006 fashioned a nine-ply (one outer layer and eight inner layers) face mask out of heavy-weight 100% cotton T-shirt material, and achieved a maximum fit factor of 67 using quantitative measurements (a Portacount Fit Tester), with minimal discomfort or difficulty breathing reported in the three test subjects.[50] Note that National Institute for Occupational Safety and Health (NIOSH)-approved N95 respirators are required to have a fit factor of 100.[50]
- Rengasamy et al. 2010 similarly found in experimental conditions that cloth masks and various fabric materials were much less efficient than N95 respirators at filtering various size aerosols.[51] Sodium chloride (NaCl) aerosol penetration tests were run at face velocities of 5.5 and 16.5 cm/s

flow rates, using a NIOSH particulate respirator certification method for polydisperse (various size) NaCl aerosol and a TSI 3160 Fractional Efficiency Tester for monodisperse (specific size) NaCl aerosol. Percentage penetration (ratio of downstream to upstream concentration) for cloth masks and fabric ranged from 40-90% for polydisperse aerosols, compared to N95 penetrations of 0.12% and <5% at the lower and higher velocities, respectively. For monodisperse aerosols, penetration varied by particle size and fabric type in the 20-1000 nm range. Certain fabrics (e.g., towels and scarves) had slightly lower penetration (around 20-80% for towels, increasing with particle diameter), which was noted by the authors to be comparable to other studies of surgical mask penetration levels (measured in cited studies ranging from 51-89%). They conclude that fabric materials provide minimal respiratory protection to the wearer from aerosol-sized particles, but that "the use of improvised fabric materials may be of some value compared to no protection at all when respirators are not available."[51]

- MacIntyre et al. 2015 conducted a cluster RCT (N=1,607) on the effectiveness of cloth or surgical masks, compared to routine practices (personal protective equipment as needed), in hospital healthcare workers.[46] The primary outcomes were rates of ILI or laboratory-confirmed respiratory viral infection. Infection rates were highest in the cloth mask group, with an RR for ILI of 13 compared to the medical mask arm, an RR for ILI of 6.6 compared to the control arm, and an RR for laboratory-confirmed virus of 1.7 compared to the medical mask group. Penetration of particles in cloth masks was 97%, compared to 44% in the medical masks.[46]
- Van der Sande et al. 2008 compared homemade tea cloth masks, surgical masks, and FFP-2 (European equivalent of N95 respirators) in healthy volunteers performing various physical maneuvers and measured quantitative differences in particles with a Portacount®.[33] They calculated median protection factors (or PFs, the ratio of particle concentrations sized 0.02-1 µm outside to inside the mask) of 2.2-3.2 for cloth masks, 4.1-5.3 for surgical masks, and 66-113 for FFP-2 respirators among the adult volunteers. Marginal protection was seen for all mask types when testing for reduction in outgoing transmission of respiratory particles.[33]
- Konda et al. 2020 evaluated filtration efficiency for particle sizes in the 10nm to 10µm range for 15 different cloth types (e.g. cotton, silk, flannel, etc.).[52] These were evaluated in different configurations (e.g. layers, combinations, and with simulated "gaps" in seal as may be expected in real-world use), and compared to N95 and surgical masks, using an aerosol generator. They observed that combinations of materials (e.g. high threads-per-inch cotton along with silk, chiffon, or flannel) filtered particles across the tested size spectrum (<300nm-6um), and that was likely due to the combined effects of electrostatic and physical filtering, with efficiencies that were generally >80%. They also noted a significant drop in filter efficiency with simulated gaps, 60% drop in the >300 nm range, and this was observed for all materials including N95 and surgical masks.[52]
- Zhao et al. 2020 evaluated filtration efficiency for various common household materials (e.g. cotton, silk, nylon), as well as materials used in N95 and surgical masks (i.e. polypropylene).[53] Filtration efficiency for polypropylene in N95 masks was >95%, whereas for most other materials (including polypropylene from surgical masks) ranged from 5-30%. The authors noted that the testing did not account for leakage that would be expected in real-world settings, which would reduce efficiency further.[53]
- Lustig et al. 2020 evaluated filtration efficiency using simulated cough/sneeze-generated aerosols comprised of fluorescent aqueous droplets (intended to simulate viruses), testing over 70 different common fabric combinations.[54] Combinations of materials with hydrophilic, hydrophobic, and absorbent layers were most efficient, and were comparable to materials in N95 respirators in this laboratory setting.[54]

- Zangmeister et al. 2020 evaluated 32 different cloth materials and combinations of materials using NaCl aerosols of diameters of 50-825nm, and found that 3 of 5 top performing materials were high thread-count cottons.[55]

Risks Associated with Wearing Masks

Mask use by the general public could be associated with a theoretical elevated risk of COVID-19 through decreased physical distancing and self-contamination. The external surface of the mask may become contaminated and touching one's face is a common practice.[56] Continuous mask use may be associated with facial skin lesions, irritant dermatitis, impaired vision in those wearing glasses, or worsening acne.[4,57,58] One study observed physiologic respiratory changes from the use of N95 respirators in healthcare workers (with prolonged use), these finding were subtle and not considered clinically relevant.[59] Another study in healthcare workers reported various subjective complaints (e.g. headache, impaired cognition); however, only skin effects (e.g. irritation, acne) were consistently noted.[60] The Canadian Thoracic Society position statement on mask use for the public states, "There is NO evidence that wearing a face mask will exacerbate (cause a 'flare up' of) an underlying lung condition."[61] Studies in children have identified low adherence to proper use in school settings.[30-32] No study has evaluated the impact of mask use on children's education quality. Further studies are needed on optimal methods for optimizing mask use in children.

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Ontario Agency for Health Protection and Promotion (Public Health Ontario). Wearing masks in public and COVID-19 – what we know so far. Toronto, ON: Queen's Printer for Ontario; 2020.

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Ontario

This is **"Exhibit I"**
to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022

A Commissioner, etc.

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SYNOPSIS

02/02/2021

Review of "Rapid review on the characteristics of effective non-medical face masks in reducing the risk of SARS-CoV-2 transmission"

Article citation: Young K, Otten A. Rapid review on the characteristics of effective non-medical face masks in reducing the risk of SARS-CoV-2 transmission [Internet]. Ottawa, ON: Public Health Agency of Canada; 2021 [cited 2021 Jan 27]. Available upon request from: https://www.nccmt.ca/covid-19/covid-19-evidence-reviews/261

One-Minute Summary

- This rapid review examined the evidence on the characteristics and efficacy of non-medical masks in reducing severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission.
- **Primary findings of the rapid review:**
  - Experimental simulation studies have found that non-medical masks were more effective for source control (i.e., preventing the spread of SARS-CoV-2 if worn by an infectious person) than preventing infections in the person wearing the mask.
  - Non-medical masks reduced the distance respiratory droplets travelled during indoor talking, coughing and sneezing.
  - The filtration efficiency of non-medical face masks (with variable designs and fabrics) ranged from less than 10% to more than 95% in 42 studies.
  - The efficacy of non-medical masks depended on: 1) filtration efficiency, 2) breathability, and 3) fit.
    - When non-medical masks were made from high quality fabrics consisting of multiple layers and snug fit, they reduced the expulsion of respiratory droplets, although to a lesser extent than medical masks.
- **The characteristics of non-medical masks that reduced the risk of spreading or contracting SARS-CoV-2 included:**
  - Tight-fitting, double-layer masks with different material types (e.g., combed cotton and polyester) or masks made from one type of material but with greater than 2 layers exhibited similar source reduction efficiencies as medical masks (>90%). Loose-fitting non-medical masks reduced filtration effectiveness by more than 50% in some studies.
  - Multiple-layer non-medical masks improved filtration efficiency, but masks with more than three layers reduced breathability.
  - Fabrics should be of high-quality and tightly woven, including hydrophobic fabrics (e.g., polyester, spunbound polypropylene, polyaramid); fabrics that can capture charged particles (e.g., polyester, silk); or fabrics with hydrophilic properties that increase comfort

and longevity (e.g., cotton). The filtration efficiencies of most household fabrics were higher for larger, low-velocity respiratory droplets.
    - A triple-layered mask made of a hydrophobic exterior, blended non-woven fabric middle, and hydrophilic interior was the ideal combination for source reduction and potential infection prevention.
- The authors stated that "The existing research on how effective non-medical masks are is of low quality and results will likely change with additional research".

Additional Information

- The authors included 54 primary research articles in their rapid review. Twenty-two studies investigated non-medical masks as source control and 37 studies investigated how non-medical masks can prevent infection. Studies used human volunteers (n=15), manikins (n=15), filter-holders (n=34) and animal models (n=1). Of note, filter holder studies use fabric samples mounted in place by a filter holder and do not take fit of a human face into account.
- Non-medical masks, whether homemade or manufactured, are not considered personal protective equipment since they do not undergo standardized testing. Non-medical masks are not recommended for use by healthcare professionals and those with an increased risk of infection where physical distancing cannot be maintained.
- **Fabrics and designs to avoid in non-medical face masks:**
    - Avoid using vacuum cleaner bags as fabric, as they may contain harmful ingredients and fibers.
    - Avoid loosely-folded face masks, bandana-style face masks, and single-layered neck gaiters, as they do not effectively block respiratory droplets.
    - Avoid respirators with an exhalation valve, as these masks are not effective for source control.
- **Limitations:**
    - The majority of included studies were experimental and used non-human models. None of the studies identified how effective specific types of non-medical masks are in real-world settings.
    - The types and composition of non-medical masks used in the included studies, along with variability in fit and methodologies, made comparisons among studies difficult.
    - Studies that examined filtration efficiency used a variety of methods that targeted a wide variety of droplet sizes (<1 to >5 µm in diameter) using artificial materials. This variability made it difficult to compare filtration efficiencies between studies.

PHO Reviewer's Comments

- The evidence comparing non-medical masks to medical grade masks is limited to experimental studies evaluating filtering efficiency and is not based on clinical or real-world settings. The clinical data on public mask-wearing has been reviewed separately.[1]
- The body of evidence supports mask-wearing in public as effective for source control with possible synergistic effects for infection prevention if both the source and contact are appropriately wearing well-fitted non-medical masks.
- Experimental data supports higher quality masks, such as 3-layer non-medical masks or medical grade masks, as providing superior filtering efficiency. By inference, this may reduce the potential for transmission.

- Variants of Concern (VOC) have emerged in Ontario which have been associated with increased transmissibility. At the time of posting no studies have evaluated the relative effectiveness of different mask types in mitigating transmission from SARS-CoV-2 VOCs.[2]

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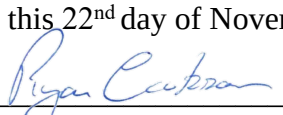
Ontario

This is **"Exhibit J"**
to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022



A Commissioner, etc.

Mask use in the context of COVID-19

Interim guidance

1 December 2020

World Health Organization

This document, which is an update of the guidance published on 5 June 2020, includes new scientific evidence relevant to the use of masks for reducing the spread of SARS-CoV-2, the virus that causes COVID-19, and practical considerations. It contains updated evidence and guidance on the following:

- mask management;
- SARS-CoV-2 transmission;
- masking in health facilities in areas with community, cluster and sporadic transmission;
- mask use by the public in areas with community and cluster transmission;
- alternatives to non-medical masks for the public;
- exhalation valves on respirators and non-medical masks;
- mask use during vigorous intensity physical activity;
- essential parameters to be considered when manufacturing non-medical masks (Annex).

Key points

- The World Health Organization (WHO) advises the use of masks as part of a comprehensive package of prevention and control measures to limit the spread of SARS-CoV-2, the virus that causes COVID-19. A mask alone, even when it is used correctly, is insufficient to provide adequate protection or source control. Other infection prevention and control (IPC) measures include hand hygiene, physical distancing of at least 1 metre, avoidance of touching one's face, respiratory etiquette, adequate ventilation in indoor settings, testing, contact tracing, quarantine and isolation. Together these measures are critical to prevent human-to-human transmission of SARS-CoV-2.
- Depending on the type, masks can be used either for protection of healthy persons or to prevent onward transmission (source control).
- WHO continues to advise that anyone suspected or confirmed of having COVID-19 or awaiting viral laboratory test results should wear a medical mask when in the presence of others (this does not apply to those awaiting a test prior to travel).
- For any mask type, appropriate use, storage and cleaning or disposal are essential to ensure that they are as effective as possible and to avoid an increased transmission risk.

<u>Mask use in health care settings</u>

- WHO continues to recommend that health workers (1) providing care to suspected or confirmed COVID-19 patients wear the following types of mask/respirator in addition to other personal protective equipment that are part of standard, droplet and contact precautions:
  - medical mask in the absence of aerosol generating procedures (AGPs)
  - respirator, N95 or FFP2 or FFP3 standards, or equivalent in care settings for COVID-19 patients where AGPs are performed; these may be used by health workers when providing care to COVID-19 patients in other settings if they are widely available and if costs is not an issue.
- In areas of known or suspected community or cluster SARS-CoV-2 transmission WHO advises the following:
  - universal masking for all persons (staff, patients, visitors, service providers and others) within the health facility (including primary, secondary and tertiary care levels; outpatient care; and long-term care facilities)
  - wearing of masks by inpatients when physical distancing of at least 1 metre cannot be maintained or when patients are outside of their care areas.
- In areas of known or suspected sporadic SARS-CoV-2 transmission, health workers working in clinical areas where patients are present should continuously wear a medical mask. This is known as targeted continuous medical masking for health workers in clinical areas;
- Exhalation valves on respirators are discouraged as they bypass the filtration function for exhaled air by the wearer.

<u>Mask use in community settings</u>

- Decision makers should apply a risk-based approach when considering the use of masks for the general public.
- In areas of known or suspected community or cluster SARS-CoV-2 transmission:
  - WHO advises that the general public should wear a non-medical mask in indoor (e.g. shops, shared workplaces, schools - see Table 2 for details) or outdoor settings where physical distancing of at least 1 metre cannot be maintained.
  - If indoors, unless ventilation has been be assessed to be adequate[1], WHO advises that the general public should wear a non-medical mask, regardless of whether physical distancing of at least 1 metre can be maintained.

[1] For adequate ventilation refer to regional or national institutions or heating, refrigerating and air-conditioning societies enacting ventilation requirements. If not available or applicable, a recommended ventilation rate of 10 l/s/person should be met (except healthcare facilities which have specific requirements). For more information consult "Coronavirus (COVID-19) response

  - Individuals/people with higher risk of severe complications from COVID-19 (individuals ≥ 60 years old and those with underlying conditions such as cardiovascular disease or diabetes mellitus, chronic lung disease, cancer, cerebrovascular disease or immunosuppression) should wear medical masks when physical distancing of at least 1 metre cannot be maintained.
- In any transmission scenarios:
  - Caregivers or those sharing living space with people with suspected or confirmed COVID-19, regardless of symptoms, should wear a medical mask when in the same room.

Mask use in children (2)

- Children aged up to five years should not wear masks for source control.
- For children between six and 11 years of age, a risk-based approach should be applied to the decision to use a mask; factors to be considered in the risk-based approach include intensity of SARS-CoV-2 transmission, child's capacity to comply with the appropriate use of masks and availability of appropriate adult supervision, local social and cultural environment, and specific settings such as households with elderly relatives, or schools.
- Mask use in children and adolescents 12 years or older should follow the same principles as for adults.
- Special considerations are required for immunocompromised children or for paediatric patients with cystic fibrosis or certain other diseases (e.g., cancer), as well as for children of any age with developmental disorders, disabilities or other specific health conditions that might interfere with mask wearing.

Manufacturing of non-medical (fabric) masks (Annex)

- Homemade fabric masks of three-layer structure (based on the fabric used) are advised, with each layer providing a function: 1) an innermost layer of a hydrophilic material 2) an outermost layer made of hydrophobic material 3) a middle hydrophobic layer which has been shown to enhance filtration or retain droplets.
- Factory-made fabric masks should meet the minimum thresholds related to three essential parameters: filtration, breathability and fit.
- Exhalation valves are discouraged because they bypass the filtration function of the fabric mask rendering it unserviceable for source control.

Methodology for developing the guidance

Guidance and recommendations included in this document are based on published WHO guidelines (in particular the WHO Guidelines on infection prevention and control of epidemic- and pandemic-prone acute respiratory infections in health care) (2) and ongoing evaluations of all available scientific evidence by the WHO ad hoc COVID-19 Infection Prevention and Control Guidance Development Group (COVID-19 IPC GDG) (see acknowledgement section for list of GDG members). During emergencies WHO publishes interim guidance, the development of which follows a transparent and robust process of evaluation of the available evidence on benefits and harms. This evidence is evaluated through expedited systematic reviews and expert consensus-building through weekly GDG consultations, facilitated by a methodologist and, when necessary, followed up by surveys. This process also considers, as much as possible, potential resource implications, values and preferences, feasibility, equity, and ethics. Draft guidance documents are reviewed by an external review panel of experts prior to publication.

Purpose of the guidance

This document provides guidance for decision makers, public health and IPC professionals, health care managers and health workers in health care settings (including long-term care and residential), for the public and for manufactures of non-medical masks (Annex). It will be revised as new evidence emerges.

WHO has also developed comprehensive guidance on IPC strategies for health care settings (3), long-term care facilities (LTCF) (4), and home care (5).

Background

The use of masks is part of a comprehensive package of prevention and control measures that can limit the spread of certain respiratory viral diseases, including COVID-19. Masks can be used for protection of healthy persons (worn to protect oneself when in contact with an infected individual) or for source control (worn by an infected individual to prevent onward transmission) or both.

However, the use of a mask alone, even when correctly used (see below), is insufficient to provide an adequate level of protection for an uninfected individual or prevent onward transmission from an infected individual (source control). Hand hygiene, physical distancing of at least 1 metre, respiratory etiquette, adequate ventilation in indoor settings, testing, contact tracing, quarantine, isolation and other infection prevention and control (IPC) measures are critical to prevent human-to-human transmission of SARS-CoV-2, whether or not masks are used (6).

Mask management

For any type of mask, appropriate use, storage and cleaning, or disposal are essential to ensure that they are as effective as possible and to avoid any increased risk of transmission. Adherence to correct mask management practices varies, reinforcing the need for appropriate messaging (7).

WHO provides the following guidance on the correct use of masks:

- Perform hand hygiene before putting on the mask.
- Inspect the mask for tears or holes, and do not use a damaged mask.
- Place the mask carefully, ensuring it covers the mouth and nose, adjust to the nose bridge and tie it securely to minimize any gaps between the face and the mask. If using ear loops, ensure these do not cross over as this widens the gap between the face and the mask.

resources from ASHRAE and others''
https://www.ashrae.org/technical-resources/resources

- Avoid touching the mask while wearing it. If the mask is accidently touched, perform hand hygiene.
- Remove the mask using the appropriate technique. Do not touch the front of the mask, but rather untie it from behind.
- Replace the mask as soon as it becomes damp with a new clean, dry mask.
- Either discard the mask or place it in a clean plastic resealable bag where it is kept until it can be washed and cleaned. Do not store the mask around the arm or wrist or pull it down to rest around the chin or neck.
- Perform hand hygiene immediately afterward discarding a mask.
- Do not re-use single-use mask.
- Discard single-use masks after each use and properly dispose of them immediately upon removal.
- Do not remove the mask to speak.
- Do not share your mask with others.
- Wash fabric masks in soap or detergent and preferably hot water (at least 60° Centigrade/140° Fahrenheit) at least once a day. If it is not possible to wash the masks in hot water, then wash the mask in soap/detergent and room temperature water, followed by boiling the mask for 1 minute.

Scientific evidence

Transmission of the SARS-CoV-2 virus

Knowledge about transmission of the SARS-CoV-2 virus is evolving continuously as new evidence accumulates. COVID-19 is primarily a respiratory disease, and the clinical spectrum can range from no symptoms to severe acute respiratory illness, sepsis with organ dysfunction and death.

According to available evidence, SARS-CoV-2 mainly spreads between people when an infected person is in close contact with another person. Transmissibility of the virus depends on the amount of viable virus being shed and expelled by a person, the type of contact they have with others, the setting and what IPC measures are in place. The virus can spread from an infected person's mouth or nose in small liquid particles when the person coughs, sneezes, sings, breathes heavily or talks. These liquid particles are different sizes, ranging from larger 'respiratory droplets' to smaller 'aerosols.' Close-range contact (typically within 1 metre) can result in inhalation of, or inoculation with, the virus through the mouth, nose or eyes (8-13).

There is limited evidence of transmission through fomites (objects or materials that may be contaminated with viable virus, such as utensils and furniture or in health care settings a stethoscope or thermometer) in the immediate environment around the infected person (14-17). Nonetheless, fomite transmission is considered a possible mode of transmission for SARS-CoV-2, given consistent finding of environmental contamination in the vicinity of people infected with SARS-CoV-2 and the fact that other coronaviruses and respiratory viruses can be transmitted this way (12).

Aerosol transmission can occur in specific situations in which procedures that generate aerosols are performed. The scientific community has been actively researching whether the SARS-CoV-2 virus might also spread through aerosol transmission in the absence of aerosol generating procedures (AGPs) (18, 19). Some studies that performed air sampling in clinical settings where AGPs were not performed found virus RNA, but others did not. The presence of viral RNA is not the same as replication- and infection-competent (viable) virus that could be transmissible and capable of sufficient inoculum to initiate invasive infection. A limited number of studies have isolated viable SARS-CoV-2 from air samples in the vicinity of COVID-19 patients (20, 21).

Outside of medical facilities, in addition to droplet and fomite transmission, aerosol transmission can occur in specific settings and circumstances, particularly in indoor, crowded and inadequately ventilated spaces, where infected persons spend long periods of time with others. Studies have suggested these can include restaurants, choir practices, fitness classes, nightclubs, offices and places of worship (12).

High quality research is required to address the knowledge gaps related to modes of transmission, infectious dose and settings in which transmission can be amplified. Currently, studies are underway to better understand the conditions in which aerosol transmission or superspreading events may occur.

Current evidence suggests that people infected with SARS-CoV-2 can transmit the virus whether they have symptoms or not. However, data from viral shedding studies suggest that infected individuals have highest viral loads just before or around the time they develop symptoms and during the first 5-7 days of illness (12). Among symptomatic patients, the duration of infectious virus shedding has been estimated at 8 days from the onset of symptoms (22-24) for patients with mild disease, and longer for severely ill patients (12). The period of infectiousness is shorter than the duration of detectable RNA shedding, which can last many weeks (17).

The incubation period for COVID-19, which is the time between exposure to the virus and symptom onset, is on average 5-6 days, but can be as long as 14 days (25, 26).

Pre-symptomatic transmission – from people who are infected and shedding virus but have not yet developed symptoms – can occur. Available data suggest that some people who have been exposed to the virus can test positive for SARS-CoV-2 via polymerase chain reaction (PCR) testing 1-3 days before they develop symptoms (27). People who develop symptoms appear to have high viral loads on or just prior to the day of symptom onset, relative to later on in their infection (28).

Asymptomatic transmission – transmission from people infected with SARS-CoV-2 who never develop symptoms – can occur. One systematic review of 79 studies found that 20% (17–25%) of people remained asymptomatic throughout the course of infection. (28). Another systematic review, which included 13 studies considered to be at low risk of bias, estimated that 17% of cases remain asymptomatic (14%–20%) (30). Viable virus has been isolated from specimens of pre-symptomatic and asymptomatic individuals, suggesting that people who do not have symptoms may be able to transmit the virus to others. (25, 29-37)

Studies suggest that asymptomatically infected individuals are less likely to transmit the virus than those who develop symptoms (29). A systematic review concluded that individuals who are asymptomatic are responsible for transmitting fewer infections than symptomatic and pre-symptomatic cases (38). One meta-analysis estimated that there is a 42% lower relative risk of asymptomatic transmission compared to symptomatic transmission (30).

Guidance on mask use in health care settings

Masks for use in health care settings

Medical masks are defined as surgical or procedure masks that are flat or pleated. They are affixed to the head with straps that go around the ears or head or both. Their performance characteristics are tested according to a set of standardized test methods (ASTM F2100, EN 14683, or equivalent) that aim to balance high filtration, adequate breathability and optionally, fluid penetration resistance (39, 40).

Filtering facepiece respirators (FFR), or respirators, offer a balance of filtration and breathability. However, whereas medical masks filter 3 micrometre droplets, respirators must filter more challenging 0.075 micrometre solid particles. European FFRs, according to standard EN 149, at FFP2 performance there is filtration of at least 94% solid NaCl particles and oil droplets. US N95 FFRs, according to NIOSH 42 CFR Part 84, filter at least 95% NaCl particles. Certified FFRs must also ensure unhindered breathing with maximum resistance during inhalation and exhalation. Another important difference between FFRs and other masks is the way filtration is tested. Medical mask filtration tests are performed on a cross-section of the masks, whereas FFRs are tested for filtration across the entire surface. Therefore, the layers of the filtration material and the FFR shape, which ensure the outer edges of the FFR seal around wearer's face, result in guaranteed filtration as claimed. Medical masks, by contrast, have an open shape and potentially leaking structure. Other FFR performance requirements include being within specified parameters for maximum CO_2 build up, total inward leakage and tensile strength of straps (41, 42).

A. Guidance on the use of medical masks and respirators to provide care to suspected or confirmed COVID-19 cases

Evidence on the use of mask in health care settings

Systematic reviews have reported that the use of N95/P2 respirators compared with the use of medical masks (see mask definitions, above) is not associated with statistically significant differences for the outcomes of health workers acquiring clinical respiratory illness, influenza-like illness (risk ratio 0.83, 95%CI 0.63-1.08) or laboratory-confirmed influenza (risk ratio 1.02, 95%CI 0.73-1.43); harms were poorly reported and limited to discomfort associated with lower compliance (43, 44). In many settings, preserving the supply of N95 respirators for high-risk, aerosol-generating procedures is an important consideration (45).

A systematic review of observational studies on the betacoronaviruses that cause severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS) and COVID-19 found that the use of face protection (including respirators and medical masks) is associated with reduced risk of infection among health workers. These studies suggested that N95 or similar respirators might be associated with greater reduction in risk than medical or 12–16-layer cotton masks. However, these studies had important limitations (recall bias, limited information about the situations when respirators were used and limited ability to measure exposures), and very few studies included in the review evaluated the transmission risk of COVID-19 (46). Most of the studies were conducted in settings in which AGPs were performed or other high-risk settings (e.g., intensive care units or where there was exposure to infected patients and health workers were not wearing adequate PPE).

WHO continues to evaluate the evidence on the effectiveness of the use of different masks and their potential harms, risks and disadvantages, as well as their combination with hand hygiene, physical distancing of at least 1 metre and other IPC measures.

Guidance

WHO's guidance on the type of respiratory protection to be worn by health workers providing care to COVID-19 patients is based on 1) WHO recommendations on IPC for epidemic- and pandemic-prone acute respiratory infections in health care (47); 2) updated systematic reviews of randomized controlled trials on the effectiveness of medical masks compared to that of respirators for reducing the risk of clinical respiratory illness, influenza-like illness (ILI) and laboratory-confirmed influenza or viral infections. WHO guidance in this area is aligned with guidelines of other professional organizations, including the European Society of Intensive Care Medicine and the Society of Critical Care Medicine, and the Infectious Diseases Society of America (48, 49).

The WHO COVID-19 IPC GDG considered all available evidence on the modes of transmission of SARS-CoV-2 and on the effectiveness of medical mask versus respirator use to protect health workers from infection and the potential for harms such as skin conditions or breathing difficulties.

Other considerations included availability of medical masks versus respirators, cost and procurement implications and equity of access by health workers across different settings.

The majority (71%) of the GDG members confirmed their support for previous recommendations issued by WHO on 5 June 2020:

1. In the absence of aerosol generating procedures (AGPs)[2], WHO recommends that health workers providing care to patients with suspected or confirmed COVID-19 should wear a medical mask (in addition to other PPE that are part of droplet and contact precautions).
2. In care settings for COVID-19 patients where AGPs are performed, WHO recommends that health workers should wear a respirator (N95 or FFP2 or FFP3 standard, or equivalent) in addition to other PPE that are part of airborne and contact precautions.

In general, health workers have strong preferences about having the highest perceived protection possible to prevent COVID-19 infection and therefore may place high value on the potential benefits of respirators in settings without AGPs. WHO recommends respirators primarily for settings where AGPs are performed; however, if health workers prefer them and they are sufficiently available and cost is not an issue, they could also be used during care for COVID-19 patients in other settings. For additional guidance on PPE, including PPE

[2] The WHO list of AGPs includes tracheal intubation, non-invasive ventilation, tracheotomy, cardiopulmonary resuscitation, manual ventilation before intubation, bronchoscopy, sputum induction using nebulized hypertonic saline, and dentistry and autopsy procedures.

beyond mask use by health workers, see WHO IPC guidance during health care when COVID-19 infection is suspected (3) and also WHO guidance on the rational use of PPE (45).

Exhalation valves on respirators are discouraged as they bypass the filtration function for exhaled air.

B. Guidance on the use of mask by health workers, caregivers and others based on transmission scenario

Definitions

Universal masking in health facilities is defined as the requirement for all persons (staff, patients, visitors, service providers and others) to wear a mask at all times except for when eating or drinking.

Targeted continuous medical mask use is defined as the practice of wearing a medical mask by all health workers and caregivers working in clinical areas during all routine activities throughout the entire shift.

Health workers are all people primarily engaged in actions with the primary intent of enhancing health. Examples are: nursing and midwifery professionals, doctors, cleaners, other staff who work in health facilities, social workers, and community health workers.

Evidence on universal masking in health care settings

In areas where there is community transmission or large-scale outbreaks of COVID-19, universal masking has been adopted in many hospitals to reduce the potential of transmission by health workers to patients, to other staff and anyone else entering the facility (50).

Two studies found that implementation of a universal masking policy in hospital systems was associated with decreased risk of healthcare-acquired SARS-CoV-2 infection. However, these studies had serious limitations: both were before-after studies describing a single example of a phenomenon before and after an event of interest, with no concurrent control group, and other infection control measures were not controlled for (51, 52). In addition, observed decreases in health worker infections occurred too quickly to be attributable to the universal masking policy.

Guidance

Although more research on universal masking in heath settings is needed, it is the expert opinion of the majority (79%) of WHO COVID-19 IPC GDG members that universal masking is advisable in geographic settings where there is known or suspected community or cluster transmission of the SARS-CoV-2 virus.

1. In areas of known or suspected community or cluster SARS-CoV-2 transmission, universal masking should be advised in all health facilities (see Table 1).

- All health workers, including community health workers and caregivers, should wear a medical mask at all times, for any activity (care of COVID-19 or non-COVID-19 patients) and in any common area (e.g., cafeteria, staff rooms).
- Other staff, visitors, outpatients and service providers should also wear a mask (medical or non-medical) at all times
- Inpatients are not required to wear a mask (medical or non-medical) unless physical distancing of at least 1 metre cannot be maintained (e.g., when being examined or visited at the bedside) or when outside of their care area (e.g., when being transported).
- Masks should be changed when they become soiled, wet or damaged or if the health worker/caregiver removes the mask (e.g., for eating or drinking or caring for a patient who requires droplet/contact precautions for reasons other than COVID-19).

2. In the context of known or suspected sporadic SARS-CoV-2 virus transmission, WHO provides the following guidance:

- Health workers, including community health workers and caregivers who work in clinical areas, should continuously wear a medical mask during routine activities throughout the entire shift, apart from when eating and drinking and changing their medical masks after caring for a patient who requires droplet/contact precautions for other reasons. In all cases, medical masks must be changed when wet, soiled, or damaged; used medical masks should be properly disposed of at the end of the shift; and new clean ones should be used for the next shift or when medical masks are changed.
- It is particularly important to adopt the continuous use of masks in potentially high transmission risk settings including triage, family physician/general practitioner offices; outpatient departments; emergency rooms; COVID-19 designated units; haematology, oncology and transplant units; and long-term health and residential facilities.
- Staff who do not work in clinical areas (e.g., administrative staff) do not need to wear a medical mask during routine activities if they have no exposure to patients.

Whether using masks for universal masking within health facilities or targeted continuous medical mask use throughout the entire shift, health workers should ensure the following:

- Medical mask use should be combined with other measures including frequent hand hygiene and physical distancing among health workers in shared and crowded places such as cafeterias, break rooms, and dressing rooms.
- The medical mask should be changed when wet, soiled, or damaged.
- The medical mask should not be touched to adjust it or if displaced from the face for any reason. If this happens, the mask should be safely removed and replaced, and hand hygiene performed.
- The medical mask (as well as other personal protective equipment) should be discarded and changed after caring for any patient who requires contact/droplet precautions for other pathogens, followed by hand hygiene.
- Under no circumstances should medical masks be shared between health workers or between others wearing them. Masks should be appropriately disposed of whenever removed and not reused.

- A particulate respirator at least as protective as a United States of America (US) National Institute for Occupational Safety and Health-certified N95, N99, US Food and Drug Administration surgical N95, European Union standard FFP2 or FFP3, or equivalent, should be worn in settings for COVID-19 patients where AGPs are performed (see WHO recommendations below). In these settings, this includes continuous use by health workers throughout the entire shift, when this policy is implemented.

Note: Decision makers may consider the transmission intensity in the catchment area of the health facility or community setting and the feasibility of implementing a universal masking policy compared to a policy based on assessed or presumed exposure risk. Decisions need to take into account procurement, sustainability and costs of the policy. When planning masks for all health workers, long-term availability of adequate medical masks (and when applicable, respirators) for all workers should be ensured, in particular for those providing care for patients with confirmed or suspected COVID-19. Proper use and adequate waste management should be ensured.

The potential harms and risks of mask and respirator use in the health facility setting include:

- contamination of the mask due to its manipulation by contaminated hands (53, 54);
- potential self-contamination that can occur if medical masks are not changed when wet, soiled or damaged; or by frequent touching/adjusting when worn for prolonged periods (55);
- possible development of facial skin lesions, irritant dermatitis or worsening acne, when used frequently for long hours (56-58);
- discomfort, facial temperature changes and headaches from mask wearing (44, 59, 60);
- false sense of security leading potentially to reduced adherence to well recognized preventive measures such as physical distancing and hand hygiene; and risk-taking behaviours (61-64);
- difficulty wearing a mask in hot and humid environments
- possible risk of stock depletion due to widespread use in the context of universal masking and targeted continuous mask use and consequent scarcity or unavailability for health workers caring for COVID 19 patients and during health care interactions with non-COVID-19 patients where medical masks or respirators might be required.

Alternatives to medical masks in health care settings

The WHO's disease commodity package (DCP) for COVID-19 recommends medical masks for health workers to be type II or higher (65). Type II medical masks provide a physical barrier to fluids and particulate materials and have bacterial filtration efficiency of ≥98% compared to Type I mask, which has bacterial filtration efficiency of ≥95% and lower fluid resistance (66) In case of stock outs of type II or higher medical masks, health workers should use a type I medical mask as an alternative. Other alternatives such as face shields or fabric masks should be carefully evaluated.

Face shields are designed to provide protection from splashes of biological fluid (particularly respiratory secretions), chemical agents and debris (67, 68) into the eyes. In the context of protection from SARS-CoV-2 transmission through respiratory droplets, face shields are used by health workers as personal protective equipment (PPE) for eye protection in combination with a medical mask or a respirator (69, 70) While a face shield may confer partial protection of the facial area against respiratory droplets, these and smaller droplets may come into contact with mucous membranes or with the eyes from the open gaps between the visor and the face (71,67).

Fabric masks are not regulated as protective masks or part of the PPE directive. They vary in quality and are not subject to mandatory testing or common standards and as such are not considered an appropriate alternative to medical masks for protection of health workers. One study that evaluated the use of cloth masks in a health care facility found that health care workers using 2 ply cotton cloth masks (a type of fabric mask) were at increased risk of influenza-like illness compared with those who wore medical masks (72).

In the context of severe medical mask shortage, face shields alone or in combination with fabric mask may be considered as a last resort (73). Ensure proper design of face shields to cover the sides of the face and below the chin.

As for other PPE items, if production of fabric masks for use in health care settings is proposed locally in situations of shortage or stock out, a local authority should assess the product according to specific minimum performance standards and required technical specifications (see Annex).

Additional considerations for community care settings

Like other health workers, community health workers should apply standard precautions for all patients at all times, with particular emphasis regarding hand and respiratory hygiene, surface and environmental cleaning and disinfection and the appropriate use of PPE. When a patient is suspected or confirmed of having COVID-19, community health workers should always apply contact and droplet precautions. These include the use of a medical mask, gown, gloves and eye protection (74).

IPC measures that are needed will depend on the local COVID-19 transmission dynamics and the type of contact required by the health care activity (see Table 1). The community health workforce should ensure that patients and workforce members apply precautionary measures such as respiratory hygiene and physical distancing of at least 1 metre (3.3 feet). They also may support set-up and maintenance of hand hygiene stations and community education (74). In the context of known or suspected community or cluster transmission, community health workers should wear a medical mask when providing essential routine services (see Table 1).

Table 1. Mask use in health care settings depending on transmission scenario, target population, setting, activity and type*

Transmission scenario	Target population (who)	Setting (where)	Activity (what)	Mask type (which one) *
Known or suspected community or cluster transmission of SARS-CoV-2	Health workers and caregivers	Health facility (including primary, secondary, tertiary care levels, outpatient care, and long-term care facilities)	For any activity in patient-care areas (COVID-19 or non-COVID-19 patients) or in any common areas (e.g., cafeteria, staff rooms)	Medical mask (or respirator if aerosol generating procedures performed)
	Other staff, patients, visitors, service suppliers		For any activity or in any common area	Medical or fabric mask
	Inpatients	In single or multiple-bed rooms	When physical distance of at least 1 metre cannot be maintained	
	Health workers and caregivers	Home visit (for example, for antenatal or postnatal care, or for a chronic condition)	When in direct contact with a patient or when a distance of at least 1 metre cannot be maintained.	Medical mask
		Community	Community outreach programmes/essential routine services	
Known or suspected sporadic transmission of SARS-CoV-2 cases	Health workers and caregivers	Health facility (including primary, secondary, tertiary care levels, outpatient care, and long-term care facilities)	In patient care area- irrespective of whether patients have suspected/confirmed COVID-19	Medical mask
	Other staff, patients, visitors, service suppliers and all others		No routine activities in patient areas	Medical mask not required. Medical mask should be worn if in contact or within 1 metre of patients, or according to local risk assessment
	Health workers and caregivers	Home visit (for example, for antenatal or postnatal care, or for a chronic condition)	When in direct contact or when a distance of at least 1metre cannot be maintained.	Medical mask
		Community	Community outreach programs (e.g., bed net distribution)	
No documented SARS-CoV-2 transmission	Health workers and caregivers	Health facility (including primary, secondary, tertiary care levels, outpatient care, and long-term care facilities)	Providing any patient care	Medical mask use according to standard and transmission-based precautions
		Community	Community outreach programs	
Any transmission scenario	Health workers	Health care facility (including primary, secondary, tertiary care levels, outpatient care, and long-term care facilities), in settings where aerosol generating procedures (AGP) are performed	Performing an AGP on a suspected or confirmed COVID-19 patient or providing care in a setting where AGPs are in place for COVID-19 patients	Respirator (N95 or N99 or FFP2 or FFP3)

**This table refers only to the use of medical masks and respirators. The use of medical masks and respirators may need to be combined with other personal protective equipment and other measures as appropriate, and always with hand hygiene.*

Guidance on mask use in community settings

Evidence on the protective effect of mask use in community settings

At present there is only limited and inconsistent scientific evidence to support the effectiveness of masking of healthy people in the community to prevent infection with respiratory viruses, including SARS-CoV-2 (75). A large randomized community-based trial in which 4862 healthy participants were divided into a group wearing medical/surgical masks and a control group found no difference in infection with SARS-CoV-2 (76). A recent systematic review found nine trials (of which eight were cluster-randomized controlled trials in which clusters of people, versus individuals, were randomized) comparing medical/surgical masks versus no masks to prevent the spread of viral respiratory illness. Two trials were with healthcare workers and seven in the community. The review concluded that wearing a mask may make little or no difference to the prevention of influenza-like illness (ILI) (RR 0.99, 95%CI 0.82 to 1.18) or laboratory confirmed illness (LCI) (RR 0.91, 95%CI 0.66-1.26) (44); the certainty of the evidence was low for ILI, moderate for LCI.

By contrast, a small retrospective cohort study from Beijing found that mask use by entire families before the first family member developed COVID-19 symptoms was 79% effective in reducing transmission (OR 0.21, 0.06-0.79) (77). A case-control study from Thailand found that wearing a medical or non-medical mask all the time during contact with a COVID-19 patient was associated with a 77% lower risk of infection (aOR 0.23; 95% CI 0.09–0.60) (78). Several small observational studies with epidemiological data have reported an association between mask use by an infected person and prevention of onward transmission of SARS-CoV-2 infection in public settings. (8, 79-81).

A number of studies, some peer reviewed (82-86) but most published as pre-prints (87-104), reported a decline in the COVID-19 cases associated with face mask usage by the public, using country- or region-level data. One study reported an association between community mask wearing policy adoption and increased movement (less time at home, increased visits to commercial locations) (105). These studies differed in setting, data sources and statistical methods and have important limitations to consider (106), notably the lack of information about actual exposure risk among individuals, adherence to mask wearing and the enforcement of other preventive measures (107, 108).

Studies of influenza, influenza-like illness and human coronaviruses (not including COVID-19) provide evidence that the use of a medical mask can prevent the spread of infectious droplets from a symptomatic infected person to someone else and potential contamination of the environment by these droplets (75). There is limited evidence that wearing a medical mask may be beneficial for preventing transmission between healthy individuals sharing households with a sick person or among attendees of mass gatherings (44, 109-114).

A meta-analysis of observational studies on infections due to betacoronaviruses, with the intrinsic biases of observational data, showed that the use of either disposable medical masks or reusable 12–16-layer cotton masks was associated with protection of healthy individuals within households and among contacts of cases (46). This could be considered to be indirect evidence for the use of masks (medical or other) by healthy individuals in the wider community; however, these studies suggest that such individuals would need to be in close proximity to an infected person in a household or at a mass gathering where physical distancing cannot be achieved to become infected with the virus. Results from cluster randomized controlled trials on the use of masks among young adults living in university residences in the United States of America indicate that face masks may reduce the rate of influenza-like illness but showed no impact on risk of laboratory-confirmed influenza (115, 116).

Guidance

The WHO COVID-19 IPC GDG considered all available evidence on the use of masks by the general public including effectiveness, level of certainty and other potential benefits and harms, with respect to transmission scenarios, indoor versus outdoor settings, physical distancing and ventilation. Despite the limited evidence of protective efficacy of mask wearing in community settings, in addition to all other recommended preventive measures, the GDG advised mask wearing in the following settings:

1. In areas with known or suspected community or cluster transmission of SARS-CoV-2, WHO advises mask use by the public in the following situations (see Table 2):

   <u>Indoor settings:</u>

- in public indoor settings where ventilation is known to be poor regardless of physical distancing: limited or no opening of windows and doors for natural ventilation; ventilation system is not properly functioning or maintained; or cannot be assessed;
- in public indoor settings that have adequate[3] ventilation if physical distancing of at least 1 metre cannot be maintained;
- in household indoor settings: when there is a visitor who is not a household member and ventilation is known to be poor, with limited opening of windows and doors for natural ventilation, or the ventilation system cannot be assessed or is not properly functioning, regardless of whether physical distancing of at least 1 metre can be maintained;
- in household indoor settings that have adequate ventilation if physical distancing of at least 1 metre cannot be maintained.

[3] For adequate ventilation refer to regional or national institutions or heating, refrigerating and air-conditioning societies enacting ventilation requirements. If not available or applicable, a recommended ventilation rate of 10 l/s/person should be met (except healthcare facilities which have specific requirements). For more information consult "Coronavirus (COVID-19) response resources from ASHRAE and others'' https://www.ashrae.org/technical-resources/resources

Table 2. Mask use in community settings depending on transmission scenario, setting, target population, purpose and type*

Transmission scenario	Situations/settings (where)	Target Population (who)	Purpose of mask use (why)	Mask type (which one)
Known or suspected community or cluster transmission of SARS-CoV-2	Indoor settings, where ventilation is known to be poor or cannot be assessed or the ventilation system is not properly maintained, regardless of whether physical distancing of at least 1 meter can be maintained	General population in public* settings such as shops, shared workplaces, schools, churches, restaurants, gyms, etc. or in enclosed settings such as public transportation. For households, in indoor settings, when there is a visitor who is not a member of the household	Potential benefit for source control	Fabric mask
	Indoor settings that have adequate [4] ventilation if physical distancing of at least 1 metre cannot be maintained			
	Outdoor settings where physical distancing cannot be maintained	General population in settings such as crowded open-air markets, lining up outside a building, during demonstrations, etc.		
	Settings where physical distancing cannot be maintained, and the individual is at increased risk of infection and/or negative outcomes	Individuals/people with higher risk of severe complications from COVID-19: • People aged ≥60 years • People with underlying comorbidities, such as cardiovascular disease or diabetes mellitus, chronic lung disease, cancer, cerebrovascular disease, immunosuppression, obesity, asthma	Protection	Medical mask
Known or suspected sporadic transmission, or no documented SARS-CoV-2 transmission	Risk-based approach	General population	Potential benefit for source control and/or protection	Depends on purpose (see details in the guidance content)
Any transmission scenario	Any setting in the community	Anyone suspected or confirmed of having COVID-19, regardless of whether they have symptoms or not, or anyone awaiting viral test results, when in the presence of others	Source control	Medical mask

**Public indoor setting includes any indoor setting outside of the household*

[4] For adequate ventilation refer to regional or national institutions or heating, refrigerating and air-conditioning societies enacting ventilation requirements. If not available or applicable, a recommended ventilation rate of 10l/s/person should be met (except healthcare facilities which have specific requirements).). For more information consult "Coronavirus (COVID-19) response resources from ASHRAE and others'' https://www.ashrae.org/technical-resources/resources

In outdoor settings:

- where physical distancing of at least 1 metre cannot be maintained;
- individuals/people with higher risk of severe complications from COVID-19 (individuals ≥ 60 years old and those with underlying conditions such as cardiovascular disease or diabetes mellitus, chronic lung disease, cancer, cerebrovascular disease or immunosuppression) should wear medical masks in any setting where physical distance cannot be maintained.

2. In areas with known or suspected sporadic transmission or no documented transmission, as in all transmission scenarios, WHO continues to advise that decision makers should apply a risk-based approach focusing on the following criteria when considering the use of masks for the public:

- **Purpose of mask use**. Is the intention source control (preventing an infected person from transmitting the virus to others) or protection (preventing a healthy wearer from the infection)?
- **Risk of exposure to SARS-CoV-2**. Based on the epidemiology and intensity of transmission in the population, is there transmission and limited or no capacity to implement other containment measures such as contact tracing, ability to carry out testing and isolate and care for suspected and confirmed cases? Is there risk to individuals working in close contact with the public (e.g., social workers, personal support workers, teachers, cashiers)?
- **Vulnerability of the mask wearer/population**. Is the mask wearer at risk of severe complications from COVID-19? Medical masks should be used by older people (≥ 60 years old), immunocompromised patients and people with comorbidities, such as cardiovascular disease or diabetes mellitus, chronic lung disease, cancer and cerebrovascular disease (117).
- **Setting in which the population lives**. Is there high population density (such as in refugee camps, camp-like settings, and among people living in cramped conditions) and settings where individuals are unable to keep a physical distance of at least 1 metre (for example, on public transportation)?
- **Feasibility**. Are masks available at an affordable cost? Do people have access to clean water to wash fabric masks, and can the targeted population tolerate possible adverse effects of wearing a mask?
- **Type of mask**. Does the use of medical masks in the community divert this critical resource from the health workers and others who need them the most? In settings where medical masks are in short supply, **stocks should be prioritized for health workers and at-risk individuals.**

The decision of governments and local jurisdictions whether to recommend or make mandatory the use of masks should be based on the above assessment as well as the local context, culture, availability of masks and resources required.

3. In any transmission scenario:

- Persons with any symptoms suggestive of COVID-19 should wear a medical mask and (5) additionally:
  - self-isolate and seek medical advice as soon as they start to feel unwell with potential symptoms of COVID-19, even if symptoms are mild);
  - follow instructions on how to put on, take off, and dispose of medical masks and perform hand hygiene (118);
  - follow all additional measures, in particular respiratory hygiene, frequent hand hygiene and maintaining physical distance of at least 1 metre from other persons (46). If a medical mask is not available for individuals with suspected or confirmed COVID-19, a fabric mask meeting the specifications in the Annex of this document should be worn by patients as a source control measure, pending access to a medical mask. The use of a non-medical mask can minimize the projection of respiratory droplets from the user (119, 120).
  - Asymptomatic persons who test positive for SARS-CoV-2, should wear a medical mask when with others for a period of 10 days after testing positive.

Potential benefits/harms

The potential advantages of mask use by healthy people in the general public include:

- reduced spread of respiratory droplets containing infectious viral particles, including from infected persons before they develop symptoms (121);
- reduced potential for stigmatization and greater of acceptance of mask wearing, whether to prevent infecting others or by people caring for COVID-19 patients in non-clinical settings (122);
- making people feel they can play a role in contributing to stopping spread of the virus;
- encouraging concurrent transmission prevention behaviours such as hand hygiene and not touching the eyes, nose and mouth (123-125);
- preventing transmission of other respiratory illnesses like tuberculosis and influenza and reducing the burden of those diseases during the pandemic (126).

The potential disadvantages of mask use by healthy people in the general public include:

- headache and/or breathing difficulties, depending on type of mask used (55);
- development of facial skin lesions, irritant dermatitis or worsening acne, when used frequently for long hours (58, 59, 127);
- difficulty with communicating clearly, especially for persons who are deaf or have poor hearing or use lip reading (128, 129);
- discomfort (44, 55, 59)
- a false sense of security leading to potentially lower adherence to other critical preventive measures such as physical distancing and hand hygiene (105);
- poor compliance with mask wearing, in particular by young children (111, 130-132);
- waste management issues; improper mask disposal leading to increased litter in public places and environmental hazards (133);
- disadvantages for or difficulty wearing masks, especially for children, developmentally challenged persons, those with mental illness, persons with cognitive impairment, those with asthma or chronic respiratory or breathing problems, those who have had facial trauma or recent oral maxillofacial surgery and those living in hot and humid environments (55, 130).

Considerations for implementation

When implementing mask policies for the public, decision-makers should:

- clearly communicate the purpose of wearing a mask, including when, where, how and what type of mask should be worn; explain what wearing a mask may achieve and what it will not achieve; and communicate clearly that this is one part of a package of measures along with hand hygiene, physical distancing, respiratory etiquette, adequate ventilation in indoor settings and other measures that are all necessary and all reinforce each other;
- inform/train people on when and how to use masks appropriately and safely (see mask management and maintenance sections);
- consider the feasibility of use, supply/access issues (cleaning, storage), waste management, sustainability, social and psychological acceptance (of both wearing and not wearing different types of masks in different contexts);
- continue gathering scientific data and evidence on the effectiveness of mask use (including different types of masks) in non-health care settings;
- evaluate the impact (positive, neutral or negative) of using masks in the general population (including behavioural and social sciences) through good quality research.

Mask use during physical activity

Evidence

There are limited studies on the benefits and harms of wearing medical masks, respirators and non-medical masks while exercising. Several studies have demonstrated statistically significant deleterious effects on various cardiopulmonary physiologic parameters during mild to moderate exercise in healthy subjects and in those with underlying respiratory diseases (134-140). The most significant impacts have been consistently associated with the use of respirators and in persons with underlying obstructive airway pulmonary diseases such as asthma and chronic obstructive pulmonary disease (COPD), especially when the condition is moderate to severe (136). Facial microclimate changes with increased temperature, humidity and perceptions of dyspnoea were also reported in some studies on the use of masks during exercise (134, 141). A recent review found negligeable evidence of negative effects of mask use during exercise but noted concern for individuals with severe cardiopulmonary disease (142).

Guidance

WHO advises that people should not wear masks during vigorous intensity physical activity (143) because masks may reduce the ability to breathe comfortably. The most important preventive measure is to maintain physical distancing of at least 1 meter and ensure good ventilation when exercising.

If the activity takes place indoors, adequate ventilation should be ensured at all times through natural ventilation or a properly functioning or maintained ventilation system (144). Particular attention should be paid to cleaning and disinfection of the environment, especially high-touch surfaces. If all the above measures cannot be ensured, consider temporary closure of public indoor exercise facilities (e.g., gyms).

Face shields for the general public

At present, face shields are considered to provide a level of eye protection only and should not be considered as an equivalent to masks with respect to respiratory droplet protection and/or source control. Current laboratory testing standards only assess face shields for their ability to provide eye protection from chemical splashes (145).

In the context of non-availability or difficulties wearing a non-medical mask (in persons with cognitive, respiratory or hearing impairments, for example), face shields may be considered as an alternative, noting that they are inferior to masks with respect to droplet transmission and prevention. If face shields are to be used, ensure proper design to cover the sides of the face and below the chin.

Medical masks for the care of COVID-19 patients at home

WHO provides guidance on how to care for patients with confirmed and suspected COVID-19 at home when care in a health facility or other residential setting is not possible (5).

- Persons with suspected COVID-19 or mild COVID-19 symptoms should wear a medical mask as much as possible, especially when there is no alternative to being in the same room with other people. The mask should be changed at least once daily. Persons who cannot tolerate a medical mask should rigorously apply respiratory hygiene (i.e., cover mouth and nose with a disposable paper tissue when coughing or sneezing and dispose of it immediately after use or use a bent elbow procedure and then perform hand hygiene).
- Caregivers of or those sharing living space with people with suspected COVID-19 or with mild COVID-19 symptoms should wear a medical mask when in the same room as the affected person.

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WHO continues to monitor the situation closely for any changes that may affect this interim guidance. Should any factors change, WHO will issue a further update. Otherwise, this interim guidance document will expire 1 year after the date of publication.

Annex: Updated guidance on non-medical (fabric) masks

Background

A non-medical mask, also called fabric mask, community mask or face covering, is neither a medical device nor personal protective equipment. Non-medical masks are aimed at the general population, primarily for protecting others from exhaled virus-containing droplets emitted by the mask wearer. They are not regulated by local health authorities or occupational health associations, nor is it required for manufacturers to comply with guidelines established by standards organizations. Non-medical masks may be homemade or manufactured. The essential performance parameters include good breathability, filtration of droplets originating from the wearer, and a snug fit covering the nose and mouth. Exhalation valves on masks are discouraged as they bypass the filtration function of the mask.

Non-medical masks are made from a variety of woven and non-woven fabrics, such as woven cotton, cotton/synthetic blends, polyesters and breathable spunbond polypropylene, for example. They may be made of different combinations of fabrics, layering sequences and available in diverse shapes. Currently, more is known about common household fabrics and combinations to make non-medical masks with target filtration efficiency and breathability (119, 146-150). Few of these fabrics and combinations have been systematically evaluated and there is no single design, choice of material, layering or shape among available non-medical masks that are considered optimal. While studies have focussed on single fabrics and combinations, few have looked at the shape and universal fit to the wearer. The unlimited combination of available fabrics and materials results in variable filtration and breathability.

In the context of the global shortage of medical masks and PPE, encouraging the public to create their own fabric masks may promote individual enterprise and community integration. Moreover, the production of non-medical masks may offer a source of income for those able to manufacture masks within their communities. Fabric masks can also be a form of cultural expression, encouraging public acceptance of protection measures in general. The safe re-use of fabric masks will also reduce costs and waste and contribute to sustainability (151-156).

This Annex is destined intended for two types of readers: homemade mask makers and factory-made masks manufacturers. Decision makers and managers (national/sub-national level) advising on a type of non-medical mask are also the focus of this guidance and should take into consideration the following features of non-medical masks: breathability, filtration efficiency (FE), or filtration, number and combination of fabric layers material used, shape, coating and maintenance.

Evidence on the effectiveness of non-medical (fabric) masks

A number of reviews have been identified on the effectiveness of non-medical masks (151-156). One systematic review (155) identified 12 studies and evaluated study quality. Ten were laboratory studies (157-166), and two reports were from a single randomized trial (72, 167). The majority of studies were conducted before COVID-19 emerged or used laboratory generated particles to assess filtration efficacy. Overall, the reviews concluded that cloth face masks have limited efficacy in combating viral infection transmission.

Homemade non-medical masks

Homemade non-medical masks made of household fabrics (e.g., cotton, cotton blends and polyesters) should ideally have a three-layer structure, with each layer providing a function (see Figure 1) (168). It should include:

1. an innermost layer (that will be in contact with the face) of a hydrophilic material (e.g., cotton or cotton blends of terry cloth towel, quilting cotton and flannel) that is non-irritating against the skin and can contain droplets (148)
2. a middle hydrophobic layer of synthetic breathable non-woven material (spunbond polypropylene, polyester and polyaramid), which may enhance filtration, prevent permeation of droplets or retain droplets (148, 150)
3. an outermost layer made of hydrophobic material (e.g. spunbond polypropylene, polyester or their blends), which may limit external contamination from penetrating through the layers to the wearer's nose and mouth and maintains and prevents water accumulation from blocking the pores of the fabric (148).

Although a minimum of three layers is recommended for non-medical masks for the most common fabric used, single, double or other layer combinations of advanced materials may be used if they meet performance requirements. It is important to note that with more tightly woven materials, breathability may be reduced as the number of layers increases. A quick check may be performed by attempting to breathe, through the mouth, through the multiple layers.

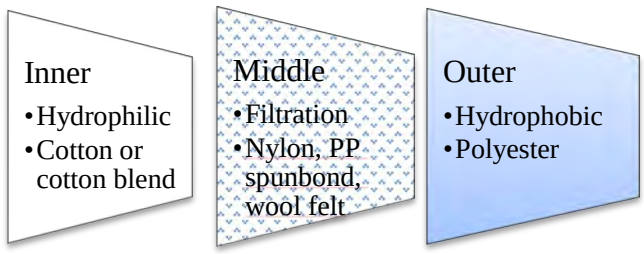

Figure 1. Non-medical mask construction using breathable fabrics such as cotton, cotton blends, polyesters, nylon and polypropylene spunbond that are breathable may impart adequate filtration performance when layered. Single- or double-layer combinations of advanced materials may be used if they meet performance requirements (72).

Assumptions regarding homemade masks are that individual makers only have access to common household fabrics and do not have access to test equipment to confirm target performance (filtration and breathability). Figure 1 illustrates a multi-layer mask construction with examples of fabric options. Very porous materials, such as gauze, even with multiple layers, may provide very low filtration efficiency (147). Higher thread count fabrics offer improved filtration performance (169). Coffee filters, vacuum bags and materials not meant for clothing should be avoided as they may contain injurious content when breathed in. Microporous films such as Gore-Tex are not recommended (170).

Factory-made non-medical masks: general considerations for manufacturers

The non-medical mask, including all components and packaging, must be non-hazardous, non-toxic and child-friendly (no exposed sharp edges, protruding hardware or rough materials). Factory-made non-medical masks must be made using a process that is certified to a quality management system (e.g., ISO 9001). Social accountability standards (e.g., SAI SA8000) for multiple aspects of fair labour practices, health and safety of the work force and adherence to UNICEF's Children's Rights and Business Principles are strongly encouraged.

Standards organizations' performance criteria

Manufacturers producing masks with consistent standardized performance can adhere to published, freely available guidance from several organizations including those from: the French Standardization Association (AFNOR Group), The European Committee for Standardization (CEN), Swiss National COVID-19 Task Force, the American Association of Textile Chemists and Colorists (AATCC), the South Korean Ministry of Food and Drug Safety (MFDS), the Italian Standardization Body (UNI) and the Government of Bangladesh.

Essential parameters

The essential parameters presented in this section are the synthesis of the abovementioned regional and national guidance. They include filtration, breathability and fit. Good performance is achieved when the three essential parameters are optimized at the preferred threshold (Figure 2).

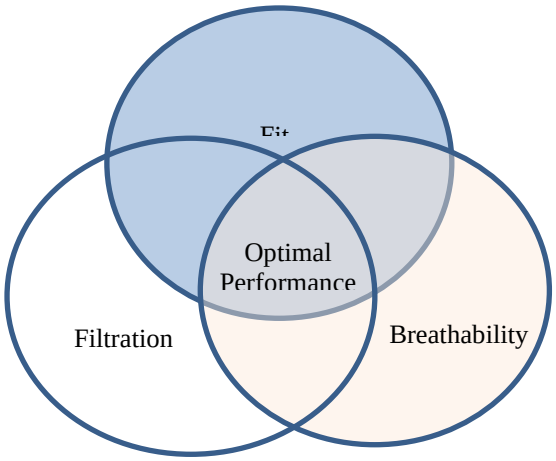

Figure 2. Illustration of the three essential parameters of filtration, breathability and fit.

The summary of the three essential parameters can be found in Table 1 and the additional performance considerations in Table 2. The minimum threshold is the minimum acceptable parameter, while the preferred threshold is the optimum.

Filtration and breathability

Filtration depends on the filtration efficiency (in %), the type of challenge particle (oils, solids, droplets containing bacteria) and the particle size (see Table 1). Depending on the fabrics used, filtration and breathability can complement or work against one another. The selection of material for droplet filtration (barrier) is as important as breathability. Filtration is dependent on the tightness of the weave, fibre or thread diameter. Non-woven materials used for disposable masks are manufactured using processes to create polymer fibres that are thinner than natural fibres such as cotton and that are held together by partial melting.

Breathability is the difference in pressure across the mask and is typically reported in millibars (mbar) or Pascals (Pa) or, normalized to the cm^2 in $mbar/cm^2$ or Pa/cm^2. Acceptable breathability of a medical mask should be below 49 Pa/cm^2. For non-medical masks, an acceptable pressure difference, over the whole mask, should be below 60 Pa/cm^2, with lower values indicating better breathability.

Non-medical fabric masks consisting of two layers of polypropylene spunbond and two layers of cotton have been shown to meet the minimum requirements for droplet filtration and breathability of the CEN CWA 17553 guidance. It is preferable not to select elastic material to make masks as the mask material may be stretched over the face, resulting in increased pore size and lower filtration through multiple usage. Additionally, elastic fabrics are sensitive to washing at high temperatures thus may degrade over time.

Coating the fabric with compounds like wax may increase the barrier and render the mask fluid resistant; however, such coatings may inadvertently completely block the pores and make the mask difficult to breathe through. In addition to decreased breathability unfiltered air may more likely escape the sides of the mask on exhalation. Coating is therefore not recommended.

Valves that let unfiltered air escape the mask are discouraged and are an inappropriate feature for masks used for the purpose of preventing transmission.

Table 1. Essential parameters (minimum and preferred thresholds) for manufactured non-medical mask

Essential Parameters	Minimum threshold	Preferred threshold
1. Filtration*		
1.1. filtration efficiency	70% @ 3 micron	> 70%, without compromising breathability
1.2. Challenge particle	Solid: sodium chloride (NaCl), Talcum powder, Holi powder, dolomite, Polystyrene Latex spheres Liquid: DEHS Di-Ethyl-Hexyl-Sebacat, paraffin oil	Based on availability
1.3. Particle size	Choose either sizes: 3 µm, 1 µm, or smaller	Range of particle sizes
2. Breathability		
2.1. Breathing resistance**	≤60 Pa/cm^2	Adult: ≤ 40 Pa/cm^2 Paediatric: ≤ 20 Pa/cm^2
2.2 Exhalation valves	Not recommended	N/A
3. Fit		
3.1. Coverage	Full coverage of nose and mouth, consistent, snug perimeter fit at the nose bridge, cheeks, chin and lateral sides of the face; adequate surface area to minimize breathing resistance and minimize side leakage	Same as current requirements
3.2 Face seal	Not currently required	Seal as good as FFR (respirator): Fit factor of 100 for N95 Maximum Total Inward Leakage of 25% (FFP1 requirement)
3.2. Sizing	Adult and child	Should cover from the bridge of the nose to below the chin and cheeks on either side of the mouth Sizing for adults and children (3-5, 6-9, 10-12, >12)
3.3Strap strength		> 44.5 N

* Smaller particle may result in lower filtration.
** High resistance can cause bypass of the mask. Unfiltered air will leak out the sides or around the nose if that is the easier path.

Fit: shape and sizing

Fit is the third essential parameter, and takes into consideration coverage, seal, sizing, and strap strength. Fit of masks currently is not defined by any standard except for the anthropometric considerations of facial dimensions (ISO/TS 16976-2) or simplified to height mask (South Korean standard for KF-AD). It is important to ensure that the mask can be held in place comfortably with as little adjustment of the elastic bands or ties as possible.

Mask shapes typically include flat-fold or duckbill and are designed to fit closely over the nose, cheeks and chin of the wearer. Snug fitting designs are suggested as they limit leaks of unfiltered air escaping from the mask (148). Ideally the mask should not have contact with the lips, unless hydrophobic fabrics are used in at least one layer of the mask (148). Leaks where unfiltered air moves in and out of the mask may be attributed to the size and shape of the mask (171).

Additional considerations

Optional parameters to consider in addition to the essential performance parameters include if reusable, biodegradability for disposal masks, antimicrobial performance where applicable and chemical safety (see Table 2).

Non-medical masks intended to be reusable should include instructions for washing and must be washed a minimum of five cycles, implying initial performance is maintained after each wash cycle.

Advanced fabrics may be biodegradable or compostable at the end of service life, according to a recognized standard process (e.g., UNI EN 13432, UNI EN 14995 and UNI / PdR 79).

Manufacturers sometimes claim their NM masks have antimicrobial performance. Antimicrobial performance may be due to coatings or additives to the fabric fibres. Treated fabrics must not come into direct contact with mucous membranes; the innermost fabric should not be treated with antimicrobial additives, only the outermost layer. In addition, antimicrobial fabric standards (e.g., ISO 18184, ISO 20743, AATCC TM100, AATCC 100) are generally slow acting. The inhibition on microbial growth may take full effect after 2- or 24-hour contact time depending on the standard. The standards have generally been used for athletic apparel and substantiate claims of odour control performance. These standards are not appropriate for non-medical cloth masks and may provide a false sense of protection from infectious agents. If claims are maid, manufacturers should specify which standard supports antimicrobial performance, the challenge organism and the contact time.

Volatile additives are discouraged as these may pose a health risk when inhaled repeatedly during wear. Certification according to organizations including OEKO-TEX (Europe) or SEK (Japan), and additives complying with REACH (Europe) or the Environmental Protection Agency (EPA, United States of America) indicate that textile additives are safe and added at safe levels.

Table 2. Additional parameters for manufactured non-medical masks

Additional parameters	Minimum thresholds
If reusable, number of wash cycles	5 cycles
Disposal	Reusable If biodegradable (CFC-BIO), according to UNI EN 13432, UNI EN 14995
Antimicrobial (bacteria, virus, fungus) performance	ISO 18184 (virus) ISO 20743 (bacteria) ISO 13629 (fungus) AATCC TM100 (bacteria)
Chemical safety	Comply with REACH regulation, including inhalation safety

WHO reference number: WHO/2019-nCoV/IPC_Masks/2020.5

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to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022

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COVID cases in ICU and ICU occupancy*

Hospitals' ability to maintain scheduled surgeries is at risk as there are more than 150 COVID+ patients in ICU in Ontario.

Table 4: COVID-19 cases in ICU (+/- daily change) and available adult baseline beds – April 18

Total CRCI patients in ICU	# CRCI patients in ICU with mechanical ventilation	# CRCI patients in ICU not on mechanical ventilation	Total suspected COVID-19 patients in ICU	# suspected COVID-19 patients in ICU with mechanical ventilation	# suspected COVID-19 patients in ICU not on mechanical ventilation	# available baseline adult ICU beds in the system
755 (+14)	516 (+10)	239 (+4)	322 (+14)	110 (-6)	212 (+20)	400 (+3)

Table 5: ICU occupancy (adult baseline beds and adult vented beds), province and region – April 18

Region	Number of patients in ICU	Number of ICU beds	ICU occupancy	Number of vented patients	Number of vented beds	Vented occupancy
1 -West	563	675	83.4%	235	431	54.5%
2 -Central	424	490	86.5%	217	372	58.3%
3 -Toronto	385	437	88.1%	205	312	65.7%
4 -East	446	559	79.8%	228	364	62.6%
5 -North	87	144	60.4%	23	81	28.4%
ONTARIO	**1905 (+5)**	**2305 (+8)**	**82.6% (-0.1%)**	**908 (+9)**	**1560 (+8)**	**58.2% (+0.3%)**

Data source: Critical Care Information System (CCIS), CritiCALL based on patient counts April 18, 2021 at 11:59 pm; COVID status as of 6 am April 19, 2021.
Data quality notes and caveats: Incremental beds that were readily available in the case of a surge in ICU admissions have returned to their previous function in the hospital (e.g., acute beds), and have been removed from the above table as of October 14. CRCI includes patients in ICU currently testing positive for COVID and patients who remain in ICU due to COVID but are currently testing negative.

Ontario

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FACT SHEET

Comparing SARS-CoV-2 Variants of Concern (VOCs)* as of May 31, 2021

This table compares characteristics of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Variants of Concern (VOCs). This table is current as of May 31, 2021 and will be updated as more information becomes available.

	B.1.1.7	B.1.351	B.1.617[†]	P.1
Public Health England name	VOC-20DEC-01	VOC-20DEC-02	VOC-21APR-02	VOC-21JAN-02
Nextstrain clade	20I/S:501Y.V1	20H/S:501Y.V2	21A/S:154K (for B.1.617.1) 21A/S:478K (for B.1.617.2)	20J/S:501Y.V3
World Health Organization label	Alpha	Beta	Delta (for B.1.617.2)	Gamma
Location first detected	United Kingdom (Kent)	South Africa (Eastern Cape)	India	Brazil (Manaus)
Detected in multiple countries?	Yes	Yes	Yes	Yes
Detected in Ontario?	Yes	Yes	Yes	Yes
Increased transmissibility?	Yes +55%[‡]	Yes +58%[‡]	Yes	Yes +58%[‡]
Increased disease severity?	Yes	Unknown[§]	Unknown[§]	Unknown[§]
Impact on molecular tests?	Yes[¶]	No	No	No
Impact on antigen tests?	No	No	Unknown[§] (but unlikely)	No

	B.1.1.7	B.1.351	B.1.617[†]	P.1
Impact on serological tests?	Unknown[§]	Unknown[§]	Unknown[§]	Unknown[§]
Immune escape?	No	Yes	Potential[#]	Yes
Impact on vaccine effectiveness?	No	Yes[**,††]	Potential impact[††]	Potential impact[††]
Notable mutations (key mutations in bold) [‡‡]	**Δ69-70[¶], N501Y[§§]** D614G, P681H/R	L18F, **K417N, E484K, N501Y,** D614G, A701V	**L452R**, D614G, G142D **P681R**, **E484Q**	L18F, **K417T, E484K, N501Y,** D614G

Abbreviations: Δ, deletion; VOC, variant of concern

For additional information on VOCs and interpreting this table, please refer to PHO's *Companion Guide to Variants of Concern (VOCs)*[1]

* VOCs are classified according to the national definitions for Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) variants established by the Canadian SARS-CoV-2 Variant Surveillance Group.[2]

† B.1.617 contains three sub-lineages (B.1.617.1; B.1.617.2; B.1.617.3) which differ by few potentially relevant mutations in the spike protein and their global prevalence of detection.[3] Designation of the sublineages in Canada may change as evidence on their attributes are being reviewed by the Canadian SARS-CoV-2 Variant Surveillance Group.[2]

‡ Based on the odds ratio of secondary household transmission using a household study of VOC transmission in Ontario (forthcoming). For methods, see (https://doi.org/10.1093/cid/ciab186).[4]

§ Unknown indicates that it is under investigation or there is currently no data for assessment.

¶ Spike (S) gene target failure (SGTF) is observed for variants with the Δ69-70 mutation using some SARS-CoV-2 molecular assays that target this region of the S gene. These are multiple gene target assays that will still detect SARS-CoV-2 via the additional targets.

Laboratory evidence suggests resistance to certain therapeutic monoclonal antibodies and/or slightly reduced neutralization by convalescent sera.

** Reduced effectiveness to AstraZeneca and Johnson & Johnson.

†† Laboratory evidence to suggest reduced effectiveness by AstraZeneca, Moderna mRNA-1273, and Pfizer-BioNTech vaccines.

‡‡ Mutations in other genes are not represented in this table.

§§ A small subset of B.1.1.7 variants have been found to have the E484K mutation.

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Citation

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Ontario

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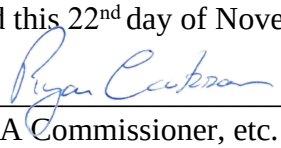

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SYNTHESIS

05/26/2021

COVID-19 B.1.617 Variant of Concern – What We Know So Far

Introduction

Public Health Ontario (PHO) is actively monitoring, reviewing and assessing relevant information related to Coronavirus Disease 2019 (COVID-19). "What We Know So Far" documents provide a rapid review of the evidence related to a specific aspect or emerging issue related to COVID-19.

Key Findings

- Lineage B.1.617 is a new variant of concern (VOC) of Severe Acute Respiratory Syndrome coronavirus 2 (SARS-CoV-2) and is associated with the notable mutations L452R and E484Q, which have the potential for greater transmissibility and reduced vaccine effectiveness.
- B.1.617 was first reported in India in late March 2021 and has spread to over 40 other countries around the world in less than two months' time. However, its geographic distribution and incidence trends are not fully understood due to inconsistent testing and sequencing in different regions of the world.
- Field evidence from the United Kingdom (UK), where most B.1.617.2 sequences outside of India have been reported, suggest higher transmissibility for this lineage. Data to date are insufficient to determine if B.1.617 causes more severe disease.
- Preliminary in-vitro studies suggest that B.1.617 has reduced neutralization by vaccine-induced sera and convalescent sera, while an observational study suggests a possible small reduction in effectiveness after full vaccination.

Background

On March 24, 2021, the Ministry of Health and Family Welfare of India reported a new variant that contains two mutations in the Spike gene of SARS-CoV-2: E484Q and L452R.[1] The discovery of this "double mutant" generated concern in India as it took place when the incidence of Coronavirus Disease 2019 (COVID-19) surged rapidly after a long decline from late September 2020 to mid-February 2021.

In less than a month's time, this variant was detected in several other countries including the UK, Singapore, Australia and the United States (US), and was named B.1.617.[2] Public health scientists internationally have noted that the E484Q and L452R mutations may enable B.1.617 to transmit more easily and render vaccines less effective.[3,4]

In the UK, sublineage B.1.617.1 was designated as a Variant Under Investigation (VUI-21APR-01) on April 1, 2021, given its mutation profile and increasing incidence in England, while sublineages B.1.617.2 (with

a different mutation profile) and B.1.617.3 (rapid spread not apparent) were under surveillance.[5] On May 6, 2021, sublineage B.1.617.2 was escalated in its designation to VOC (VOC-21APR-02) when its transmissibility was assessed to be at least equivalent to that of the VOC B.1.1.7. Meanwhile, B.1.617.3 became a VUI (VUI-21APR-03) as of April 27, 2021.[6]

On May 10, 2021, the World Health Organization characterized B.1.617 as a VOC lineage which contains three sublineages: B.1.617.1, B.1.617.2 and B.1.617.3. The designation was based on early evidence of rapid increases in prevalence observed in multiple countries (for B.1.617.1 and B.1.617.2), preliminary laboratory findings of reduced effectiveness of monoclonal therapeutic antibody Bamlanivimab, and potentially slight reduction in neutralization abilities of vaccinee sera.[7]

On May 14, 2021, the Canadian SARS-CoV-2 Variant Surveillance Group classified B.1.617 as a VOC, noting that the designation of the sublineages may change as evidence on their attributes is reviewed (See Appendix A for the Canadian definitions of variant of concern).[8]

Methods

From January 17 to May 26, 2021, PHO Library Services conducted daily searches of primary and preprint literature using the MEDLINE database (search strategies available upon request). In addition, we performed grey literature searches daily using news feeds in the Shared Library Services Partnership. English-language peer-reviewed and non-peer-reviewed (preprint) records that described "double mutant" or B.1.617 were included.

Prior to posting, PHO subject-matter experts reviewed the content of this document.

As the COVID-19 outbreak continues to evolve and the scientific evidence rapidly expands, the information provided in this document is only current as of the date of respective literature searches.

Jurisdictional scan of involving data from England involved keyword searches conducted on May 17 and 18, 2021 in the Google search engine for literature related to COVID-19 epidemiology, vaccination programs, and public health measures in England. A formal database search was not conducted due to time constraints; thus, some relevant articles may not be included.

Epidemiology

- The first B.1.617 genome noted in the global database (GISAID) dates back to October 5, 2020. It was first detected in the UK on February 22, 2021 and in the US on February 23, 2021.[9] As of May 17, 2021, the three sublineages of B.1.617 (B.1.617.1, B.1.617.2 and B.1.617.3) have been reported in 50 countries from Asia, Europe, North America and Australia.[5,9,10] The relative frequency of B.1.617 and the sublineages in different countries is unknown due to the different sequencing capacities and strategies.

- B.1.617 was first detected in India where the majority of this lineage (412 reports as of April 22, 2021) was reported.[10,11] On March 24, 2021, the Indian SARS-CoV-2 Consortium on Genomics reported that about 15%–20% of samples from Maharashtra carry the E484Q and L452R mutations, and there was an increase in the percentage of samples carrying these two mutations since December 2020. Subsequently, B.1.617 was classified as a VOC in India.[1] B.1.617 was found in 61% of 361 cases sequenced between January and March, 2021 in Maharashtra, India. However, the scale of testing was too small to conclude if this lineage was driving the surge in COVID-19 cases in Maharashtra.[9,12]

- In the UK, B.1.617.1 was first detected in mid-February 2021. Its daily incidence rose quickly in April to peak at 15 cases in mid-April, then declined quickly in late April to <4 cases as of early May 2021.[13] B.1.617.3 was first detected in late March 2021 and its daily incidence has remained low, peaking at 3 cases a day in mid-April and dropping to a case occasionally.[13] On the other hand, the daily incidence of B.1.617.2 had remained low from first detection in mid-March 2021 before slowly increasing in early April, after which it rose quickly to 235 cases a day in early May 2021.[13] The proportion of specimens belonging to the B.1.617.2 sublineage among all variants sequenced in the UK increased from 1% in the first week of April 2021, to 26% in the first week of May 2021, and reached 58% by the week of May 16, 2021.[14] (See What's Happening in England? for further epidemiological context and response measures).

- In the US, B.1.617.1 comprised 0.2% (95% confidence interval [CI]: 0.1%–0.2%) of VOCs and variants of interest (VOIs) sequences collected through the Centers for Disease Control and Prevention's national genomic surveillance; B.1.617.2 0.5% (95% CI: 0.3%–0.7%); and <10 observations of B.1.617.3 between April 11 and 24, 2021.[15]

- In Canada, B.1.617 and the sublineages have been reported in one territory and all provinces.[16] The first patient identified in Quebec was reported to have been vaccinated against COVID-19 two months prior.[17]

Genomic Features

B.1.617 contains three sublineages: B.1.617.1; B.1.617.2 and B.1.617.3 with different mutation profiles (see Appendix B). Common spike gene mutations of concern across the sublineages are L452R, P681R and D614G. In addition, B.1.617.1 and B.1.617.3 carry the amino acid mutations E484Q and G142D[7] (the latter may also be found in some B.1.617.2 sequences[18]).

- L452R: this amino acid mutation occurs in the receptor-binding domain and has been associated with **immune escape** from therapeutically relevant monoclonal antibodies and convalescent sera,[9,19,20] and **enhanced receptor binding affinity and transmissibility**.[5] A preprint by Jacobson et al. reported on the detection of L452R in **breakthrough infections** by SARS-CoV-2 after vaccination; however, the risk ratios were not elevated for this mutation when community prevalence was taken into consideration.[21] It is also found in other variants including B.1.427 and B.1.429 (both first detected in California and are estimated to have increased transmissibility by up to 24%),[18,22] and B.1.526.1 (first detected in New York).[18]

- P681R: this mutation occurs near the furin cleavage site and is similar to P681H. The P681R/H mutation is also found in B.1.1.7 and has been shown to optimise spike cleavage by furin with **potentially enhanced transmissibility**.[19]

- D614G: this mutation occurs in the receptor-binding domain and is **linked to increased transmissibility, infectivity and viral loads**.[23-26]

- E484Q: this amino acid mutation has **not been associated with any change in receptor-binding avidity**,[19] unlike mutation E484K which is found in VOCs B.1.351 and P.1, and which have been linked to immune escape and potentially decreased vaccine effectiveness.[27] Findings of a preprint by Chen et al. suggest that **clinical effectiveness of some monoclonal antibodies may be compromised** by the E484Q mutation.[28] Another preprint by Ranjan et al. finds lower binding energy against antibody (CR3022) and higher binding affinity for angiotensin-converting enzyme 2 (ACE2) receptor by the E484Q and L452R mutations, compared to wild-type (not defined), and suggests **reduced vaccine efficacy**.[29]

- G142D: this mutation is associated with **immune escape from some monoclonal antibodies** but further studies are required to determine the impact on the effectiveness of vaccine and convalescent serum.[19]

Potential Public Health Impacts

Data on potential public health impacts are mostly for B.1.617.1 and B.1.617.2; there have been very few cases of B.1.617.3 globally.

Transmissibility

Epidemiological data from India and the UK, as well as two modelling studies from the UK, indicate that **B.1.617.1 and B.1.617.2 may be more easily transmitted** than non-variant strains of SARS-CoV-2.

B.1.617.1

- In India, the **proportion of B.1.617.1** among the sequenced viruses uploaded to GISAID **has increased to about 50% in late March 2021** before starting to decline in April 2021.[30]

B.1.617.2

- In India, the **proportion of B.1.617.2** among the sequenced viruses uploaded to GISAID **has been increasing since early March to become the dominant variant reported in mid-April 2021**.[30]

- In the UK, the Scientific Advisory Group for Emergencies (SAGE) reported on May 13, 2021 with high confidence that **B.1.617.2 can be up to 50% more transmissible than the VOC B.1.1.7**.[31] This is based on an observed rise in the number of sequenced cases of B.1.617.2 and of the proportion of spike-gene (S-gene)–positives being B.1.617.2 in a small number of areas.[32] S-gene–positives are specimens with cycle threshold values ≤ 30 in all S, N and ORF1ab gene targets of a specific 3-target assay (TaqPath assay) used in some laboratories. The proportion of B.1.617.2 in S-gene–positives rose from 72.2% (570/754) in the second half of April to 93% (368/397) in early May of 2021,[32] and to 97.3% in the week of May 11, 2021.[33] This happened when the proportion of B.1.1.7 among all VOCs and VOIs was declining, so local contact and behaviour patterns alone could not account for the rapid rise in B.1.617.2. However, many of these increases were detected in a small number of local regions, some of which had a higher proportion of specimens tested in laboratories using the TaqPath assay. The B.1.617.2 sublineage may also have been overrepresented as a result of targeted contact tracing in outbreak settings.[32]

- A modelling study by the Centre for Mathematical Modelling of Infectious Diseases COVID-19 Working Group **estimated the reproduction number (R) of B.1.617.2 as 1.64 (95% CI: 1.61–1.67)**. The working group used data on imported and local cases between February 1 and April 27, 2021 and assumed the same generation interval for B.1.617.2 and other strains. Imported cases of B.1.617.2 were estimated from three data sources: reported cases in India, proportion of sequenced cases that were B.1.617.2, and reported imported cases into the UK from India. The authors noted that the estimates may not generalize to other areas in the UK.[34]

- Another modelling study by the Joint Universities Pandemic and Epidemiological Research Consortium using S-gene–positives as proxy of B.1.617.2 **estimated that B.1.617.2 may have a transmission advantage of >1.4 compared to S-gene negatives**. The authors used primarily community-based COVID-19 testing data and there were significant delays in sequencing results. The authors also noted that the conclusion of increased transmissibility of B.1.617.2 could not be made due to the following factors: S-gene positives may contain other VOCs, wild-type, even

some B.1.1.7; different population and behavioural patterns and superspreading events could not be ruled out; travelling status of cases were not available; uneven geographic distribution of laboratories that test for S-gene positives.[35]

- A cluster analysis by Public Health England found that the size of COVID-19 **clusters initiated by travellers from India** tended to be larger if the index cases were infected with B.1.617.2 vs. B.1.1.7. However, the **difference in cluster sizes was not statistically significant (P=0.19)** after adjusting for the number of travellers at the origin of each cluster.[33]

SECONDARY ATTACK RATES

Data from the UK between March 29 and May 4, 2021 estimate **higher secondary attack rates for contacts of individuals infected with B.1.617.2 than those infected with B.1.1.7 or B.1.617.1**.[33]

- For contacts of cases with travel history:
    - B.1.617.2: 2.9% (174/5,908); 95% CI: 2.5%–3.4%
    - B.1.617.1: 2.2% (56/2,509); 95% CI: 1.7%–2.9%
    - B.1.1.7: 1.7% (452/26,934); 95% CI: 1.5%–1.8%
- For contacts of cases with no or unknown travel history:
    - B.1.617.2: 13.5% (537/3,977); 95% CI: 12.5%–14.6%
    - B.1.617.1: 11.0% (33/301); 95% CI: 7.9%–15.0%
    - B.1.1.7: 8.1% (5,587/68,713); 95% CI: 7.9%–8.3%

UK contact tracing data between March 29 and May 4, 2021 estimate **higher secondary attack rates among household and non-household contacts of the 1,446 cases with B.1.617.2 compared to those of cases with B.1.1.7 and with no or unknown travel history**.[33]

- For household contacts of cases with no or unknown travel history:
    - B.1.617.2: 15.0% (490/3,274); 95% CI: 13.8%–16.2%
    - B.1.1.7: 8.9% (5,019/56,374); 95% CI: 8.7%–9.1%
- For non-household contacts of cases with no or unknown travel history:
    - B.1.617.2: 6.7% (47/703); 95% CI: 5.1%–8.8%
    - B.1.1.7: 4.6% (568/12,339); 95% CI: 4.2%–5.0%

Serial Interval and Incubation Period

Contact tracing data from the UK between March 29 and May 5, 2021 estimate that the median serial interval (time between symptom-onset or testing date of index cases and symptom-onset household contacts) is 4 days for both B.1.617.2 (n=618; range 2–10 days) and B.1.1.7 (n=5,376; range 2–12 days). For non-household contacts, the median incubation period (time between exposure and symptom-onset) is 5 days for B.1.617.2 (n=160; range 2–7 days) and 4 days for B.1.1.7 (n=888; range 2–10 days).[33] In progress are longitudinal sampling studies to provide a clearer picture by overcoming some of the challenges in recall error.

Disease Severity

In India, anecdotal evidence from clinicians suggests that B.1.617 is less virulent (most patients do not require hospitalization).[12] However, a sharp rise in death rates was observed at the time of increasing incidence of B.1.617, but patient-level data are not available to determine if the increase death rates was due to higher transmission and/or suboptimal access to health care services.[30]

In the UK, there have been 12 deaths out of 5,599 cases due to B.1.617.2 as of May 25, 2021, with a case fatality rate of 0.2% (95% CI: 0.1%–0.4%), compared to 2.0% (95% CI: 1.9%–2.0%) for B.1.1.7. The actual case fatality rate may change as a high proportion of recent cases have not completed a follow up of 28 days. Meanwhile, there have been no deaths reported out of 406 cases of B.1.617.1 and 14 cases of B.1.617.3.[33]

From February 1 to May 25, 2021, 0.8% (34/5,599) of the patients with B.1.617.2 who presented to emergency departments were admitted, compared to 1.5% (2,079/136,048) of those with B.1.1.7 and 0.5% (2/406) of those with B.1.617.1.[33] There is insufficient information to date to determine if any sublineages of B.1.617 would result in more severe infections, as most cases were very recent.[36]

Impact on Testing

There is no evidence to date that indicates reduced effectiveness of molecular tests in use for diagnosing B.1.617.[30] While the detection capability of antigen tests for B.1.617 detection has not been assessed, it is unlikely that their performance would be affected. However, it is unclear at this time if B.1.617 and the sublineages may impact on serological tests.

Immunity and Reinfection

As of 25 May, 2021, 2 cases of re-infection with B.1.617.1 and 54 cases of re-infection with B.1.617.2 have been reported in the UK, as expected with any prevalent variant.[33] Also, the SARS-CoV-2 Immunity and Reinfection Evaluation (The SIREN study), which monitors COVID-19 infections among National Health Service health care workers in the UK, reported only one reinfection (VOC status not reported) between April 22 and May 21, 2021.[14]

On the other hand, SAGE speculates on some **potential reduction in protection offered by natural infection or vaccine due to the observed antigenic distance between B.1.617.2 and wild-type virus**, which is less than that for B.1.351, similar to that for B.1.617.1; greater than that for B.1.1.7.[37] Four preprints of in vitro neutralization experiments also report on **reduced neutralization of B.1.617 or the sublineages B.1.617.1 and B.1.617.2 by convalescent sera**.

- Edara et al. reported that 19/24 (79%) of convalescent sera were able to neutralize live virus of B.1.617.1 despite a significant 6.8-fold reduction in neutralization titre, compared to that against the WA1/2020 wild-type.[38]
- Planas et al. reported 6-fold reduction in neutralization titres against live virus of B.1.617.2 compared to B.1.1.7 by convalescent sera of a cohort of unvaccinated individuals (n=56) at 6 months post-infection.[39]
- Hoffmann et al. reported an approximately 2-fold reduction in neutralization titre against pseudovirus bearing B.1.617 S protein by convalescent sera (n=15), compared to the Wuhan-1 wild-type. The authors suggest that B.1.617 might evade with moderate efficiency humoral immunity in convalescent patients.[40]

- Tada et al. reported approximately 2-fold reduction in neutralization titre against pseudovirus bearing L452R/E4384Q/P681R S protein by convalescent sera (n=8), compared to the wild-type with D614G mutation.[41]

Vaccine Effectiveness

REAL-WORLD EXPERIENCE FROM THE UK: B.1.617.2

Lopez Bernal et al. compared the vaccine effectiveness against symptomatic COVID-19 in individuals tested for COVID-19 in the UK up to May 16, 2021. The authors reported that **after only one dose, vaccine effectiveness against symptomatic COVID-19 with B.1.617.2 was reduced by approximately 20% compared to that for B.1.1.7**: 33.2% (95% CI: 8.3%–51.4%) vs. 49.2% (95% CI: 42.6%–55.0%) for the Pfizer vaccine, 32.9% (95% CI: 19.3%–44.3%) vs. 51.4% (95% CI: 47.3%–55.2%) for the ChAdOx1 (i.e., AstraZeneca) vaccine. However, the **reduction in vaccine effectiveness after two doses of vaccine was very small**: 87.9% (78.2%–93.2%) vs. 93.4% (95% CI: 90.4%–95.5%) for the Pfizer vaccine; 59.8% (95% CI: 28.9%–77.3%) vs. 66.1% (95% CI: 54.0%–75.0%) for the ChAdOx1 vaccine. The study included 12,675 sequenced COVID-19 variant cases (11,621 cases with B.1.1.7 and 1,054 cases with B.1.617.2). The authors noted that shorter follow-up time after two doses of ChAdOx1 (i.e., AstraZeneca) vaccine may explain the lower vaccine effectiveness.[42]

Experience from Bolton, UK (where clusters of B.1.617.2 are have been detected) **suggests that COVID-19 vaccines are effective against B.1.617.2**, as nearly 90% of the 25 people hospitalized with COVID-19 as of May 19, 2021 were not fully vaccinated.[43] (COVID-19 vaccines used in the UK include Pfizer BNT162b2 mRNA, Moderna mRNA-1273, and Oxford/AstraZeneca.)[44]

IN VITRO NEUTRALIZATION ASSAYS

Findings from seven preprints and one peer-reviewed study, however, **suggest potential slight to moderate reduction in effectiveness** of four COVID-19 vaccines (Pfizer-BioNTech BNT162b2 mRNA, Moderna mRNA-1273, AstraZeneca, and Covaxin) compared to the wild-type or the B.1.1.7 strains. Three of the studies looked at B.1.617 while the other four focused on sublineage B.1.617.1.

B.1.617

- Hoffmann et al. reported approximately **3-fold reduction in neutralization ability by sera from fully-vaccinated Pfizer vaccinees** (n=15) against pseudovirus with B.1.617 S protein, compared to the Wuhan-1 wild-type.[40]

- Yadav et al. reported a **2-fold reduction in neutralization ability by sera from Covaxin vaccinees** (n=28; vaccination status not reported) against live virus of B.1.617, compared to the B.1 (D614G) prototype and VOC B.1.1.7.[45]

- Tada et al. reported approximately **4-fold reduction in neutralization ability by sera from Pfizer vaccinees** (n=6; vaccination status not reported) **and Moderna vaccinees** (n=3; vaccination status not reported) against pseudovirus with L452R, E484Q and P681R spike mutations, compared to the wild-type with D614G mutation.[41]

B.1.617.1

- Ferreira et al. reported **significant reduction in neutralization ability** (actual titre not reported) compared to the Wuhan-1 D614G wild-type, when pseudovirus bearing spike mutations in L452R and E484Q (proxy of B.1.617.1) were tested with sera from Pfizer vaccinees (n=9; vaccination status not reported).[46]

- Edara et al. reported that **all sera from Moderna fully-vaccinated vaccinees (n=15) and Pfizer fully-vaccinated vaccinees (n=10) were able to neutralize live virus** of B.1.617.1 despite a **significant 6.8-fold reduction in neutralization ability** compared to that against the WA1/2020 wild-type.[38]

- Yadav et al. reported that 22/43 (51%) of sera from fully-vaccinated Covishield vaccinees without prior COVID-19 infection did not show any neutralizing antibodies against B.1.617.1. A **significant 2-fold reduction in neutralization ability** against B.1.617.1 was observed compared to the B.1 (D614G) prototype. With a geometric mean titre of 21.92 ± 4.42 (95% CI: 24.4–62.64) against B.1.617.1, the authors speculate that the vaccine are likely to protect against severe infection and death from that sublineage.[47]

- Shi et al. reported that **all sera from Pfizer fully-vaccinated vaccinees (n=20) were able to neutralize pseudovirus** bearing mutations in G142D, E154K, L452R, E484Q, D614G, P618R, Q1071H, H1101D and D111 as proxy of B.1.617.1, despite a 0.26 times reduction in plaque reduction neutralization testing ($PRNT_{50}$) compared to that of the wild-type WA1/2020.[48]

B.1.617.2

- Planas et al. reported that 94% of sera (n=16) at 8 weeks after two doses of **Pfizer** vaccine were **able to neutralize live virus of B.1.617.2, despite a 3-fold reduction in neutralization titres compared to that for B.1.1.7**. Even at 16 weeks after vaccination, neutralization ability was retained by 85% of the sera. On the other hand, **only 8% of sera (n=12) from vaccinees with one dose of AstraZeneca vaccine were able to neutralize the virus**. However, even one dose of vaccine (9 with Pfizer, 9 with AstraZeneca, 3 with Moderna) was observed to increase the median neutralizing titres in convalescent sera (n=23) by 130-fold against both B.1.1.7 and B.1.617.2 even at 12 months after infection, suggesting a **single dose of vaccine could boost cross-neutralizing antibody responses**.[39]

What's Happening in England?

Epidemiological Context

- The 7-day rolling average daily cases of COVID-19 rose slowly from late February 2020 to plateau around 4,500 to 4,800 in April 2020, then declined to stay below 700 during late-June to late-July 2020. Daily cases started to climb in September 2020 and plateaued around 21,000 and 24,600 from mid-October to mid-November 2020, dipped quickly to around 14,500 in late November before shooting to the peak of 61,239 in early January 2021. Since then, daily cases have been declining rapidly to around 12,000 in mid-February, then slowly to a low of 1,847 at the end of April 2021, and hovering around 1,900 to 2,100 for the first week of May. As of May 15, 2021, the 7-day rolling average number of daily new COVID-19 cases in England was 1,563 (22 cases per 100,000). As of May 14, 2021, the cumulative number of cases in England was 4.4 million.[49]

- The 7-day average daily admission to hospitals due to COVID-19 rose sharply from late March 2020 to a peak at 3,116 in early April 2020, then dropped slowly to a low of 97 in late August 2020. Daily admission then rose to a high of 1,777 in mid-November 2020 and peaked at 4,232 in mid-January 2021. Daily admission was at 234 at the start of April and hovered around 100 and 120 for the first week of May in 2021.[50]

- In the past 7 days (as of May 17, 2021) the areas with the greatest rates of cases per 100,000 were the Yorkshire and The Humber regions (2151 cases or 39.1 per 100,000) and the North West region (2764 cases or 37.7 per 100,000)[51]

- On April 9, 2021, B.1.617.2 made up 0.1% of COVID-19 cases in England, and by May 7, 2021, the lineage made up 19.6% of cases.[52] UK experts expect B.1.617.2 to become the dominant lineage by the end of the week of May 18, 2021, if not already.[53] As of May 17, 2021, there were 2,323 confirmed cases of B.1.617 in the UK, which represents a 77% increase from just five days earlier.[54]

- North West and South Central England have the highest proportions of B.1.617.2 cases, but cases are being reported across the country.[54]

- In Blackburn and Bolton (North West England) where the B.1.617 variant are spreading the fastest,[55] the number of cases among those under 60 years of age has increased significantly more than among those over 60 (who are more likely to be vaccinated) suggesting the effectiveness of vaccines.[56] The majority of the cases in Bolton were individuals in their teens, 20s and 30s, most of whom had not been vaccinated against Covid-19.[57]

Vaccine Context

- As of May 18, 2021, 57.9 million doses of the COVID-19 vaccine had been administered; 70.2% of the population had received at least one dose of the COVID-19 vaccine and 39.6% were fully vaccinated.[58]

- As of May 13, 2021, the vaccine is currently being offered to: individuals aged 36 and over and individuals who will turn 36 before July 1, 2021, individuals at high risk from COVID-19 (clinically extremely vulnerable), individuals who live or work in care homes, health and social care workers, individuals with a condition that puts them at higher risk (clinically vulnerable), individuals with a learning disability, and individuals who are a main carer for someone at high risk from COVID-19.[44]

- To address the rising cases of B.1.617.2, the government announced on May 14, 2021 that it would shorten the interval for second doses from 12 weeks to 8 weeks for the country's top 9 priority groups.[59] England is also accelerating COVID-19 vaccinations in regions with a high proportion of B1.617.2 cases.

Public Health Measures

- As of May 17, 2021, the English government started loosening restrictions for a variety of public health measures, including indoor settings such as hospitality and organized sports.[55]

- The government recommends that particular caution be used in certain areas of England (i.e., Bolton Metropolitan Borough and Blackburn with Darwen Borough) where variants are spreading the fastest.[55]

- In a press conference on May 14, 2021, the prime minister stated that if the B.1.617 variant turns out to be only marginally more transmissible, the country can continue to move forwards with their re-opening plan; however, if it is significantly more transmissible the roadmap to re-opening may have to be delayed or adapted (particular Step 4 in June[60] which involves removing all legal limits on social contact[61]).

Actions Taken to Control the Spread of Variants

- A press release from May 13, 2021 stated that due to the recent surge in B.1.617.2 cases in select regions, "a new Surge Rapid Response Team is being deployed in Bolton, additional surge testing will shortly launch in areas such as Formby, and enhanced contact tracing is in place across England".[62] Additionally, in areas where clusters of cases have been identified additional contact tracing, increased genomic sequencing of positive cases, increased community engagement and support for individual to get tested and self-isolate, and ensure access to vaccination and encourage uptake.

- England has also accelerated genomic sequencing, enhanced contact tracing and implemented surge testing in the North West in efforts to rapidly break chains of B.1.617.2 transmission.[63]

Ontario Context

- Currently, all positive SARS-CoV-2 specimens in Ontario with a cycle threshold (Ct) value ≤35 are tested for presence of the N501Y and E484K mutations, and only specimens positive for E484K mutation with Ct value ≤30 will be sequenced.[64] It is unclear at this time whether the current E484K assay will detect the E484Q mutation associated with B.1.617.

- Approximately 90%–95% of positive specimens that undergo VOC testing in Ontario have either N501Y and/or E484K mutations.[65] As these mutations are not associated with the B.1.617 lineage, the vast majority of specimens in Ontario are highly unlikely to be B.1.617. A proportion of non-VOC specimens are routinely sent for sequencing, in addition to all travel-related positive specimens, as part of Ontario's ongoing surveillance for emerging variants.

- As of May 19, 2021, there have been 260 cases with B.1.617 detected in Ontario (an increase from 45 as of May 12). Of the 260 cases, 203 were tested by the National Microbiology Laboratory as part of international travel arrival quarantine procedures, while 57 were detected by PHO, most of whom were associated with out-of-country travel.[66]

Risk Assessment and Practice Implications

Overall risk assessment: The risk of B.1.617 transmission in Ontario is moderate to high and depends on the number of existing B.1.617 cases and continued introductions into the province. Given the rapid emergence of B.1.617, PHO's level of confidence in the existing primary literature, preprint literature and grey literature is low but building up quickly with emergence of new evidence. This overall risk assessment may change as new evidence emerges.

- **Transmissibility:** The risk of increased transmissibility by B.1.617 is high, with a relatively low degree of uncertainty.

- **Disease severity:** The risk of B.1.617 causing severe disease is unknown.

- **Immunity and re-infection:** The risk of re-infection with B.1.617 in convalescent patients is low, with a high degree of uncertainty.

- **Vaccine effectiveness:** The risk of B.1.617 causing lowered vaccine effectiveness is moderate, with a moderate degree of uncertainty.

- **Surveillance:** The risk of B.1.617 cases not being detected in Ontario's surveillance program is moderate, with a moderate degree of uncertainty.

Surveillance testing (including genomic sequencing of a sufficient sample of positive cases) will help us better understand the epidemiology of B.1.617. Currently, there is no indication that individual or societal public health measures such as case and contact management, vaccination rollout and non-pharmaceutical interventions such as physical distancing in Ontario need to be changed. However, ongoing monitoring of single-dose vaccine effectiveness and the impact of England's shortened second-dose schedule will help to inform Ontario's second-dose roll-out. Heightened surveillance, close monitoring of case rate indicators, and local assessment of transmissibility are also needed to inform public health measures and Ontario's new recovery plan.[67]

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Appendix A

For the purposes of this document, the definition of variants of interest (VOI) and variants of concern (VOC) as proposed by the Canadian SARS-CoV-2 Variants Expert Working Group (CSVEWG) are used.[8]

Variant of Interest (VOI)

A SARS-CoV-2 variant is a variant of interest (VOI) if it:

- has a genome with mutations associated with changes in epidemiology, antigenicity, or virulence, or changes that potentially have a negative impact on available diagnostics, vaccines, therapeutics or public health measures; AND is known to cause community transmission/multiple COVID-19 cases/clusters in Canada or has been detected in multiple countries; OR
- is otherwise assessed to be a VOI by WHO; OR
- is otherwise assessed to be a VOI by the CSVEWG.

Variant of Concern (VOC)

A variant is a VOC if, through a comparative assessment, it:

- has been demonstrated to be associated with one or more of the following:
    - increased transmissibility or detrimental change in COVID-19 epidemiology;
    - increased virulence or change in clinical disease presentation;
    - decreased effectiveness of available diagnostics, vaccines, therapeutics or public health measures; OR
- is otherwise assessed to be a VOC by WHO; OR
- is otherwise assessed to be a VOC by the CSVEWG.

Appendix B

Notable mutations in the spike protein (non-synonymous) found in the B.1.617 sublineages[§7]

Amino acid substitution or deletion	B.1.617.1	B.1.617.2	B.1.617.3
D614G	**Yes**	**Yes**	**Yes**
D950N	No	**Yes**	**Yes**
E484Q	**Yes**	No	**Yes**
G142D	**Yes**	**Yes**	No
E154K	**Yes**	No	No
L452R	**Yes**	**Yes**	**Yes**
P681R	**Yes**	**Yes**	**Yes**
Q1071H	**Yes**	No	No
T19R	No	**Yes**	**Yes**
T478K	No	**Yes**	No
Δ157/158	No	**Yes**	No

§ Characteristic spike mutations detected in more than 60% of sequences.[7]

Citation

Ontario Agency for Health Protection and Promotion (Public Health Ontario). COVID-19 B.1.617 variant of concern – what we know so far. Toronto, ON: Queen's Printer for Ontario; 2021.

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Ontario

This is **"Exhibit N"**
to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022

A Commissioner, etc.

Public Health Ontario | Santé publique Ontario

EVIDENCE BRIEF

COVID-19 Delta: Risk Assessment and Implications for Practice (September 20, 2021 Update)

09/24/2021

Key Messages

- Since the end of June 2021, the Delta (B.1.617.2, first identified in India) variant of concern (VOC) has been the dominant severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) strain in Ontario, with 99.4% of samples sequenced as the Delta variant during the week of August 28, 2021. As of September 4, 2021, data from Ontario observed that the rate of Coronavirus Disease 2019 (COVID-19) infection in unvaccinated individuals is higher compared to fully vaccinated individuals, a trend that has remained consistent over time.
- There is evidence that Delta has increased transmissibility (higher viral load and potentially shorter incubation period), compared with previous SARS-CoV-2 strains after controlling for other variables. The viral load of COVID-19 infections caused by the Delta variant is higher than those caused by Alpha or non-VOC.
- There is evidence that Delta has increased disease severity compared with previous SARS-CoV-2 strains. However, this evidence focuses on adult populations with limited available evidence at the time of writing on Delta's severity in children.
- In the context of Delta, vaccines are effective against moderate and severe COVID-19 with slightly reduced vaccine effectiveness (VE) against symptomatic infection, compared to the pre-Delta period. Full vaccination against COVID-19 is more effective in protecting against Delta infection and severe illness than partial vaccination.
- Emerging data also indicate that the prevalence and risk of breakthrough cases caused by the Delta variant is higher than those caused by the Alpha variant.
- With Delta now the dominant SARS-CoV-2 strain in many global jurisdictions, some public health measures (i.e., masks, physical distancing) continue to be in place despite increasing vaccination rates. Similar to Ontario, many jurisdictions included in this review have introduced vaccine certificates programs to permit access to community settings.
- Overall, the risk of Delta transmission in Ontario is high. The prevalence can rise sharply with outbreaks of high case numbers due to Delta's higher transmissibility, pockets of the provincial population with suboptimal vaccine coverage, and slightly reduced VE.

Issue and Research Question

Ontario is in the fourth wave of the Coronavirus Disease 2019 (COVID-19) pandemic,[1] and the Delta (B.1.617.2, first identified in India) variant of concern (VOC) is the dominant strain of SARS-CoV-2 in the province.[2] Current evidence indicates higher transmissibility for Delta.[3,4] While the Delta variant has been documented to result in increased severity of disease in adults, it is unclear if Delta causes more severe COVID-19 in the pediatric population compared to previous non-Delta variants.[5]

The Government of Ontario implemented its proof of vaccination program on September 22, 2021, and eased capacity limits for select indoor and outdoor settings where proof of vaccination is required (effective September 25, 2021). In addition, schools across the province have returned to in-person learning for the 2021-22 school year. In this context, COVID-19 case declines may stagnate or increase if reopening allows for increased contact rates in the population resulting in more Delta transmission. It is, therefore, important to consider the impact of Delta and considerations for further reopening in the province.

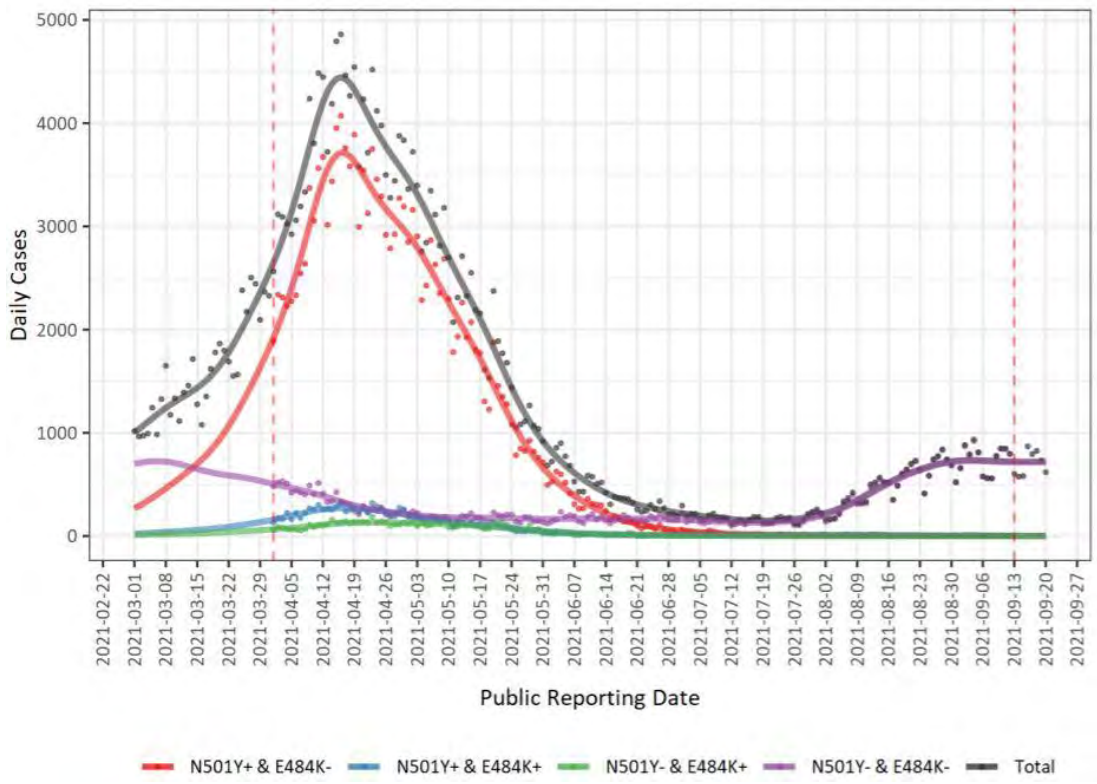
This document presents Ontario epidemiological data and also summarizes evidence published from July 23, 2021 onward (the date of the previous Public Health Ontario document on this topic). The evidence summaries cover the following topics: breakthrough infections, viral load, transmissibility, disease severity and vaccine effectiveness (VE). A scan of public health measures implemented in the context of Delta circulation in select European jurisdictions and Israel, is also summarised in this document.

Ontario Epidemiological Context

As of June 26, 2021, the majority of COVID-19 cases in Ontario are infected with Delta. From August 1 to August 28, 2021, there were 7,939 cases sequenced by the Ontario COVID-19 Genomics Network for representative surveillance, with the majority (97.8%) of these sequenced cases identified as B.1.617.2 (Delta).[2] In August 2021, the proportion of Delta cases in Ontario increased from 99.0% (August 15 to August 21) to 99.4% (August 22 to August 28).[2]

From September 14 to September 20, 2021, the incidence of the N501Y- and E484K- mutation profile (Delta variant) was stable in Ontario, shown by the effective reproduction number (Re) of 1.00.[6] In that same period, the Re of all other mutation profiles was below one.[6] See **Figure 1** for the estimated cases in Ontario by mutation profile from March 1, 2021 to September 13, 2021.[6]

Figure 1. Estimated daily COVID-19 cases, total and mutation profiles by public reporting date in Ontario, March 1, 2021 to September 20, 2021[6]



Note: Public reporting date is the date the public health unit reported the case to Public Health Ontario plus one day to account for the delay in public reporting. This is not the date on which a variant or mutation was identified. Data in the time period between the vertical dashed red lines (April 1, 2021 to September 13, 2021) were used to estimate daily cases before April 1, 2021 and in the most recent 7 days to account for surveillance biases and reporting lags.
Data Source: CCM

In Ontario, from July 4, 2021 to September 4, 2021 (when Delta was dominant), children ages 0-17 years accounted for 20.6% of confirmed COVID-19 cases.[7] For the week of September 12 to September 18, 2021, a quarter (25.8%) of outbreak-associated cases in Ontario were reported in elementary school settings.[8]

Household secondary attack rate (SAR) refers to the probability that an individual with SARS-CoV-2 will transmit the disease to a household contact. An Ontario model (based on data from England[9]) estimated that the Delta variant has a 64% SAR advantage over the Alpha variant.[10] The model also suggests Delta variant went from having a 29% transmission deficit relative to Alpha on April 1, 2021 (relative Re = 0.71, 95% CI: 0.64, 0.77) to having a 50% transmission advantage on June 12, 2021 (relative Re = 1.50, 95% CI: 1.31, 1.71).[10]

As of September 4, 2021, 10,886,925 individuals had received at least one dose of vaccine (10,032,786 of which were fully vaccinated). Of these individuals, 18,912 became partially vaccinated cases and 5,879 became breakthrough cases.[11] The rate of COVID-19 infection in unvaccinated individuals is higher compared to fully vaccinated individuals. Between February 3 and September 4, 2021, trends in VOCs among vaccinated cases reflect trends in VOCs among all cases, with Alpha being the dominant strain from approximately March to June, and an increasing number of Delta reporting since May 2021.[11]

Methods

From January 17 to September 20, 2021, Public Health Ontario (PHO) Library Services conducted daily searches of primary and preprint literature on SARS-CoV-2 variants using MEDLINE and the National Institutes of Health (NIH) COVID-19 Portfolio (preprints). English-language peer-reviewed and non-peer-reviewed (preprint) records that described Delta in terms of breakthrough infections, viral load, transmissibility, VE and severity were included. This document focuses on peer-reviewed and pre-print literature published on or after July 23, 2021 (the date of the previous PHO document on this topic). Additionally, studies identified by PHO subject matter experts are summarized in this document.

In addition, we conducted a rapid environmental scan of public health measures implemented in the context of Delta circulation in select European jurisdictions and Israel. Records were obtained through online searches conducted between September 15 and September 17, 2021 of recent policies, media articles, government websites, official press and reports.

As the COVID-19 outbreak continues to evolve and the scientific evidence rapidly expands, the information provided in this document is only current as of the date of respective literature searches.

Findings

The key findings from the evidence are described below, organised as: transmissibility, severity, VE and breakthrough Delta infections. Individual article summaries are available upon request.

Several studies summarized below use reverse transcription polymerase chain reaction (RT-PCR) cycle threshold (Ct) values as a proxy for viral load, with lower Ct values often used as a proxy for higher viral load. If the virus is found in a low number of cycles (Ct value under 30), it means that the virus was easier to find in the sample and that the sample started out with a large amount of the virus.[12]

Transmissibility

Previous PHO reporting on this topic documented Delta's increased transmissibility compared to Alpha and wild type, after controlling for other variables.[3,4] Further data corroborating its increased transmissibility and specifically on viral load of Delta infections has been published since the last evidence brief. Viral load is one factor that impacts SARS-CoV-2 transmissibility, with studies indicating that the higher the quantity of virus present (higher viral load) the higher the risk of transmission.

Evidence from China,[13] the US,[14] the Netherlands,[15] the UK,[16] and Saudi Arabia[17] suggests that COVID-19 infections caused by the Delta variant have a higher viral load when compared to infections caused by Alpha, other VOCs and wild type. Evidence from China also suggests that patients infected with Delta variant have more rapid symptom-onset, higher risk of pre-symptomatic transmission and potentially shorter incubation period than patients infected with Alpha.[13]

A study from China that followed 167 Delta variant infections (all of which were traced to a single index case) found that Delta has a shorter serial interval compared to other VOCs earlier in the pandemic.[18] A study from Korea observed that as the Delta variant increased in prevalence, the mean serial interval declined from 4.0 days pre-Delta to 2.5 days when Delta was dominant (decreased serial interval is an outcome of higher transmissibility).[19] However, the risk of super-spreading events was similar: 25% (pre-Delta) to 27% (Delta) of cases seeded 80% of all transmission.

Some evidence highlights that several characteristics of the Delta variant's genetic profile contribute to its increased transmissibility when compared to non-VOC and other variants.[19-25] For example, several studies examined the receptor-binding domain (RBD) of the spike protein of SARS-CoV-2 interacts with

the human angiotensin converting enzyme 2 (ACE2) receptor, initiating the entry of SARS-CoV-2, and found that enhanced ACE2 receptor engagement may contribute to the increased transmissibility of the Delta variant.[20-22]

Disease Severity and Implications for Health Systems

The previously published PHO reports on Delta variant risk assessment summarized evidence that Delta had increased severity when compared to Alpha and other VOCs, after controlling for other variables. Recent evidence supports findings from PHO's previous reports that Delta has increased disease severity compared with other VOC or wild type.[3,4,26,27] However, one cohort study conducted in Norway suggests that there was no difference in the risk of hospitalization between cases caused by Delta or Alpha.[28]

A recent PHO evidence brief found that while the Delta variant has result in increased severity of disease in adults, it is currently unclear if the Delta variant causes more severe COVID-19 in the pediatric population compared to previous non-Delta variants.[5] COVID-19-related hospitalizations and deaths among children remain low in comparison to the COVID-19-related clinical severity and deaths in adults.

Vaccine Effectiveness (VE)

Previously summarized evidence on the Delta variant in international jurisdictions (including the UK, Canada and India) demonstrated that while VE against severe outcomes (e.g., hospitalization, death) of Delta infection is retained, some studies suggest that VE against symptomatic infection with Delta may be lower (when compared to VE against symptomatic infection with wild type or other VOCs).[3,4]

Recent evidence reaffirms that there is high protection of COVID-19 vaccines against moderate and severe COVID-19 (i.e. hospitalizations, ICU),[29,30] however VE is slightly lower than in the period when Alpha was the dominant variant.[31-34] There is also slightly reduced VE against symptomatic infection in the context of Delta's prevalence.[32] Additionally, evidence also reaffirms that full vaccination against COVID-19 is more effective than partial vaccination against infection and severe illness.[31,35] Evidence also suggests that in the context of Delta there is lower VE for individuals with underlying medical conditions and adults over the age of 65.[29,35]

Breakthrough Delta Infections

Since the last PHO evidence brief, new evidence has emerged on breakthrough Delta infections. This section summarizes evidence on the increased risk and viral load of Delta breakthrough infections, compared with unvaccinated Delta infections and Alpha or wild-type infections.

A breakthrough case is defined by PHO as a case with a symptom-onset date that was 14 or more days following receipt of the second dose of a 2-dose series COVID-19 vaccine, or 14 or more days following the first dose of a COVID-19 vaccine product with a 1-dose schedule. These individuals would be considered fully protected from vaccination; however, as VE is not 100%, it is expected that a small number of cases will occur among fully vaccinated individuals.[11]

There is evidence to suggest that the risk of breakthrough infections is higher in the Delta context than in the Alpha context.[36,37] Emerging evidence also suggests no difference in viral load between breakthrough Delta infections and unvaccinated Delta infections.[38-41] Other studies indicate that Delta infections have a higher viral load than non-VOC or Alpha infections.[36,37,42]

- Evidence from the UK and Portugal observed higher odds of breakthrough Delta infections compared with Alpha.[36,37]

- Studies from the United States (US), United Kingdom (UK) and Singapore observed no difference in RT-PCR Ct values among breakthrough and unvaccinated Delta infections.[38-41]

- One study from Israel found that the administration of a booster vaccine dose led to a rise in Ct values or 4-fold reduction in viral load, even in the context of a surge in COVID-19 cases dominated by the Delta variant.[43]

- Studies from the US and Portugal observed that breakthrough infections caused by the Delta variant have lower Ct thresholds and a higher viral load when compared to breakthrough Alpha infections.[36,37,42]

Relevant Jurisdictions Experiencing a Delta Surge

As of September 7, 2021, at least 174 countries across all six World Health Organization (WHO) regions have reported Delta cases.[44] Described below is information for several countries with contexts relevant to Ontario in terms of epidemiology and vaccination program progress.

England

EPIDEMIOLOGY

- As of September 10, 2021 the rate of cases in a 7-day period per 100,000 people was 308.3 (a decrease from 310.8 on September 1, 2021).[45]

- On September 14, 2021 there were 6,344 COVID-19 patients in hospitals (an increase from 6,236 on September 1, 2021).[46]

- On September 3, 2021 there were 632 weekly deaths (a decrease from 649 on August 27, 2021).[47]

- The Delta variant accounted for approximately 99% of sequenced and 96% genotyped cases from August 1 to August 28, 2021.[48]

VACCINATION

- As of September 12, 2021, 71% of the total population had received at least one dose of the COVID-19 vaccine,[49] and 65% of the total population had been fully vaccinated.[50]

PUBLIC HEALTH MEASURES

- On July 19, 2021, the existing COVID-19 restrictions were replaced with advice to the public on how to remain safe from COVID-19. The advice includes letting in fresh air when meeting others indoors, wearing a face covering in crowded indoor spaces, getting tested if you have symptoms, and self-isolating if you test positive.[51]

- Workers have gradually returned to the workplace and employers are encouraged to use the National Health Service (NHS) COVID pass. This pass has been used voluntarily in some other commercial settings as a condition of entry (e.g., Premier League, nightclubs, festivals). This app confirms individuals have either: (1) been fully vaccinated, (2) have proof of a negative COVID test, or (3) have natural immunity status.[51]

- England has also prepared a “Plan B”, should the case count continue to rise and become unsustainable for the NHS. In this plan, the government will introduce mandatory vaccine-only COVID-status certifications in some settings and re-introduce mandatory mask coverings in

some settings. In addition, the government will consider asking individuals to work from home for a limited period of time.[51]

France

EPIDEMIOLOGY

- As of September 14, 2021, weekly confirmed COVID-19 cases per 100,000 people were 101.5 (a decrease from 163.2 on September 1, 2021).[52]
- On September 5, 2021 there were 10,644 patients in hospitals (a decrease from 11,119 on September 1, 2021).[53]
- As of September 14, 2021, weekly deaths per 100,000 people were 0.16 (a decrease from 0.17 on September 1, 2021).[54]
- As of August 28, 2021, the European Centre for Disease Prevention and Control (ECDC) reported that 99.1% of COVID-19 infections in France were caused by the Delta variant.[55]

VACCINATION

- As of September 13, 2021, 63% of the population had been fully vaccinated against COVID-19 and an additional 10% were only partially vaccinated (i.e. only received one dose).[56]

PUBLIC HEALTH MEASURES

- Masks are mandatory in indoor spaces where no health pass is required and on public transit. Masks are also required outside when social distancing is not an option (e.g., in queues, railway stations, etc.).[57]
- Beginning September 30, 2021, a health pass (indicating vaccination, testing, or immunity) will be required for individuals ages 12 years and older to access venues and events that have more than 50 people.[57] Until the end of August, workers in the public sector must work from home at least two days a week.[57]

Italy

EPIDEMIOLOGY

- As of September 14, 2021, weekly confirmed COVID-19 cases per 100,000 people were 55.8 (a decrease from 73.0 on September 1, 2021).[52]
- On September 5, 2021 there were 4,788 patients in hospitals (an increase from 4,771 on September 1, 2021).[53]
- As of September 14, 2021, weekly deaths per 100,000 people were 0.09 (no change since September 1, 2021).[54]
- As of August 28, 2021, ECDC reported that 90.4% of COVID-19 infections were caused by the Delta variant in Italy.[55]

VACCINATION

- As of September 13, 2021, 64% of the population had been fully vaccinated against COVID-19 and an additional 8.5% were only partially vaccinated (i.e. only received one dose).[56]

PUBLIC HEALTH MEASURES

- According to a media report published on August 23, 2021, Italy requires individuals to present a "green pass" to attend large events, dine indoors, access gyms and other settings.[58]

- Italy uses a colour system for its regions (based on infection rates and hospitalization rates) and different restrictions apply to the different colours. As of August 30, 2021, all regions are currently in either white or yellow, which have similar restrictions: for individuals over the age of six, masks and social distancing are mandated when indoors. Social distancing is required while outdoors and masks must be worn outdoors when social distancing is not possible.[58,59]

- Media reporting from September 16, 2021 states that Italy is expected to mandate a COVID-19 green pass for all workers in both private and public sectors beginning on October 15, 2021.[60] Workers who do not present a pass will be required to pay a €1000 fine. Individuals cannot be laid off for failing to present a green pass, but they will be suspended without pay. The green pass is already mandated for all health-care and care home workers.

Netherlands

EPIDEMIOLOGY

- As of September 14, 2021, weekly confirmed COVID-19 cases per 100,000 people were 96.6 (a decrease from 107.0 on September 1, 2021).[52]

- On September 5, 2021 there were 467 patients in hospitals (an increase from 436 on September 1, 2021).[53]

- As of September 14, 2021, weekly deaths per 100,000 people were 0.04 (a decrease from 0.05 on September 1, 2021).[54]

- As of August 21, 2021, ECDC reported that 99.7% of COVID-19 infections were caused by the Delta variant in the Netherlands.[55]

VACCINATION

- As of September 13, 2021, 63% of the population had been fully vaccinated against COVID-19 and an additional 6.8% were only partially vaccinated (i.e. only received one dose).[56]

PUBLIC HEALTH MEASURES

- In a press conference held on September 14, 2021, it was announced that the Netherlands will no longer require social distancing, and instead, will implement the coronavirus entry pass system beginning on September 25, 2021.[61] Using this system, individuals ages 13 and older will be required to show a valid coronavirus pass to gain admission into indoor and outdoor venues (e.g., bars, restaurants, events, cultural venues). Indoor venues without fixed seating can operate at 75% capacity, while indoor venues with fixed seating and outdoor venues can operate at full capacity.

- Although face masks are no longer required in most commercial areas, they are still mandatory on all public transportation (e.g., busses, planes, trains).[61]

- Workers are encouraged to work from home if they can and only go to the office if they must.[61]

Israel

EPIDEMIOLOGY

- As of September 14, 2021, weekly confirmed COVID-19 cases per 100,000 people were 878.1 (an increase from 741.3 on September 1, 2021).[52]
- On September 14, 2021 there were 1,280 patients in hospitals (a decrease from 1,319 on September 1, 2021).[53]
- As of September 14, 2021, weekly deaths per 100,000 people were 0.38 (an increase from 0.29 on September 1, 2021).[54]

VACCINATION

- As of September 13, 2021, 63% of the population had been fully vaccinated against COVID-19 and an additional 5.6% were only partially vaccinated (i.e. only received one dose).[56]

PUBLIC HEALTH MEASURES

- Education restrictions:
    - Effective August 18, 2021, post-secondary education may be conducted in-person only for those that present a Green Pass. The establishments must also offer online learning options for those that do not have a Green Pass. For classes that must be in-person, individuals do not need a Green Pass, but are subject to the Purple Badge.[62]
    - Effective August 18, 2021, masks are required inside educational settings for those in grade one and beyond. Clubs and movement activities are to be held outside only for regions designated as orange or red.[62]
    - Ahead of school reopening, the Israeli Ministry of Health asked parents to use the home coronavirus test kits that were delivered to each family.[63] If the test was positive, they were asked to take a PCR test and remain in isolation until the results came back. If the test was negative, they were able to send their children to school.
- Places of worship that comply with the Purple Badge scheme can allow up to 50 individuals and must post the occupancy restriction on the door.[64] Places of worship that comply with the Green Pass Scheme do not need to scan green pass barcodes upon entry during Shabbat and holidays since people who are Jewish are forbidden to use mobile devices on religious holidays. These regulations will be extended until September 29, 2021.
- The list of countries on the travel ban that was previously implemented was updated and took effect on September 9, 2021 to include the following countries: Bulgaria, Brazil, Mexico and Turkey.[65] All travellers arriving in Israel from abroad (regardless of destination and/or vaccination status) are required to enter isolation for 24 hours or until they receive their test results from the COVID-19 test they took at border control (whichever is earlier).[66]

Ontario Risk Assessment

The risk of Delta transmission in Ontario continues to be high. As of August 28, 2021, Delta variant accounted for 99.4% of sequenced COVID-19 cases in Ontario. The prevalence can rise sharply with outbreaks of high case numbers due to Delta's higher transmissibility, pockets of population with

suboptimal vaccine coverage and reduced VE. The overall risk assessment may change as new evidence emerges (see **Table 1**).

Table 1. Risk assessment for Delta

Issue	Risk level	Degree of uncertainty
Increased transmissibility	**High** As of August 28, 2021, Delta accounted for approximately 99% of sequenced COVID-19 cases in Ontario. After controlling for other variables, the evidence indicates Delta has increased transmissibility.	**Low**
Disease severity	**Moderate** After controlling for other variables, the summarized evidence indicates Delta is associated with increased disease severity (i.e., increased hospitalizations, more severe symptoms upon presentation).	**Low**
Lowered vaccine effectiveness	**Moderate** In the context of Delta, vaccines are effective against moderate and severe COVID-19 (i.e., hospitalizations, intensive care unit admissions), with slightly reduced VE against symptomatic infection (compared to the pre-Delta period).	**Moderate**
Breakthrough infections	**Moderate** The prevalence and risk of breakthrough cases caused by the Delta variant is higher than those caused by Alpha. Emerging evidence from multiple jurisdictions suggests that there is higher viral load among breakthrough Delta infections, compared with Alpha breakthrough infections.	**Moderate**
Impacts on testing/surveillance	**Low** The risk of Delta cases not being detected in Ontario's surveillance program is low.	**Low**

Implications for Practice

- The Delta variant is a global VOC that has impacted multiple jurisdictions worldwide and has replaced Alpha as the dominant SARS-CoV-2 strain in Ontario. It is a more transmissible strain with evidence of increased severity, lowered VE and increased risk of breakthrough infections.
    - The available evidence on the risk of infection associated with Delta is focused on adult populations. However, there is little available information on the severity of Delta in

children, an area that requires further research as children under 12 years of age continue to be ineligible for vaccination in Ontario

- There are many jurisdictions which are adjusting public health measures in response to the Delta variant and a surge in cases, including the introduction of mandatory vaccination or vaccine certificates.

- Efforts should be made to maintain low levels of community transmission in the context of Delta's prevalence, as there is a higher risk and prevalence of breakthrough COVID-19 infections caused by the Delta variant. These efforts may include the maintaining certain public health measures to reduce disease spread (i.e., masking, physical distancing), vaccine certificate policies and promoting an increase in two-dose vaccination uptake.

- Completion of the two-dose vaccination series will be important to protect Ontarians from the more severe and transmissible Delta variant. Ontario populations which are unvaccinated or partially vaccinated remain at-risk for serious disease associated with the Delta variant. Efforts should be invested to enhance vaccine uptake as much as possible in the province.

- Monitoring of appropriate epidemiologic, vaccination uptake and health system indicators will be important to understand how Delta is impacting COVID-19 patients and spreading in Ontario.

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Ontario

This is **"Exhibit O"**
to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022

A Commissioner, etc.

NEWS RELEASE

Ontario Announces Provincewide Shutdown to Stop Spread of COVID-19 and Save Lives

Government Providing Grants of up to $20,000 to Small Businesses Impacted by New Public Health Measures

December 21, 2020
Office of the Premier

TORONTO — As COVID-19 cases continue to rise at an alarming rate, the Ontario government, in consultation with the Chief Medical Officer of Health and other health experts, is imposing a Provincewide Shutdown. Additional restrictions will be put into place and reinforce that Ontarians should stay at home as much as possible to minimize transmission of the virus and prevent hospitals from becoming overwhelmed. The Provincewide Shutdown will go into effect as of Saturday, December 26, 2020, at 12:01 a.m.

Details were provided today by Premier Doug Ford, Christine Elliott, Deputy Premier and Minister of Health, Stephen Lecce, Minister of Education, Dr. David Williams, Chief Medical Officer of Health, and Dr. Naveed Mohammad, President and CEO, William Osler Health System.

"The number of daily cases continue to rise putting our hospitals and long-term care homes at risk," said Premier Ford. "We need to stop the spread of this deadly virus. That's why, on the advice of Dr. Williams and other health experts, we are taking the difficult but necessary decision to shutdown the province and ask people to stay home. Nothing is more important right now than the health and safety of all Ontarians."

In response to these exceptional circumstances, the Provincewide Shutdown would put in place time-limited public health and workplace safety measures similar to those in other jurisdictions. It would help stop the trend of high COVID-19 transmission in communities, preserve health system capacity, safeguard vulnerable populations and those who care for them, and save lives. Measures include, but are not limited to:

- Restricting indoor organized public events and social gatherings, except with members of the same household (the people you live with). Individuals who live alone may consider having exclusive close contact with one other household.
- Prohibiting in-person shopping in most retail settings - curbside pickup and delivery can continue. Discount and big box retailers selling groceries will be limited to 25 per cent capacity for in-store shopping. Supermarkets, grocery stores and similar stores that primarily sell food, as well as pharmacies, will continue to operate at 50 per cent capacity for in-store shopping.
- Restricting indoor access to shopping malls - patrons may only go to a designated indoor pickup area (by appointment only), essential retail stores that are permitted to be open (e.g. pharmacy, grocery store), or, subject to physical distancing and face covering requirements, to the food court for takeout purchases. Shopping malls may also establish outdoor designated pickup areas.
- Prohibiting indoor and outdoor dining. Restaurants, bars and other food or drink establishments will be permitted to operate by take out, drive-through, and delivery only.

On the advice of the Chief Medical Officer of Health, all Ontarians are advised to stay home as much as possible with trips outside the home limited to necessities such as food, medication, medical appointments, or supporting vulnerable community members. Employers in all industries should make every effort to allow employees to work from home.

The current COVID-19 Response Framework will be paused when the Provincewide Shutdown comes into effect. The impacts of these time-limited measures will be evaluated throughout the 14 days in Northern Ontario and 28 days in Southern Ontario to determine if it is safe to lift any restrictions or if they need to be extended.The Chief Medical Officer of Health will assess and apply lessons learned thus far to the COVID-19 Response Framework to ensure appropriate and effective measures are in place to protect the health of Ontarians and enable economic recovery after the Provincewide Shutdown ends. This will include an assessment of how a revised approach for the safe reopening of retail may be operationalized, according to the latest available evidence.

"This was not an easy decision before the holidays, but we have reached a tipping point," said Minister Elliott. "We continue to see sharp increases in hospitalizations and occupancy in intensive care units is reaching concerning levels. Urgent action must be taken to prevent our health care system from becoming overwhelmed. By implementing a Provincewide Shutdown, we can work to stop the virus in its tracks, safeguard hospital capacity, and save lives."

The government is also providing $12.5 million to implement a High Priority Communities Strategy to contain the virus in high-risk communities. The strategy will take a tailored, community-based approach to fund community agencies in 15 priority communities in the York, Peel, Durham, Ottawa, and Toronto regions. The funding will also allow for the hiring of community ambassadors to make people aware of available services and assistance, for coordination of increased testing opportunities and for the arrangement of wraparound supports for those who are COVID-positive. Additional funding of $42 million will also be available to establish isolation centres.

The province will work with our local municipal partners to establish new isolation centres to help those who may need to isolate following testing.

"We continue to see the number of cases in the province grow and the trends in public health indicators worsen. Additional measures are needed provincewide in order to interrupt this concerning growth," said Dr. Williams. "We must work together to enable everyone to follow these new and time-limited restrictions and protect our health system and our communities."

The government is working to limit the transmission of COVID-19 in workplaces by supporting essential businesses in doing whatever is necessary to keep workers safe. The Ministry of Labour, Training and Skills Development is leading a multi-ministry COVID-19 Safety Team. The team will partner with local authorities to carry out additional enforcement blitzes in sectors where they are needed most.

New School Protocols

While transmission in schools remains low, all publicly funded and private elementary and secondary schools are to move to teacher-led remote learning when students return from the winter break on January 4, 2021. This action is being taken in support of the Government's broader efforts to limit the spread of COVID-19.

Schools located in the following Public Health Unit regions can resume in-person instruction on January 11, 2021 for both elementary and secondary students:

- The District of Algoma Health Unit
- North Bay Parry Sound District Health Unit
- Northwestern Health Unit
- Porcupine Health Unit
- Sudbury and District Health Unit
- Thunder Bay District Health Unit
- Timiskaming Health Unit

For schools in all other Public Health Unit regions, elementary school students are planned to be able to return to in-person learning on January 11, 2021, and secondary school students will continue learning remotely until January 25, 2021, at which point they may resume in-person learning. During this period, child care centres, authorized recreational and skill building programs and home-based child care services will remain open. From January 4-8, 2021, when elementary students move to remote learning, before and after school programs will be closed and emergency child care for health care and frontline workers will be provided. As part of the government's efforts to protect the most vulnerable, boards will be required to make provisions for continued in-person support for students with special education needs who cannot be accommodated through remote learning for whom remote learning is challenging.

"While our schools are not a source of rising community transmission, we can play an important part of the solution to save lives from COVID-19," said Minister Lecce. "During this period, students will pivot to teacher-led online learning, with child care provided for our frontline workers. We are taking proactive and preventative action to protect schools following the holiday break to ensure kids can continue in-class learning — something we believe is so important — for the remainder of the year."

The New Ontario Small Business Support Grant

The government recognizes that small businesses impacted by these necessary public health measures will require additional support so they can continue serving their communities and employing people in Ontario once the COVID-19 pandemic is over. That is why the government is announcing the new *Ontario Small Business Support Grant*, which will provide a minimum of $10,000 and up to $20,000 to eligible small business owners to help navigate this challenging period.

"Ontario's business owners have shown remarkable resolve and ingenuity throughout the pandemic. They know better than anyone what they need to come through this very difficult time, so they can continue to serve and employ people in their communities," said Rod Phillips, Minister of Finance. "The new *Ontario Small Business Support Grant* will provide significant financial support to eligible small business owners in addition to the other supports made available to our small business community."

Small businesses required to close or restrict services under the Provincewide Shutdown will be able to apply for this one-time grant. Each small business will be able to use the support in whatever way makes the most sense for their individual business. For example, some businesses will need support paying employee wages or rent, while others will need support maintaining their inventory.

Eligible small businesses include those that:

- Are required to close or significantly restrict services subject to the Provincewide Shutdown effective 12:01 a.m. on December 26, 2020;
- Have less than 100 employees at the enterprise level; and
- Have experienced a minimum of 20 per cent revenue decline in April 2020 compared to April 2019.

Starting at $10,000 for all eligible businesses, the grant will provide businesses with dollar for dollar funding to a maximum of $20,000 to help cover decreased revenue expected as a result of the Provincewide Shutdown. The business must demonstrate they experienced a revenue decline of at least 20 per cent when comparing monthly revenue in April 2019 and April 2020. This time period was selected because it reflects the impact of the public health measures in spring 2020, and as such provides a representation of the possible impact of these latest measures on small businesses.

Essential businesses that are allowed to remain open will not be eligible for this grant. More information about the *Ontario Small Business Support Grant* is available here. Further details, including how to apply, will be announced in January 2021.

Businesses that are impacted by the Provincewide Shutdown will also be eligible for the property tax and energy cost rebates. In November, the government launched a program to provide rebates to offset fixed costs such as property tax and energy bills for businesses that are required to shut down or significantly restrict services due to provincial public health measures. These rebates will continue to be available for businesses impacted by the Provincewide Shutdown and earlier restrictions. Business can apply for the rebates here.

Quick Facts

- Currently, hospitalizations for COVID-19 have increased by 74 per cent over the last four weeks and are more than 15 times higher than they were at the beginning of September. Intensive care unit (ICU) occupancy for COVID-19 has more than doubled over the last four weeks and is 20 times higher than at the beginning of September.
- Ontario currently has 915 COVID-19 patients requiring acute care, 265 patients in ICU, with 152 on a ventilator.
- Based on the latest modelling data, cases across the province are continuing to grow and the number of people requiring an intensive care bed is projected to rise well above 300 people within the next 10 days.
- Some jurisdictions around the world, including those in Canada have implemented similar time-limited measures to respond to a dramatic resurgence in cases. Based on their experiences, measures of four to six weeks are expected to interrupt transmission of COVID-19 in Ontario.
- Municipalities and local medical officers of health may have additional restrictions or targeted requirements in their region.
- Get tested if you have symptoms compatible with COVID-19, or if you have been advised of exposure by your local public health unit or through the COVID Alert App. Visit Ontario.ca/covidtest to find the nearest testing location.
- The Ontario Small Business Support Grant is part of the Province's more than $13.5 billion in support for people and jobs outlined in the 2020 Budget, Ontario's Action Plan: Protect, Support, Recover. It is also in addition to $4.8 billion to address critical areas to support a strong long-term recovery that helps workers, employers and communities get back on their feet, while building the foundation for recovery and growth.
- To find the right supports, visit COVID-19: Support for People, which has information about the many available and free mental health services and supports.
- To stay safe you can download the COVID Alert App free from the Apple and Google Play app stores.
- To date, as part of the province's COVID-19 immunization program, over 3,000 frontline health care workers have been vaccinated.
- Schools continue to be safe, and according to data reported by school boards, as of Friday, December 18: approximately 99.64 per cent of students in Ontario have not reported a case of COVID-19; approximately 92 per cent of schools across the province have had either no cases or one case reported within the last 14 days; and approximately 80 per cent of schools do not have an case of COVID-19.

Additional Resources

- Ontario Building On Supports for Employers During COVID-19
- Ontario Supporting High Priority Communities
- The Digital Main Street program helps main street businesses build their online presence and reach more customers.
- Property Tax and Energy Cost Rebates
- Visit Ontario's website to learn more about how the province continues to protect the people of Ontario from COVID-19.
- COVID-19: provincewide shutdown
- **If you have questions about what will be open or impacts to your business or employment, call the Stop the Spread Business Information Line at 1-888-444-3659.**

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This is **“Exhibit P”**
to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022

A Commissioner, etc.

NEWS RELEASE

Ontario Declares Second Provincial Emergency to Address COVID-19 Crisis and Save Lives

Province Issues Stay-at-Home Order and Introduces Enhanced Enforcement Measures to Reduce Mobility

January 12, 2021
Office of the Premier

TORONTO — In response to a doubling in COVID-19 cases over the past two weeks, the real and looming threat of the collapse of the province's hospital system and alarming risks posed to long-term care homes as a result of high COVID-19 transmission rates, the Ontario government, in consultation with the Chief Medical Officer of Health and other health experts, is immediately declaring a second provincial emergency under s 7.0.1 (1) of the *Emergency Management and Civil Protection Act* (EMPCA).

Details were provided today by Premier Doug Ford, Christine Elliott, Deputy Premier and Minister of Health, Solicitor General Sylvia Jones, Dr. David Williams, Chief Medical Officer of Health, and Dr. Adalsteinn (Steini) Brown, Co-Chair of the Ontario COVID-19 Science Advisory Table.

"The latest modelling data shows that Ontario is in a crisis and, with the current trends, our hospital ICUs will be overwhelmed in a few short weeks with unthinkable consequences," said Premier Ford. "That's why we are taking urgent and decisive action, which includes declaring a provincial emergency and imposing a stay-at-home-order. We need people to only go out only for essential trips to pick up groceries or go to medical appointments. By doing the right thing and staying home, you can stay safe and save lives."

Effective Thursday, January 14, 2021at 12:01 a.m., the government is issuing a stay-at-home order requiring everyone to remain at home with exceptions for permitted purposes or activities, such as going to the grocery store or pharmacy, accessing health care services, for exercise or for work where the work cannot be done remotely. This order and other new and existing public health restrictions are aimed at limiting people's mobility and reducing the number of daily contacts with those outside an immediate household. In addition to limiting outings for these purposes, all businesses must ensure that any employee who can work from home, does work from home.

These new public health measures will help stop the spread of COVID-19 by reducing concerning levels of mobility as the province continues its vaccine rollout and ramps up to mass vaccination when the federal government is able to provide the necessary supply to do so.

Additional Public Health Restrictions

Since the implementation of the Provincewide Shutdown over two weeks ago, the latest modelling trends in key public health indicators have continued to worsen, forecasting an overwhelming of the health system unless drastic action is taken. Escalating case counts have led to increasing hospitalization rates and intensive care unit (ICU) occupancy which has resulted in cancellations of scheduled surgeries and procedures.

Provincial modelling shows growth in COVID-19 cases has accelerated, leading to increased hospitalization rates and ICU occupancy. ICU occupancy by COVID-19 patients is now over 400 beds and is projected to be as high as 1,000 beds by early February which has the potential to overwhelm Ontario's hospitals. The number of COVID-19-related deaths continues to rise and is expected to double from 50 to 100 deaths per day between now and the end of February. Notably, data shows that mobility and contacts between people have not decreased with the current restrictions. A new variant of COVID-19 emerged in November. If community transmission of this variant occurs, Ontario could experience much higher case counts, ICU occupancy and mortality.

In response to the alarming and exceptional circumstances at hand, and to further interrupt the deadly trend of transmission in Ontario communities, hospitals, and long-term care homes, the following additional public health measures will take effect January 13, 2021 at 12:01 a.m.:

- Outdoor organized public gatherings and social gatherings are further restricted to a limit of five people with limited exceptions. This is consistent with the rules during the lockdown during the first wave of COVID-19 in spring 2020 and will allow individuals and families to enjoy time outdoors safely.
- Individuals are required to wear a mask or face covering in the indoor areas of businesses or organizations that are open. Wearing a mask or face covering is now recommended outdoors when you can't physically distance more than two metres.
- All non-essential retail stores, including hardware stores, alcohol retailers, and those offering curbside pickup or delivery, must open no earlier than 7 a.m. and close no later than 8 p.m. The restricted hours of operation do not apply to stores that primarily sell food, pharmacies, gas stations, convenience stores, and restaurants for takeout or delivery.
- Non-essential construction is further restricted, including below-grade construction, exempting survey.

These measures will come into effect between Tuesday January 12, 2021 and Thursday, January 14, 2021, including the provincial declaration of emergency under the EMCPA, orders under that Act, and amendments to regulations under the *Reopening Ontario (A Flexible Response to COVID-19) Act, 2020*.

"Despite our best efforts, COVID-19 is continuing to spread in our communities, our hospitals, our long-term care homes, and our workplaces. We are continuing to see concerning trends across the province, including a tragic number of deaths," said Christine Elliott, Deputy Premier and Minister of Health. "We have made great strides in vaccinating tens of thousands of Ontarians, and we can't let these efforts go to waste. Urgent action is required to break this deadly trend of transmission, ensure people stay home, and save lives."

To help quickly identify and isolate cases of COVID-19 in workplaces and service providers permitted to remain open such as long-term care homes and schools, the province will provide up to 300,000 COVID-19 tests per week to support key sectors such as manufacturing, warehousing, supply chain and food processing, as well as additional tests for schools and long-term care homes. This volume of rapid tests would support antigen screening for up to 150,000 workers per week over the next 4-5 months in Ontario's most critical workplaces. The province is expecting to receive 12 million Panbio tests from the federal government over the next several months and continues to pursue opportunities to purchase additional rapid tests.

"The trends in key public health indicators are continuing to deteriorate, and further action is urgently required to save lives," said Dr. David Williams, Chief Medical Officer of Health. "By strictly adhering to all public health and workplace safety measures, we can reduce the transmission of COVID-19 and keep our loved ones and our communities safe. It will take the collective efforts of us all to defeat this virus."

The government knows that in order to keep Ontarians safe, it is important that they are not forced to leave their homes during the new state of emergency. Ontario is exploring all options available to put a temporary residential evictions moratorium in place, and will have more to say in the coming days.

The additional public health restrictions introduced expand on the existing measures put in place to keep Ontarians safe and healthy.

New Enforcement Measures

The province will provide authority to all provincial offences officers, including the Ontario Provincial Police, local police forces, bylaw officers, and provincial workplace inspectors to issue tickets to individuals who do not comply with the stay-at-home-order, or those not wearing a mask or face covering indoors in places open to the public, subject to limited exceptions, as well as retail operators and companies who do not enforce requirements under orders under the *Reopening Ontario (A Flexible Response to COVID-19) Act* (ROA) or EMPCA. Those who decide not to abide by orders will be subject to a set fine and/or prosecution under both the ROA and EMCPA as applicable.

In addition, all provincial offences officers will have the authority to temporarily close a premise and disperse individuals who are in contravention of gathering limits an order and will be able to disperse people who are gathering, regardless whether a premise has been closed or remains open such as a park.

"Strong, new measures will be enforced to stop the spread of COVID-19," said Solicitor General Sylvia Jones. "We are taking extraordinary action to provide law enforcement officers with the tools and support they need to protect the health and wellbeing of Ontarians."

Schools and Child Care Centres

Based on the advice of the Chief Medical Officer of Health, schools in the following public health units (PHUs) will not return to in-person instruction until February 10, 2021:

- Windsor-Essex

- Peel Region
- Toronto
- York
- Hamilton

By January 20, 2021, the Chief Medical Officer of Health will advise the Ministry of Education on which public health units (PHUs) will be permitted to resume in-person instruction, based on the most up-to-date data and modelling. Before- and after-school programs can be offered when in-person instruction resumes. Schools in northern PHUs will continue to remain open.

To continue to keep students, staff and communities safe, the following new health and safety measures will be put in place for in-person learning:

- Masking for Grade 1-3 and requirements for mask wearing outdoors;
- Enhanced screening protocols; and
- Expanded targeted testing.

The government will also implement new health and safety measures in Ontario child care settings, such as enhanced screening to align with school requirements, voluntary participation in targeted testing and additional infection prevention and control measures to align with schools. These enhancements are in addition to the existing health and safety measures already being implemented in child care settings across the province.

Child care centres for non-school aged children will remain open, and emergency child care for school-aged children will end in approved PHU regions on January 22, 2021 as these elementary schools return to in-person learning.During this extended period of online learning, in areas where in-person elementary learning is suspended, emergency child care will continue for eligible families in regions subject to school closures, as identified by the Chief Medical Officer of Health.

"At the heart of our continued efforts to protect against the spread of COVID-19 in our communities is a firm commitment to return kids to school safely," said Education Minister Stephen Lecce. "Protecting our students, staff and their families is our top priority, and these additional measures build on our comprehensive plan to reopen schools and keep young children in child care safe."

Workplace Safety

The Ministry of Labour, Training and Skills Development is taking additional steps to protect workers with the launch of the "Stay Safe All Day" campaign, focusing workplace inspections in areas of high transmission, including break rooms, and providing new educational materials to employers to

promote safe behaviour before, during and after work.

Evidence gathered from COVID-19 related workplace inspections to date shows the vast majority of employers and workers are following COVID-19 safety requirements when working. However, when in a break room, a vehicle or not on the clock, there is a tendency to forget about the importance of wearing masks, maintaining physical distance and hand hygiene.

As part of the "Stay Safe All Day" campaign, inspectors will use a data-driven approach to focus on workplaces with reported COVID-19 outbreaks, manufacturing businesses, warehouses, distribution centres, food processing operations, construction projects and publicly accessible workplaces deemed essential, such as grocery stores. The Ministry is also using a new data-sharing program, in conjunction with the Ministry of Long-Term Care and the Retirement Regulatory Authority, to focus onsite inspections of long-term-care homes and retirement homes.

"We know the majority of businesses are operating safely and responsibly to protect their workers and customers. But as COVID-19 cases continue to rise, we all need to step up and take additional measures to stop the spread," said Monte McNaughton, Minister of Labour, Training and Skills Development. "This includes increasing our inspections to look at everything workers do both while on the job and throughout the workday."

In the unfortunate event that an employee becomes infected with COVID-19, they may be entitled to federally funded paid sick leave of up to $500 a week for two weeks. Workers can also access Canada's Recovery Caregiver Benefit of up to $500 per week for up to 26 weeks if they are unable to work because they must care for their child under 12 years old or a family member who needs supervised care.

Over the summer, the government enacted a new regulatory amendment that put non-unionized employees on Infectious Disease Emergency Leave during the COVID-19 outbreak any time their hours of work are temporarily reduced by their employer due to COVID-19, ensuring businesses aren't forced to terminate employees after their ESA temporary layoff

periods have expired. As part of the Safe Restart Agreement, the federal government is funding a temporary income support program that allows workers to take up to 10 days of leave related to COVID-19, preventing the risk of further spread in the workplace and allowing workers to focus on their health.

Quick Facts

- The Government of Ontario declared its first provincial emergency in response to COVID-19 on March 17, 2020 which remained in effect until July 24, 2020 when the ROA came into force.
- An emergency declaration pursuant to s. 7.0.1 is terminated 14 days after being made and may be extended for up to a further 14 days by the Lieutenant Governor in Council. Thereafter, extensions require approval of the Legislature, which can extend the declared provincial emergency for additional periods of up to 28 days. Orders made during the declaration of emergency pursuant s. 7.0.2 (4) will automatically terminate after 14 days unless they are extended for additional periods of up to 14 days, while orders pursuant to s. 7.1 can be for a period of up to 90 days and renewed for additional periods of up to 90 days.
- The orders currently in force under the Reopening Ontario (A Flexible Response to COVID-19) Act, 2020 (ROA) remain in effect until January 20, 2021. Under the ROA, orders can be extended for up to 30 days at a time, and the government must continue to report on all order extensions to the Select Committee on Emergency Management Oversight.
- A full list of emergency orders under the EMPCA as well as orders under the ROA can be found on the e-Laws website and at Ontario.ca/alert.
- As of January 10, 2021, there have been 215,782 reported COVID-19 cases and 4,983 related deaths in Ontario.
- Ontario has implemented the largest immunization plan in its history and to date, a total of over 130,000 doses have been administered provincewide.
- Building on the efforts of the targeted testing in Phase 1, the Ministry of Education and the Ministry of Health will work together with Ontario Health, PHUs and school boards to expand access to COVID-19 testing.

Additional Resources

- Ontario Continues to Support Employers and Workers during COVID-19
- Enhancing Public Health and Workplace Safety Measures in the Provincewide Shutdown
- Visit Ontario's COVID-19 vaccine web page to view the latest provincial data and information on COVID-19 vaccines.
- Visit Ontario's website to learn more about how the province continues to protect the people of Ontario from COVID-19.
- If you have questions about what will be open or impacts to your business or employment, call the Stop the Spread Business Information Line at 1-888-444-3659.
- Get tested if you have symptoms compatible with COVID-19, or if you have been advised of exposure by your local public health unit or through the COVID Alert App. Visit Ontario.ca/covidtest to find the nearest testing location.
- To find the right supports, visit COVID-19: Support for People, which has information about the many available and free mental health services and supports.
- To stay safe, you can download the COVID Alert App free from the Apple and Google Play app stores.
- COVID-19: Reopening Schools
- COVID-19 school and child care screening
- Operational Guidance: COVID-19 Management in Schools document.

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This is **"Exhibit Q"**
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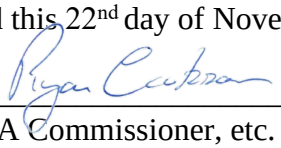
affirmed this 22nd day of November, 2022



A Commissioner, etc.

NEWS RELEASE

Stay-at-Home Order Extended in Toronto and Peel Public Health Regions Along with North Bay-Parry Sound

York Region to Return to Strengthened COVID-19 Response Framework

February 19, 2021
Health

TORONTO — In consultation with the Chief Medical Officer of Health and the local medical officers of health, the Ontario government is maintaining the shutdown, the Stay-at-Home order and all existing public health and workplace safety measures for an additional two weeks in the Toronto and Peel Public Health Regions, along with the North Bay-Parry Sound District. The York Public Health Region will transition out of the shutdown and into the revised and strengthened *COVID-19 Response Framework: Keeping Ontario Safe and Open*.

"Our government's number one priority is the safety of all individuals and families, and that's why we are taking a gradual, cautious approach to returning regions to the Framework," said Christine Elliott, Deputy Premier and Minister of Health. "These are difficult but necessary decisions, in order to protect against COVID-19 variants and maintain the progress we have all made together. Until vaccines are widely available, we continue to urge all Ontarians to follow public health advice and measures, and stay home, stay safe, and save lives."

In the Toronto and Peel Public Health Regions, and the North Bay-Parry Sound District, the shutdown measures and the Stay-at-Home order will continue to apply until at least Monday, March 8, 2021, based on key public health indicators and following consultation with the local medical officers of health. While the Peel and Toronto regions have seen a reduction in COVID-19 transmission from the period of February 8 to 17, 2021, rates still remain too high in the regions, with case rates of 83.4 cases per 100,000 people for Peel and 67.9 cases per 100,000 people for Toronto, both well above the provincial average. During this same period of time, North Bay Parry Sound District has also seen its case rate increase by 11.5 per cent to 14.6 cases per 100,000 people. Variants of concern also remain a serious risk to community transmission and health system capacity.

Based on a general improvement in trends of key indicators, York Region Public Health will be moving back to the Framework at the Red-Control level and will no longer be subject to the Stay-at-Home order. In addition, Lambton Public Health will be moving from the Orange-Restrict level to the Red-Control level as a result worsening public health trends in the region over the past week. These changes will come into effect on Monday, February 22, 2021 at 12:01 a.m.

After returning to the Framework, public health regions are required to stay in their level for at least two weeks. The government will then assess the impact of public health and workplace safety measures to determine if the region should stay where it is or be moved to a different level. Public health regions may be moved to a higher level within the two-week window, if necessary, based on the set indicators and thresholds outlined in the Framework. In addition, Ontario has introduced an "emergency brake" to allow the Chief Medical Officer of Health, in consultation with the local medical officer of health, to immediately advise moving a region into Grey-Lockdown to interrupt transmission.

"While the health indicators have improved enough to allow us to return an additional region to the Framework, we are not yet at the point where we can safely transition back the remainder of the province," said Dr. David Williams, Chief Medical Officer of Health. "Everyone is strongly advised to continue staying at home, avoid social gatherings, only travel between regions for essential purposes, and limit close contacts to your household or those you live with regardless of which level of the Framework you are in."

The Chief Medical Officer of Health will continue to consult with public health and other experts, review data, and provide advice to the government on the appropriate and effective measures that are needed to protect the health of Ontarians.

Quick Facts

- Find out what level and which regional public measures are in place for your area.

- On February 8th the government announced an extension of the shutdown in the majority of public health regions in Ontario and a gradual transition of each region to a revised and strengthened COVID-19 Response Framework when it is safe to do so.
- In addition to the Stay-at-Home orders that apply to the North Bay-Parry Sound District, Toronto and Peel public health regions, the following orders currently in force under the Emergency Management and Civil Protection Act (EMCPA) will be extended to March 8, 2021 and further if necessary: O.Reg 55/21 (Compliance Orders for Retirement Homes), O.Reg 8/21 (Enforcement of COVID-19 Measures), O.Reg. 11/21 (Stay-at-Home Order), O.Reg. 13/21 (Residential Evictions).
- Enforcement of residential evictions will remain paused in the public health regions where the provincial Stay-at-Home order remains in effect.
- Local medical officers of health continue to have the ability to issue Section 22 orders under the Health Protection and Promotion Act, to target specific transmission risks in the community.
- Ontario has implemented a six-point plan to prevent and stop the spread of COVID-19 variants.
- To support the safe return of in-person learning, Ontario has introduced new measures to continue to protect students and staff against COVID-19 in the classroom.

Additional Resources

- Please visit Ontario.ca/covidresponse for the full list of public health region classifications.
- To find the right supports, visit COVID-19: Support for People, which has information about the many available and free mental health services and supports.
- Get tested if you have COVID-19 symptoms, or if you have been advised of exposure by your local public health unit or through the COVID Alert App. Visit Ontario.ca/covidtest to find the nearest testing location.
- Visit Ontario's COVID-19 vaccine web page to view the latest provincial data and information on COVID-19 vaccines.

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This is **"Exhibit R"**
to the Affidavit of David McKeown,
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A Commissioner, etc.

NEWS RELEASE

Ontario Activates Emergency Brake in Thunder Bay District Health Unit and Simcoe-Muskoka District Health Unit

Nine Public Health Regions Moving to New Levels in the COVID-19 Response Framework

February 26, 2021
Health

TORONTO — The Ontario government, in consultation with the Chief Medical Officer of Health, is moving nine public health regions to new levels in the *Keeping Ontario Safe and Open Framework* (the "Framework"). This includes activating an "emergency brake" in Thunder Bay District Health Unit and Simcoe-Muskoka District Health Unit to move the regions to Grey-Lockdown to immediately interrupt transmission and contain community spread. Decisions were made in consultation with the local medical officers of health and are based on the trends in public health indicators and local context and conditions.

"While we continue to see the number of cases and other public health indicators lowering in many regions across the province, the recent modelling shows us that we must be nimble and put in place additional measures to protect Ontarians and stop the spread of COVID-19," said Christine Elliott, Deputy Premier and Minister of Health. "With COVID-19 variants continuing to spread in our communities, it is critically important that everyone continues strictly adhering to all public health and workplace safety measures to help contain the virus and maintain the progress we have made to date."

Based on the latest data, the following public health regions will move from their current level in the Framework to the following levels effective Monday, March 1, 2021 at 12:01 a.m.:

Grey-Lockdown

- Simcoe-Muskoka District Health Unit; and
- Thunder Bay District Health Unit.

Red-Control

- Niagara Region Public Health.

Orange-Restrict

- Chatham-Kent Public Health;
- Middlesex-London Health Unit; and
- Southwestern Public Health.

Yellow-Protect

- Haldimand-Norfolk Health Unit; and
- Huron Perth Public Health.

Green-Prevent

- Grey Bruce Health Unit.

Based on the latest assessment of data the "emergency brake" is being used to place Thunder Bay District Health Unit and Simcoe-Muskoka District Health Unit into Grey-Lockdown, helping to stop the spread of the virus and protect public health and health system capacity in the regions. This is due to a rapid worsening in key public health indicators, as well as a high presence of variants in the Simcoe-Muskoka District Health Unit that continue to increase - the highest in the province. As of February 23, 2021, there has been a total of 170 confirmed cases of a variant of concern in this region.

In Peel Public Health, Toronto Public Health, and North Bay Parry Sound District, the Shutdown measures and the Stay-at-Home order will continue to apply until at least Monday, March 8, 2021, with final decisions to be based on key public health indicators and consultation with the local medical officers of health. All other public health regions will remain at their current level. Please visit Ontario.ca/covidresponse for the full list of public health region classifications.

Based on the latest modelling data, the efforts of Ontarians in following public health measures and advice are working to decrease the number of new cases, deaths and hospitalizations across the province. However, with variants of concern continuing to spread, the number of patients requiring hospitalization and intensive care may rise once again if public health measures are not relaxed carefully and gradually. The actions of everyone over the coming weeks will be critical to maintaining the progress communities have made across the province to date.

"Quickly implementing stronger measures to interrupt transmission of COVID-19 is a key component of the government's plan to safely and gradually return public health regions to the Framework," said Dr. David Williams, Chief Medical Officer of Health. "Due to data and local context and conditions in the Simcoe-Muskoka and Thunder Bay Districts, it was necessary to tighten public health measures in these regions to ensure the health and safety of the region at large and stop the spread of the virus."

The Chief Medical Officer of Health will continue to consult with public health and other experts, review data, and provide advice to the government on the appropriate and effective measures that are needed to protect the health of Ontarians.

Quick Facts

- Find out what level and which public health and workplace safety measures are in place for your area.
- To help stop the spread of COVID-19 and safeguard health system capacity, everyone is strongly urged to continue staying at home and limit trips outside their household and between other regions for essential reasons only, not to gather with individuals outside of their household, and to wear a face covering when within two metres distance of another individual who is not part of their household (both indoor and outdoor) or when required, with limited exceptions.
- Recognizing the risk posed by new variants to the province's pandemic response, Ontario has introduced an "emergency brake" to allow the Chief Medical Officer of Health, in consultation with the local medical officer of health, to immediately advise moving a region into Grey-Lockdown to interrupt transmission.
- Local medical officers of health continue to have the ability to issue Section 22 orders under the Health Protection and Promotion Act, and municipalities may enact by-laws, to target specific transmission risks in the community.
- Ontario has implemented a six-point plan to prevent and stop the spread of COVID-19 variants.

Additional Resources

- Stay-at-Home Order Extended in Toronto and Peel Public Health Regions Along with North Bay-Parry Sound.
- To find the right supports, visit COVID-19: Support for People, which has information about the many available and free mental health services and supports.
- Get tested if you have COVID-19 symptoms, or if you have been advised of exposure by your local public health unit or through the COVID Alert App. Visit Ontario.ca/covidtest to find the nearest testing location.
- Visit Ontario's COVID-19 vaccine web page to view the latest provincial data and information on COVID-19 vaccines.
- Visit Ontario's COVID-19 information website to learn more about how the province continues to protect the people of Ontario from the virus.

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to the Affidavit of David McKeown,
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A Commissioner, etc.

NEWS RELEASE

Toronto, Peel and North Bay-Parry Sound Public Health Regions Returning to Strengthened COVID-19 Response Framework

Seven Other Public Health Regions Moving to New Levels in the Framework

March 05, 2021
Health

TORONTO — The Ontario Government, in consultation with the Chief Medical Officer of Health, is transitioning Toronto, Peel and North Bay Parry Sound District public health regions out of the shutdown and into the revised and strengthened *COVID-19 Response Framework: Keeping Ontario Safe and Open* (the "Framework"), with the Stay-at-Home order no longer in effect. In addition, seven other public health regions are being moved to new levels in the Framework. All decisions were made in consultation with the local medical officers of health and are based on the latest trends in public health indicators and local context and conditions.

"Our government is taking a safe and cautious approach to returning to the Framework and due to our progress, all regions of the province will soon be out of the provincewide shutdown," said Christine Elliott, Deputy Premier and Minister of Health. "Despite this positive step forward, a return to the Framework is not a return to normal. As we continue vaccinating more Ontarians, it remains critical for everyone to continue to follow public health measures and stay home as much as possible to protect themselves, their loved ones and their communities."

Based on a general improvement in trends of key indicators, North Bay Parry Sound District will be returning to the Framework at the Red-Control level. Toronto Public Health and Peel Public Health are also making progress, but as their case rates still remain high, they will return to the Framework at the Grey-Lockdown level.

In addition, based on the latest data, the following seven public health regions will also be moving to the following levels in the Framework:

Red-Control

- Peterborough Public Health;
- Public Health Sudbury and Districts; and
- Simcoe-Muskoka District Health Unit.

Orange-Restrict

- Haldimand-Norfolk Health Unit; and
- Timiskaming Health Unit.

Yellow-Protect

- Haliburton, Kawartha, Pine Ridge District Health Unit; and
- Renfrew County and District Health Unit.

All changes will be effective Monday, March 8, 2021 at 12:01 a.m. Please visit Ontario.ca/covidresponse for the full list of public health region classifications.

Based on the latest modelling data, the efforts of Ontarians in following public health measures and advice are working to decrease the number of new cases, deaths and hospitalizations across the province. However, with COVID-19 variants of concern continuing to spread, the actions of everyone over the coming weeks will be critical to maintaining the progress communities have made across the province to date.

"While all regions have returned to the Framework, everyone must remain vigilant to help prevent any further increases in transmission," said Dr. David Williams, Chief Medical Officer of Health. "The best defense against the virus and all of its variants of concern remains continuing to stay at home, avoiding social gatherings, only travelling outside of your community for essential purposes, and limiting close contacts to your household or those you live with."

The Chief Medical Officer of Health will continue to consult with public health and other experts, review data, and provide advice to the government on the appropriate and effective measures that are needed to protect the health of Ontarians.

Quick Facts

- Find out what level and which public health and workplace safety measures are in place for your area.
- From the period of February 23 to March 2, 2021, case rates in North Bay Parry Sound District have decreased by 84.6 per cent to 3.1 cases per 100,000 people and the number of hospitalizations has shrunk from 1 to 0.
- In Toronto Public Health the case rates have decreased by 15.7 per cent to 66.4 cases per 100,000 people and hospitalizations have seen an 11.2 per cent decrease. During this same period of time, Peel Public Health has seen its case rates increase by 6.6 per cent to 91.4 cases per 100,000 people. Peel Region has also seen the number of patients with COVID-19 in intensive care decrease from 26 to 19.
- To help stop the spread of COVID-19 and safeguard health system capacity, everyone is strongly urged to continue staying at home and limit trips outside their household and to other regions for essential reasons only, and not to gather with individuals outside of their household. In addition, people are required to wear a face covering when within two metres distance of another individual who is not part of their household (both indoor and outdoor), with limited exceptions.
- Recognizing the risk posed by new variants to the province's pandemic response, Ontario has introduced an "emergency brake" to allow the Chief Medical Officer of Health, in consultation with the local medical officer of health, to immediately advise moving a region into Grey-Lockdown to interrupt transmission.
- Local medical officers of health continue to have the ability to issue Section 22 orders under the Health Protection and Promotion Act, and municipalities may enact by-laws, to target specific transmission risks in the community.
- Emergency orders O.Reg 8/21 (Enforcement of COVID-19 Measures) and O.Reg 55/21 (Compliance Orders for Retirement Homes) currently in force under the Emergency Management and Civil Protection Act (EMCPA) will be extended to March 22, 2021. Emergency orders O.Reg 11/21 (Stay-at-Home Order), O.Reg.89/21 (Stay-at-Home Order Toronto Public Health), O.Reg. 76/21 (Stay-at-Home Order North Bay Parry Sound District), O.Reg. 73/21 (Stay-at-Home Order Peel Public Health) and O.Reg 13/21 (Residential Evictions) will expire and no longer be in effect as of March 8, 2021.

Additional Resources

- Ontario Activates Emergency Brake in Thunder Bay District Health Unit and Simcoe-Muskoka District Health Unit.
- To find the right supports, visit COVID-19: Support for People, which has information about the many available and free mental health services and supports.
- Get tested if you have COVID-19 symptoms, or if you have been advised of exposure by your local public health unit or through the COVID Alert App. Visit Ontario.ca/covidtest to find the nearest testing location.
- Visit Ontario's COVID-19 vaccine web page to view the latest provincial data and information on COVID-19 vaccines.
- Visit Ontario's COVID-19 information website to learn more about how the province continues to protect the people of Ontario from the virus.

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A Commissioner, etc.

NEWS RELEASE

Ontario Activates Emergency Brake in Sudbury Public Health Region

Immediate action required to interrupt transmission, contain community spread and save lives

March 11, 2021
Health

TORONTO — On the advice of the Chief Medical Officer of Health, the Ontario Government is activating an "emergency brake" in the Public Health Sudbury and Districts region, and moving it to the Grey-Lockdown level in the *Keeping Ontario Safe and Open Framework*. The decision was made due to the concerning trends in public health indicators and in consultation with the local medical officer of health.

"Implementing an emergency brake to immediately interrupt transmission of COVID-19 is a key component of our government's plan to safely and gradually return public health regions to the Framework," said Christine Elliott, Deputy Premier and Minister of Health. "We have seen a rapid rise in the case rate in the Sudbury area, and swift action is needed to protect individuals, families and businesses and save lives."

Based on the latest assessment of data, the "emergency brake" is being used to stop the spread, guard against variants and protect public health and health system capacity in the region. From March 3 to 9, 2021, the region's case rate increased by 54.1 per cent to 75.9 cases per 100,000 people.

The public health region will move to Grey-Lockdown effective Friday, March 12, 2021 at 12:01 a.m.

"As a result of the rapid deterioration of trends in key indicators, the emergency brake is being applied to move Public Health Sudbury and Districts to Grey-Lockdown to help reduce further spread of the virus in the region," said Dr. David Williams, Chief Medical Officer of Health. "We must remain vigilant in adhering to all public health and workplace safety measures to combat the threat posed by variants of concern."

The Chief Medical Officer of Health will continue to consult with public health and other experts, review data, and provide advice to the government on the appropriate and effective measures that are needed to protect the health of Ontarians.

Quick Facts

- Find out what level and which public health and workplace safety measures are in place for your area.
- To help stop the spread of COVID-19 and safeguard health system capacity, everyone is strongly urged to continue staying at home and limit trips outside their household and to other regions for essential purposes only, and not to gather with individuals outside of their household. In addition, people are required to wear a face covering when within two metres distance of another individual who is not part of their household (both indoor and outdoor), with limited exceptions.
- Local medical officers of health continue to have the ability to issue Section 22 orders under the Health Protection and Promotion Act, and municipalities may enact by-laws, to target specific transmission risks in the community.

Additional Resources

- To find the right supports, visit COVID-19: Support for People, which has information about the many available and free mental health services and supports.
- Get tested if you have COVID-19 symptoms, or if you have been advised of exposure by your local public health unit or through the COVID Alert App. Visit Ontario.ca/covidtest to find the nearest testing location.
- Visit Ontario's COVID-19 vaccine web page to view the latest provincial data and information on COVID-19 vaccines.
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NEWS RELEASE

Ontario Returning 27 Public Health Regions to Strengthened COVID-19 Response Framework

Province Extending Shutdown and Stay-at-Home Order in Regions at Highest Risk

February 12, 2021
Health

TORONTO — In consultation with the Chief Medical Officer of Health, the Ontario government is transitioning twenty-seven public health regions out of the shutdown and into a revised and strengthened *COVID-19 Response Framework: Keeping Ontario Safe and Open* (the "Framework"). The four remaining public health regions, Toronto Public Health, Peel Public Health, York Region Public Health and North Bay Parry Sound District, will remain in the shutdown, and the Stay-at-Home order and all existing public health and workplace safety measures will continue to apply to these four public health regions.

"The health and safety of Ontarians remains our number one priority. While we are cautiously and gradually transitioning some regions out of shutdown, with the risk of new variants this is not a reopening or a return to normal," said Christine Elliott, Deputy Premier and Minister of Health. "Until vaccines are widely available, It remains critical that all individuals and families continue to adhere to public health measures and stay home as much as possible to protect themselves, their loved ones and their communities."

Based on a general improvement in trends of key indicators, including lower transmission of COVID-19, improving hospital capacity, and available public health capacity to conduct rapid case and contact management, the following public health regions will be moving back to the Framework on Tuesday, February 16, 2021 at 12:01 a.m. and will no longer be subject to the Stay-at-Home order:

Grey-Lockdown:

- Niagara Region Public Health

Red-Control:

- Chatham-Kent Public Health;
- City of Hamilton Public Health Services;
- Durham Region Health Department;
- Halton Region Public Health;
- Middlesex-London Health Unit;
- Region of Waterloo Public Health and Emergency Services;
- Simcoe-Muskoka District Health Unit;
- Southwestern Public Health;
- Thunder Bay District Health Unit;
- Wellington-Dufferin Guelph Public Health; and
- Windsor-Essex County Health Unit.

Orange-Restrict:

- Brant County Health Unit;

- Eastern Ontario Health Unit;
- Haldimand-Norfolk Health Unit;
- Haliburton, Kawartha, Pine Ridge District Health Unit;
- Huron Perth Public Health;
- Lambton Public Health;
- Ottawa Public Health;
- Porcupine Health Unit; and
- Public Health Sudbury and Districts.

Yellow-Protect:

- Algoma Public Health;
- Grey Bruce Health Unit;
- Northwestern Health Unit; and
- Peterborough Public Health.

Green-Prevent:

- Leeds, Grenville and Lanark District Health Unit; and
- Timiskaming Health Unit.

For North Bay Parry Sound District, Peel Public Health, Toronto Public Health and York Region Public Health, it is proposed that the shutdown measures and the Stay-at-Home order will continue to apply until at least Monday, February 22, 2021. Please visit Ontario.ca/covidresponse for the full list of public health region classifications.

After returning to the Framework, public health regions will stay in their level for at least two weeks at which time, the government will assess the impact of public health and workplace safety measures to determine if the region should stay where they are or be moved to a different level. Public health regions will move up through the levels, if necessary, based on the set indicators and thresholds outlined in the Framework.

Visitor restrictions for long-term care homes will once again apply to those homes in the public health regions that are in the Orange-Restrict level or higher. In addition, long-term care homes must implement enhanced testing requirements.

Recognizing the risk posed by new variants to the province's pandemic response, Ontario is introducing an "emergency brake" to allow the Chief Medical Officer of Health, in consultation with the local medical officer of health, to immediately advise moving a region into Grey-Lockdown to interrupt transmission. Local medical officers of health also have the ability to issue Section 22 orders under the *Health Protection and Promotion Act*, to target specific transmission risks in the community.

"While the trends in public health indicators are heading in the right direction, we still have work to do," said Dr. David Williams, Chief Medical Officer of Health. "Everyone is strongly advised to continue staying at home, avoid social gatherings, only travel between regions for essential purposes, and limit close contacts to your household or those you live with."

The Chief Medical Officer of Health will continue to consult with public health and other experts, review data, and provide advice to the government on the appropriate and effective measures that are needed to protect the health of Ontarians.

Quick Facts

- Find out what level and which regional public measures are in place for your area.
- On February 10, 2021, Hastings Prince Edward Public Health, Kingston, Frontenac and Lennox & Addington Public Health, and Renfrew County and District Health Unit moved to the Framework at the Green-Prevent level.

- To help stop the spread of COVID-19 and safeguard health system capacity, Ontarians are strongly urged to continue staying at home and limit trips outside their household and between other regions for essential reasons only, not to gather with individuals outside of their household, and to wear a face covering when within two metres distance of another individual who is not part of their household (both indoor and outdoor) or when required, with limited exceptions.
- Ontario has implemented a six-point plan to deal with the new variants of concern which includes mandatory on-arrival testing of international travelers, enhanced screening and sequencing, maintaining public health measures to keep people safe, strengthening case and contact management to track the spread of new cases, enhanced protections for vulnerable populations, and leveraging the latest data to inform public health decisions.
- To support the province's economic recovery, the government has updated the Framework to allow for a safer approach to retail. Limited in-person shopping in Grey-Lockdown zones will be permitted with public health and safety measures, such as limiting capacity to 25 per cent in most retail settings.
- Digital tools have been an important part of the provincial response to COVID-19. To date, almost 6 million self-assessments have been completed using Ontario's health screening tool to help Ontarians navigate their symptoms and decide on next steps. Now, revised and updated screening tools for workers/employees and customer/visitors will help keep Ontarians safe and healthy by pre-screening for symptoms before leaving for work or to visit a business as the province re-opens. The tools help workplaces and businesses meet screening requirements.
- To support the safe return of in-person learning, Ontario has introduced new measures to continue to protect students and staff against COVID-19 in the classroom.

Additional Resources

- Ontario Extending Stay-at-Home Order across Most of the Province to Save Lives.
- Find out about the latest public health measures, advice and restrictions.
- To find the right supports, visit COVID-19: Support for People, which has information about the many available and free mental health services and supports.
- Get tested if you have COVID-19 symptoms, or if you have been advised of exposure by your local public health unit or through the COVID Alert App. Visit Ontario.ca/covidtest to find the nearest testing location.
- Visit Ontario's COVID-19 vaccine web page to view the latest provincial data and information on COVID-19 vaccines.
- Visit Ontario's COVID-19 information website to learn more about how the province continues to protect the people of Ontario from the virus.

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Update on COVID-19 Projections

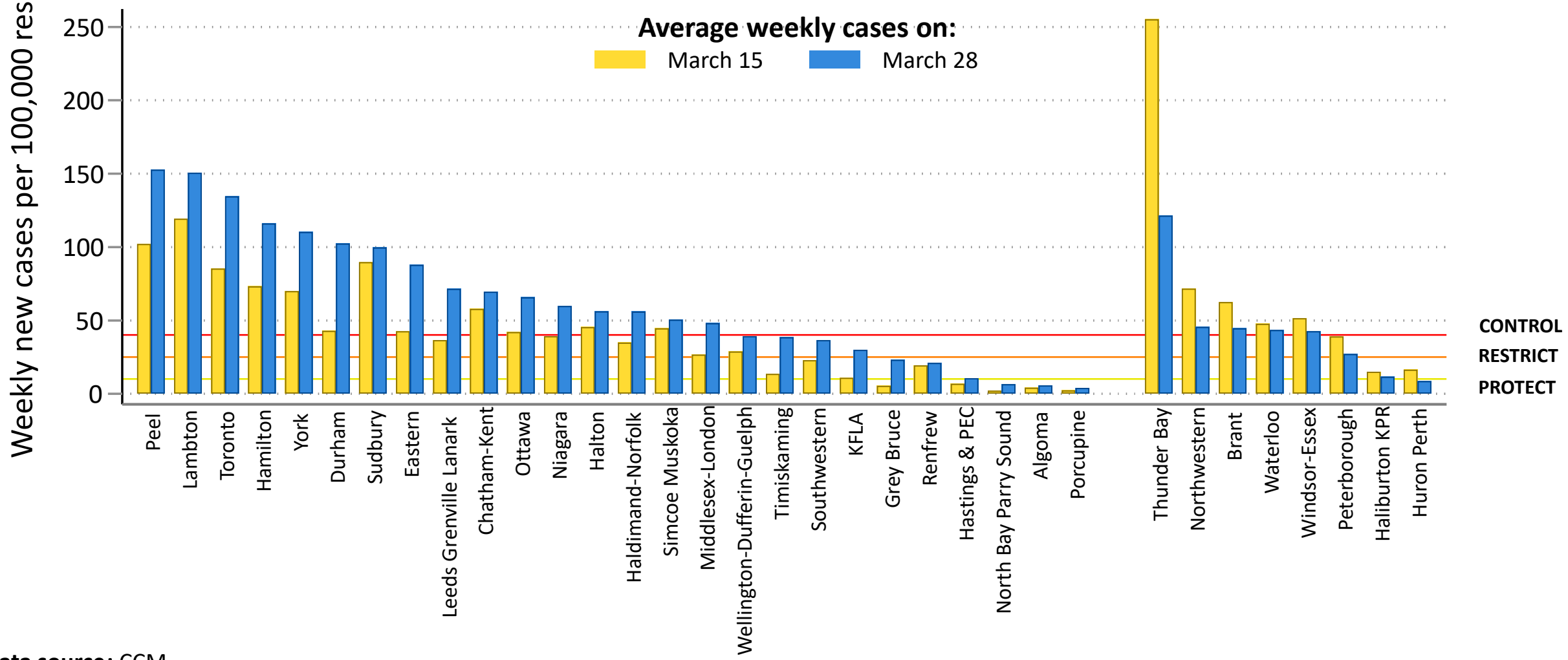
Science Advisory and Modelling Consensus Tables

April 1, 2021

Key Findings

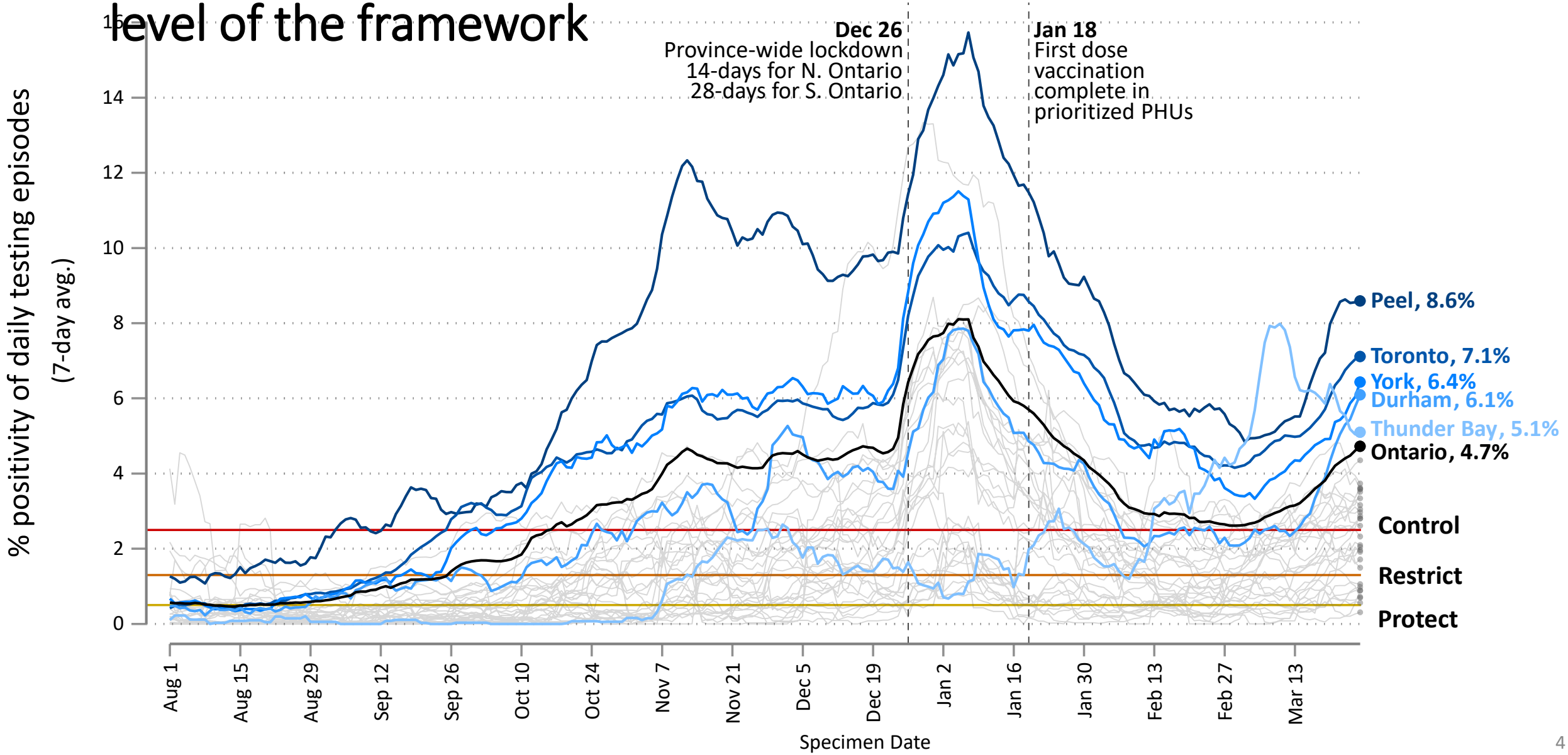
- The **third wave** is here and being **driven by variants of concern**.
- **Younger Ontarians are ending up in hospital.** Risk of ICU admission is **2 x higher** and risk of death is **1.5 x higher** for the B.1.1.7 variant.
- COVID-19 **threatens health system ability to deal with regular ICU admissions** and the ability to care for all patients.
- Vaccination is **not reaching the highest risk communities**, delaying its impact as an effective strategy.
- School disruptions have a significant and highly inequitable **impact** on students, parents and society. Further disruptions should be minimized.
- Stay-at-home orders will control the surge, protect access to care, and increase the chance of the summer Ontarians want.

Cases have increased and are above the second highest level of the framework in most Public Health Units



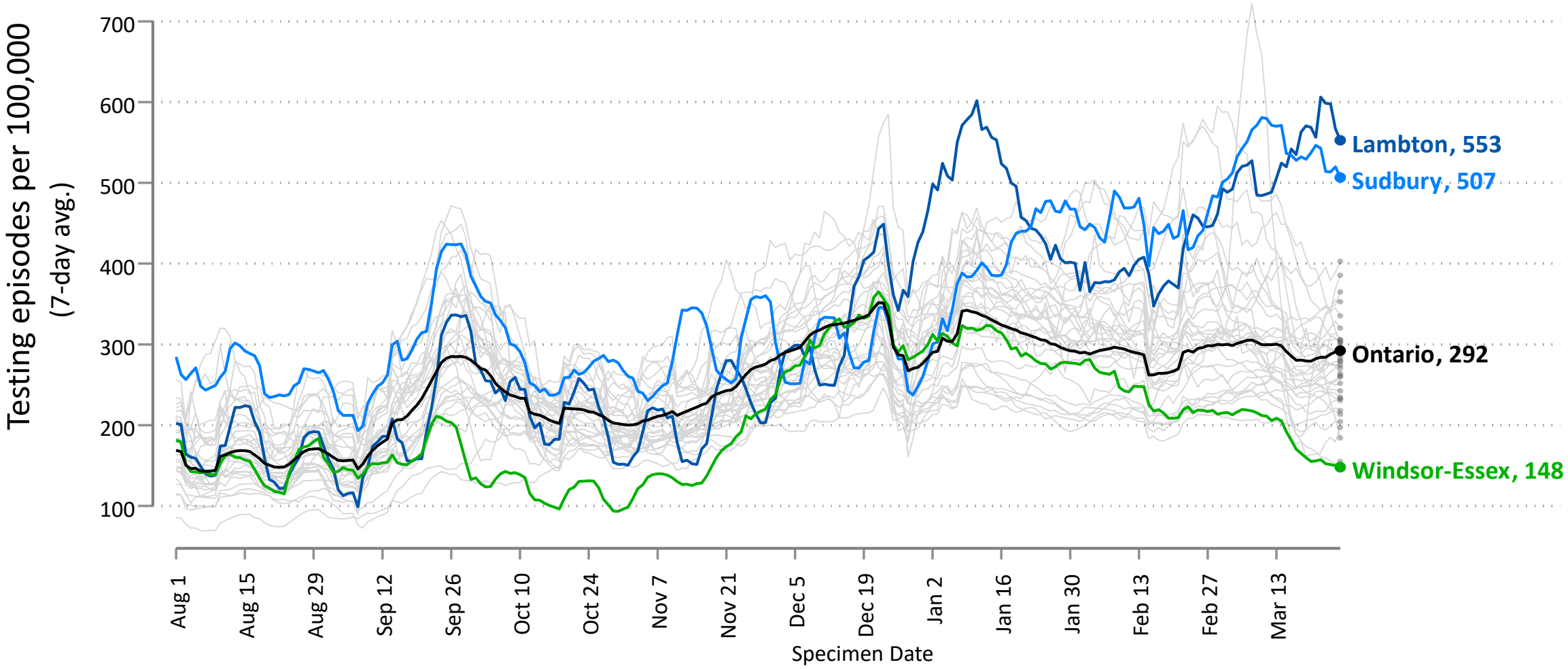
Data source: CCM
Data note: Data for the most recent day have been censored to account for reporting delays

Testing % positivity has increased and is above the second highest level of the framework



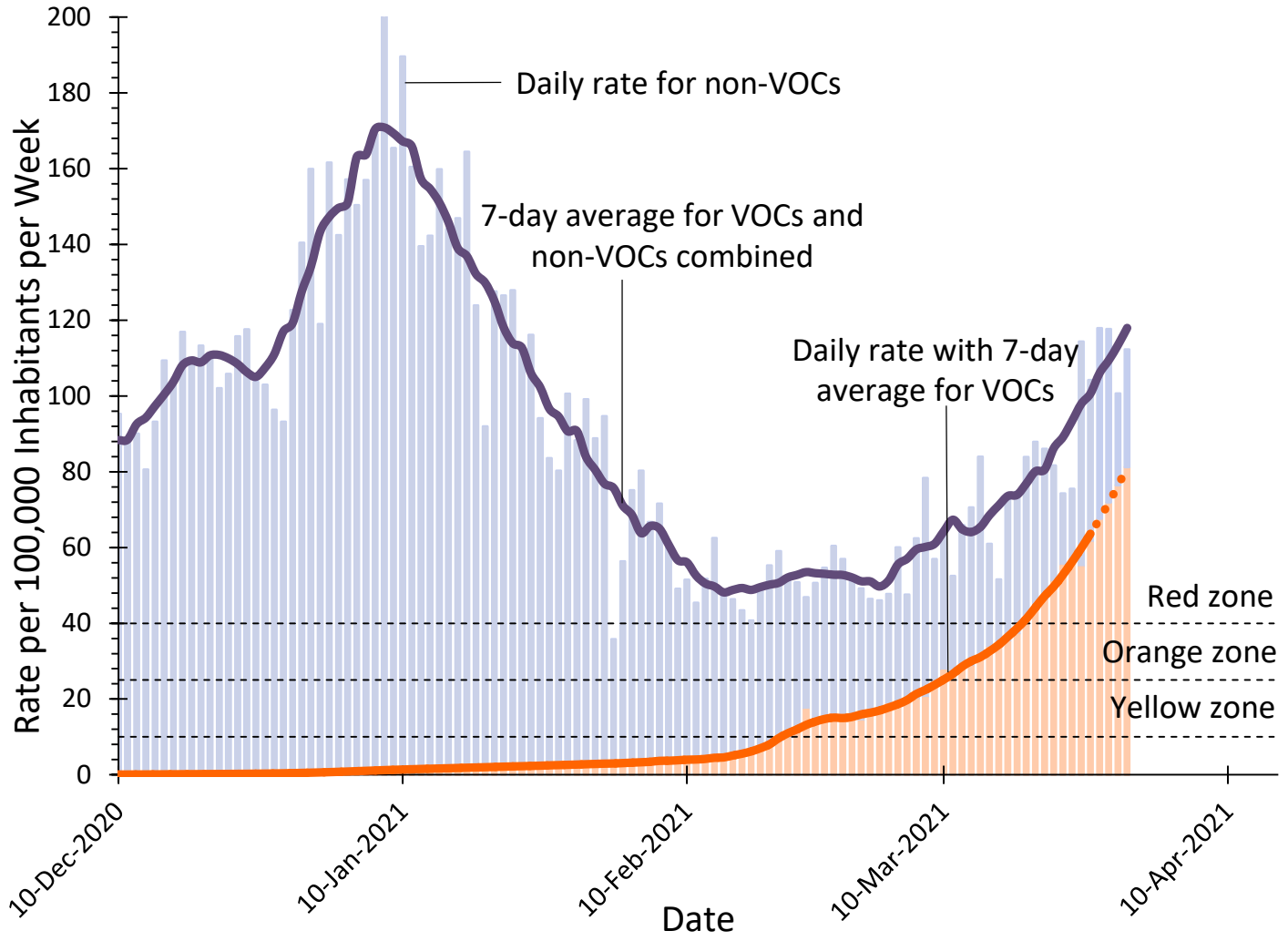
Data source: Ontario Laboratory Information System (OLIS), data up to March 26

Testing rates are flat so case growth is not a result of more testing



Data source: Ontario Laboratory Information System (OLIS), data up to March 26

Cases are increasing. Most new cases are variants of concern.



Variants of concern have more severe consequences and are more fatal

Compared to people infected with the earlier variants, more people with COVID-19 are hospitalized, admitted to ICU, and die if they are infected with the variants of concern.

Short-term case projections depend entirely on system-level public health measures and vaccination

Figure shows example, representative of predictions across 4 models, 3-5 scenarios each.

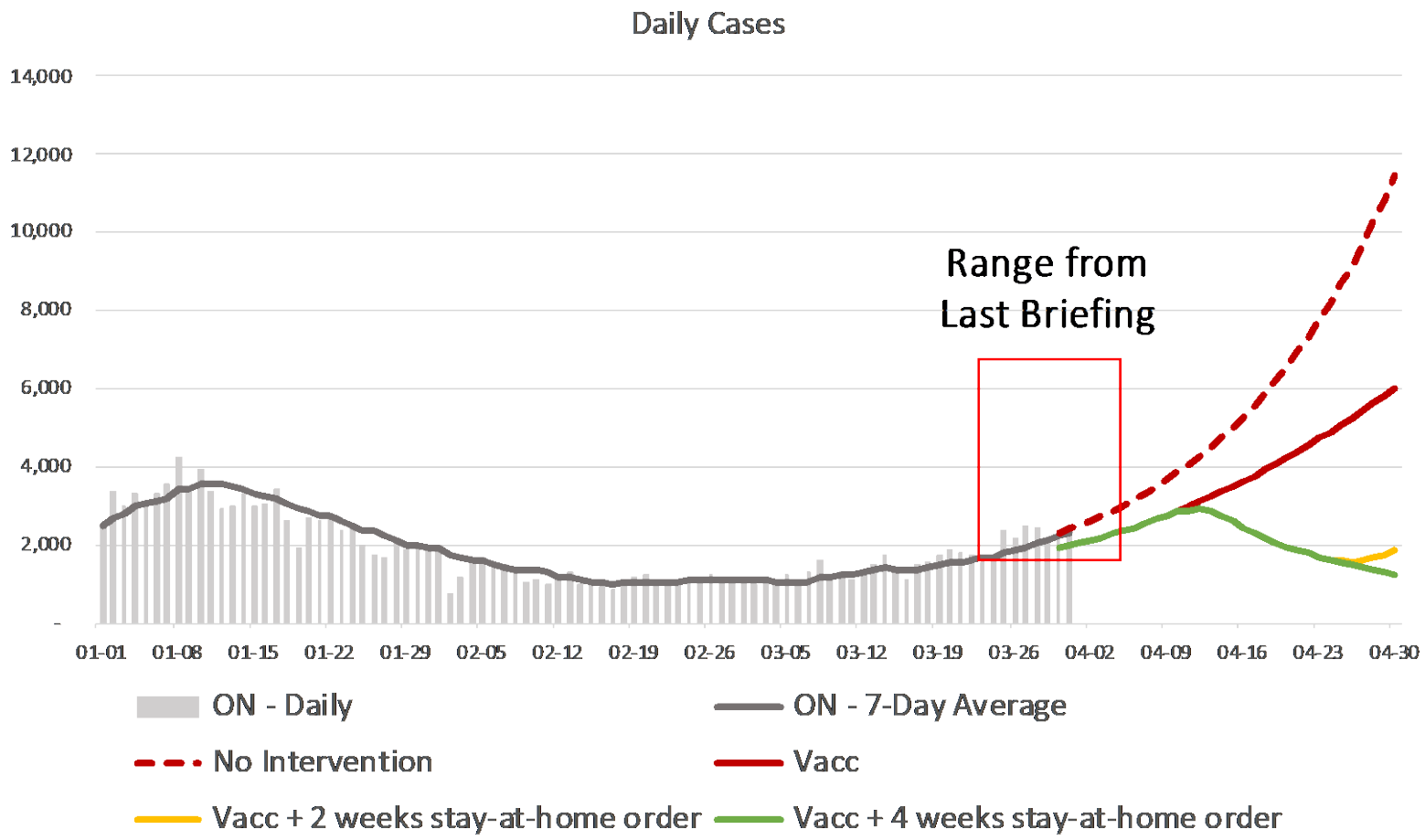
Scenarios:

Stay-at-home order assumptions:

- No stay-at-home
- 2 weeks starting Apr 5
- 4 weeks starting Apr 5

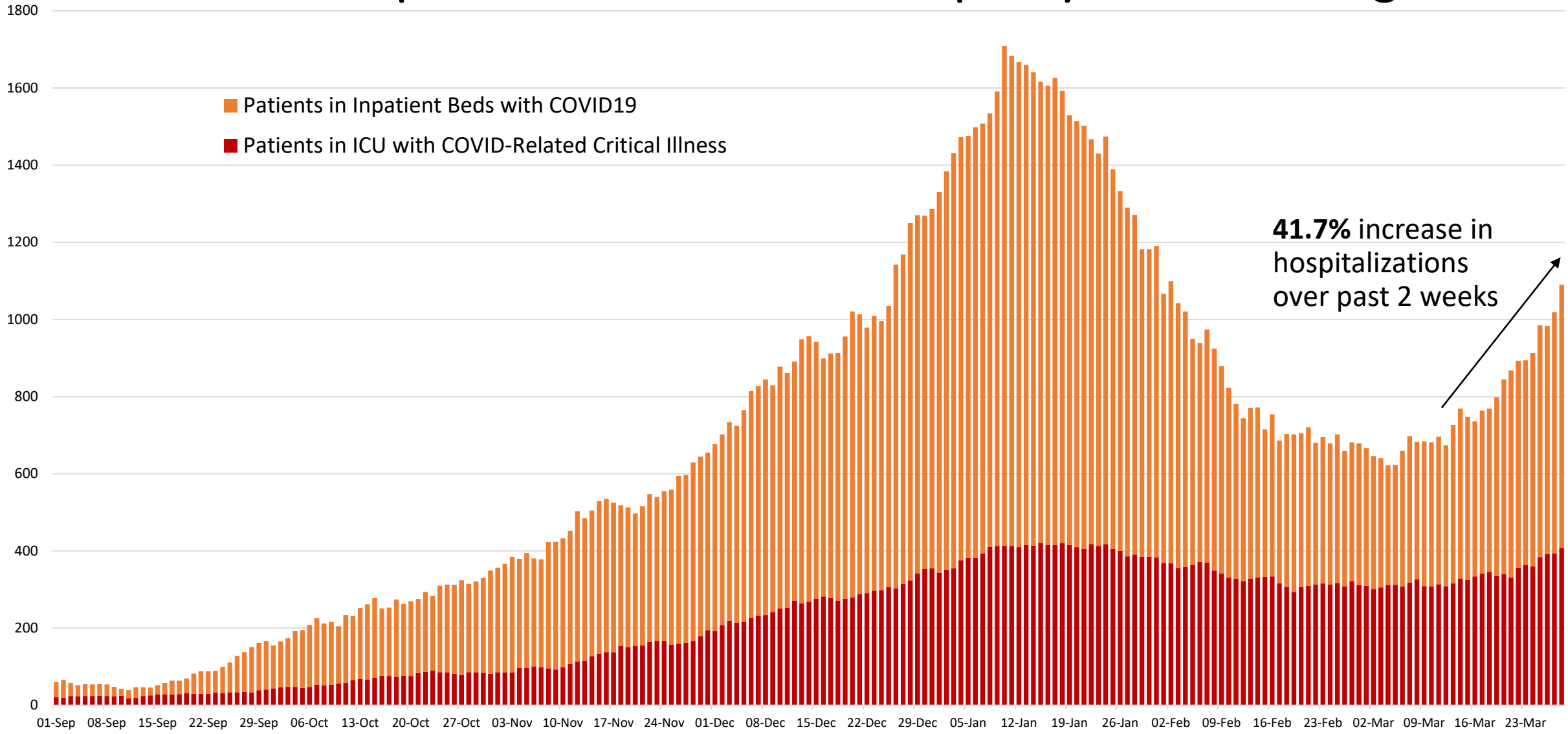
Vaccine assumptions:

- 70% effective in preventing infection
- Administered at constant rate
- Administered randomly to population



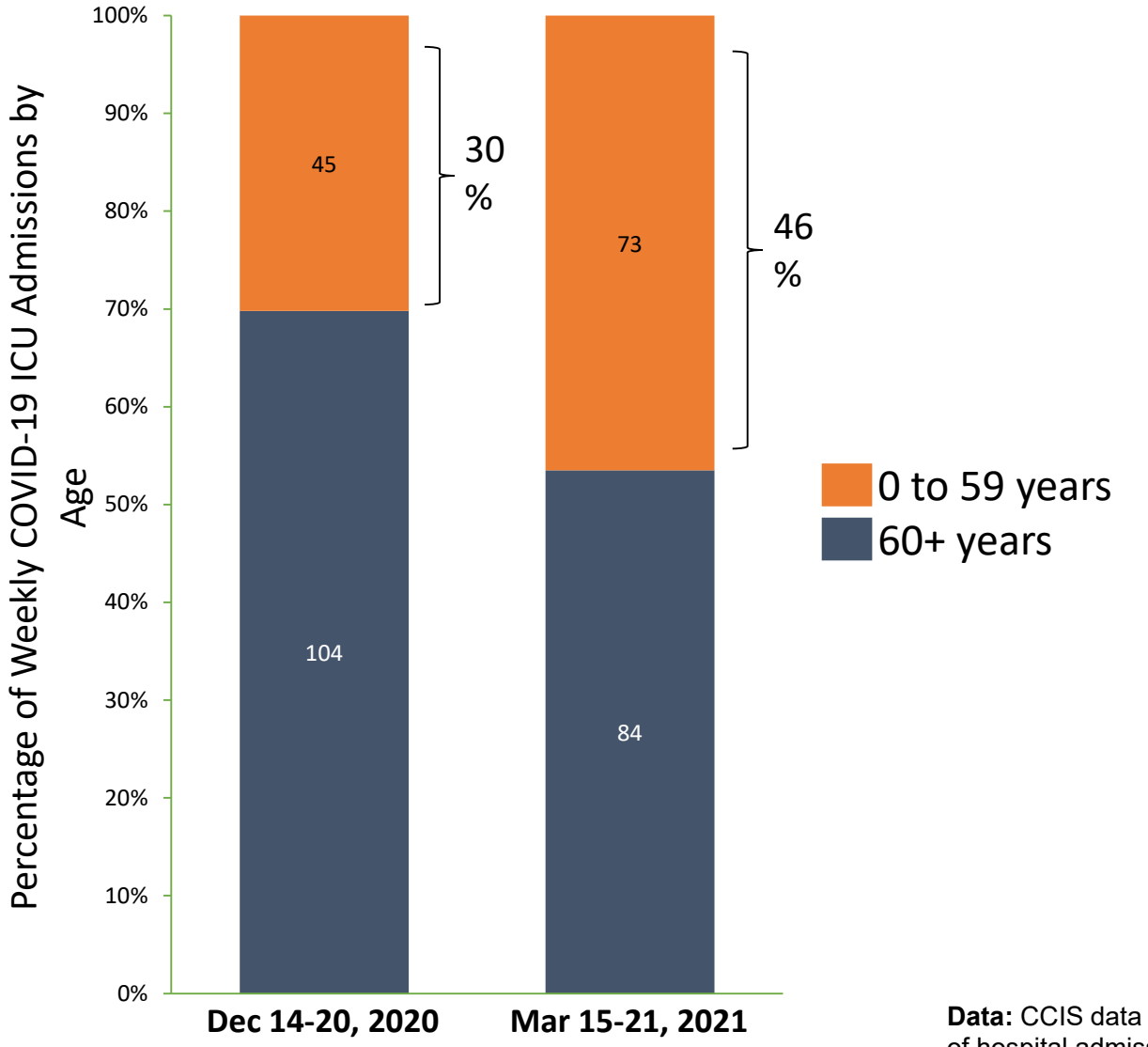
Predictions informed by modeling from COVID-19 ModCollab, Fields Institute, McMasterU, PHO, YorkU
Data (Observed Cases): covid-19.ontario.ca

COVID-19 Hospitalizations and ICU occupancy are increasing



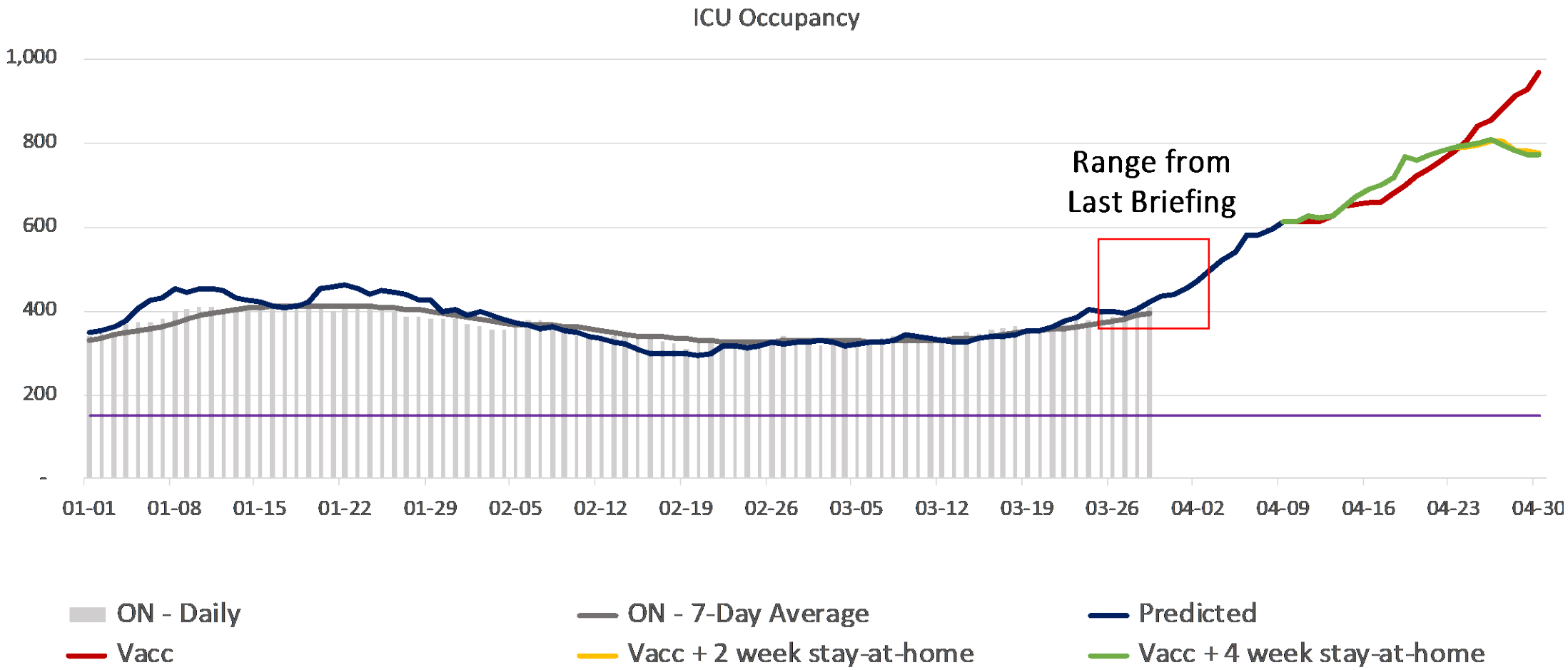
Data Sources: MOH COVID Census and Critical Care Information System

COVID-19 patients admitted to ICU continue to get younger



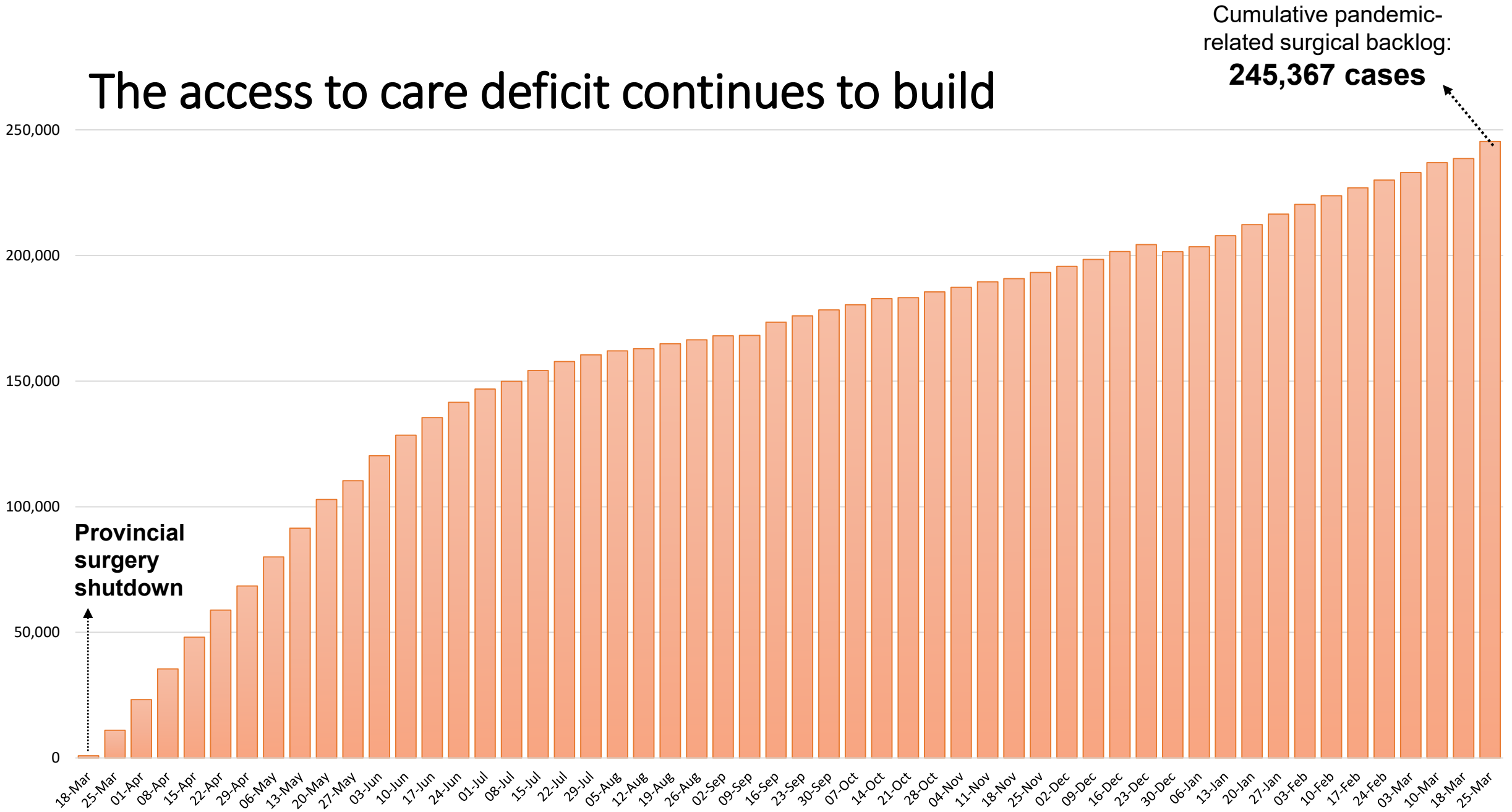
Data: CCIS data up to March 28. Based on date of hospital admission

As with cases, ICU projections depend entirely on system-level public health measures



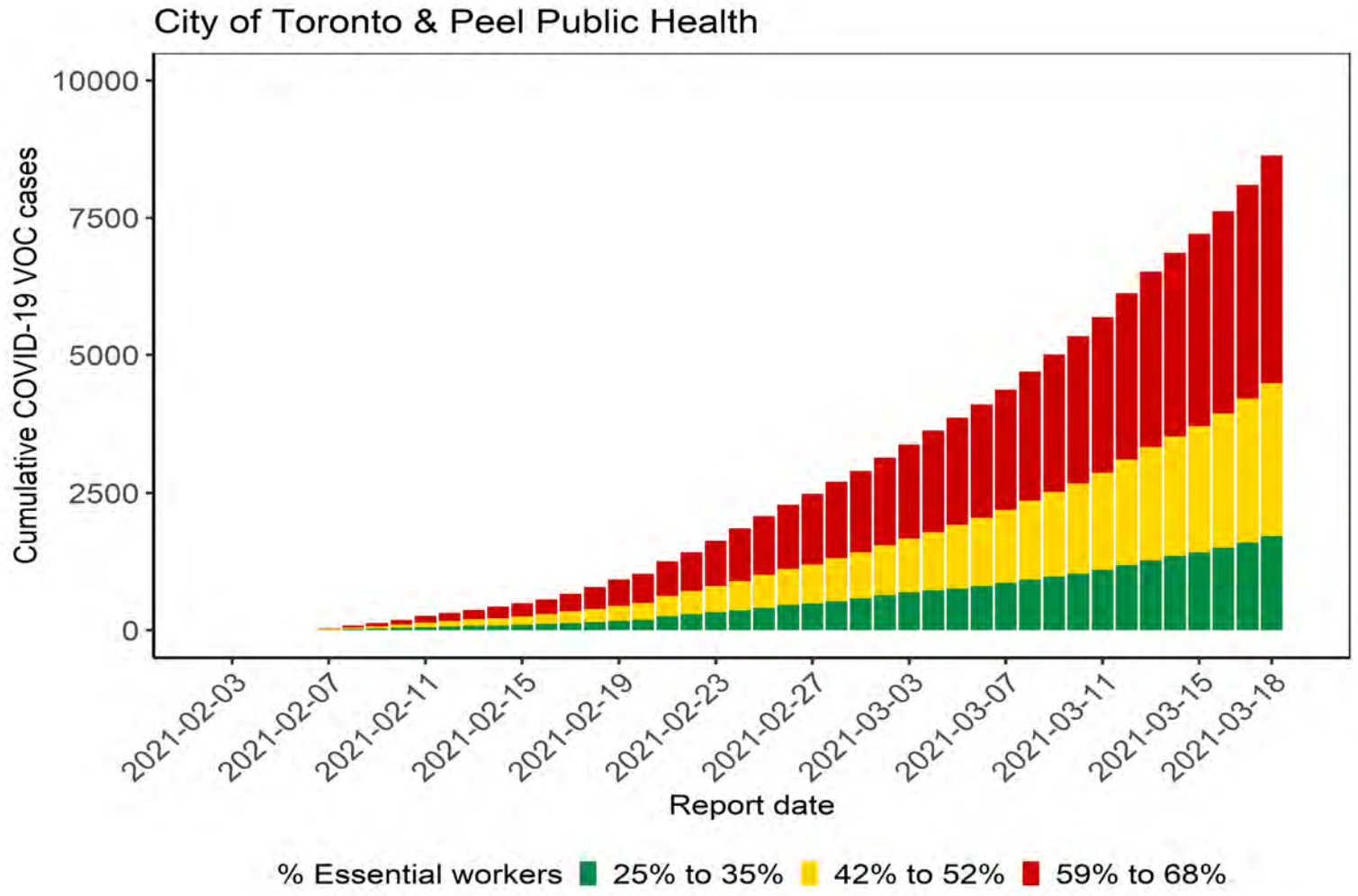
Predictions: COVID-19 ModCollab.
Data (Observed ICU Occupancy): CCSO

The access to care deficit continues to build



Data Source: Wait Times Information System. Backlog estimated based on comparison of 2020/21 with 2019/20 surgical volumes

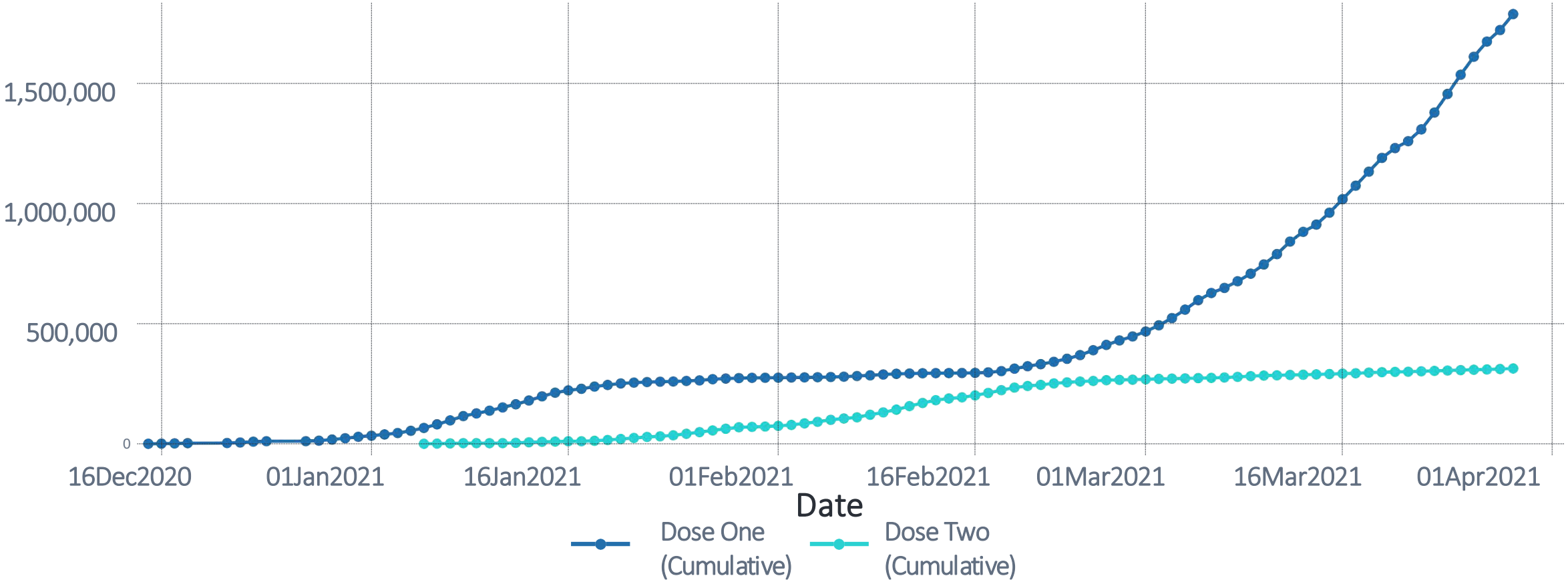
Essential workers are keeping things moving and bearing the brunt of the pandemic. Vaccination and control of workplace outbreaks will be critical.



Source: Chagla Z, Ma H, Sander B, Baral S, Mishra S. (2021). Characterizing the disproportionate burden of SARS-CoV-2 variants of concern among essential workers in the Greater Toronto Area, Canada. https://www.medrxiv.org/content/10.1101/2021.03.22.21254127v1.full.pdf

First dose vaccine coverage expanding but remains incomplete

80 years and older - 17% incomplete; 75-79 years – 40% incomplete; 70-74 years – 72% incomplete

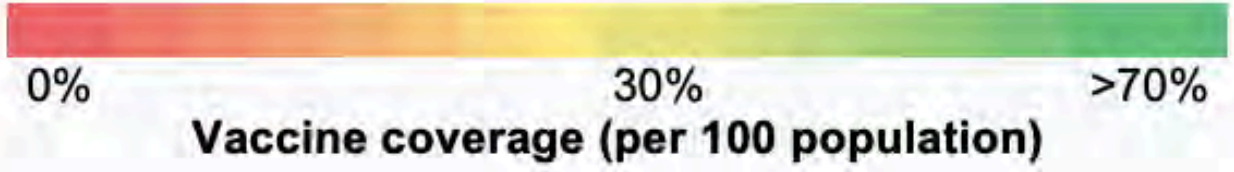


Dose 1 Administered was determined based on the first Time Given for each client.
Dose 2 Administered was determined based on the last Time Given for each client where there is more than 1 dose administered

Vaccination is not reaching the highest risk populations

Figure excludes long-term care vaccination

	Neighbourhood Risk‡ **1** = high incidence of COVID-19 infections → **10** = low incidence of COVID-19 infections										
Age group	1	2	3	4	5	6	7	8	9	10	**Overall**
80+	50%	55%	59%	66%	66%	66%	65%	72%	69%	70%	**64%**
75-79	37%	43%	43%	46%	45%	46%	40%	40%	30%	29%	**39%**
70-74	13%	19%	19%	18%	19%	21%	17%	17%	10%	9%	**16%**
65-69	8%	10%	10%	11%	10%	11%	10%	10%	7%	8%	**9%**
60-64	18%	23%	22%	21%	21%	21%	19%	18%	14%	20%	**20%**
55-59	7%	9%	9%	10%	11%	11%	10%	11%	10%	12%	**10%**
50-54	6%	7%	7%	8%	9%	8%	9%	9%	10%	11%	**8%**
45-49	6%	7%	6%	8%	8%	8%	8%	9%	10%	11%	**8%**
40-44	5%	6%	6%	7%	8%	7%	8%	8%	9%	10%	**7%**
16-39	4%	5%	5%	6%	6%	6%	6%	6%	7%	8%	**6%**
Overall	**8%**	**10%**	**10%**	**11%**	**11%**	**12%**	**11%**	**12%**	**11%**	**13%**	**13%**



School interruptions will have significant impacts on students, families, and society

Economic modeling suggests schooling impacts will have long term economic effects:

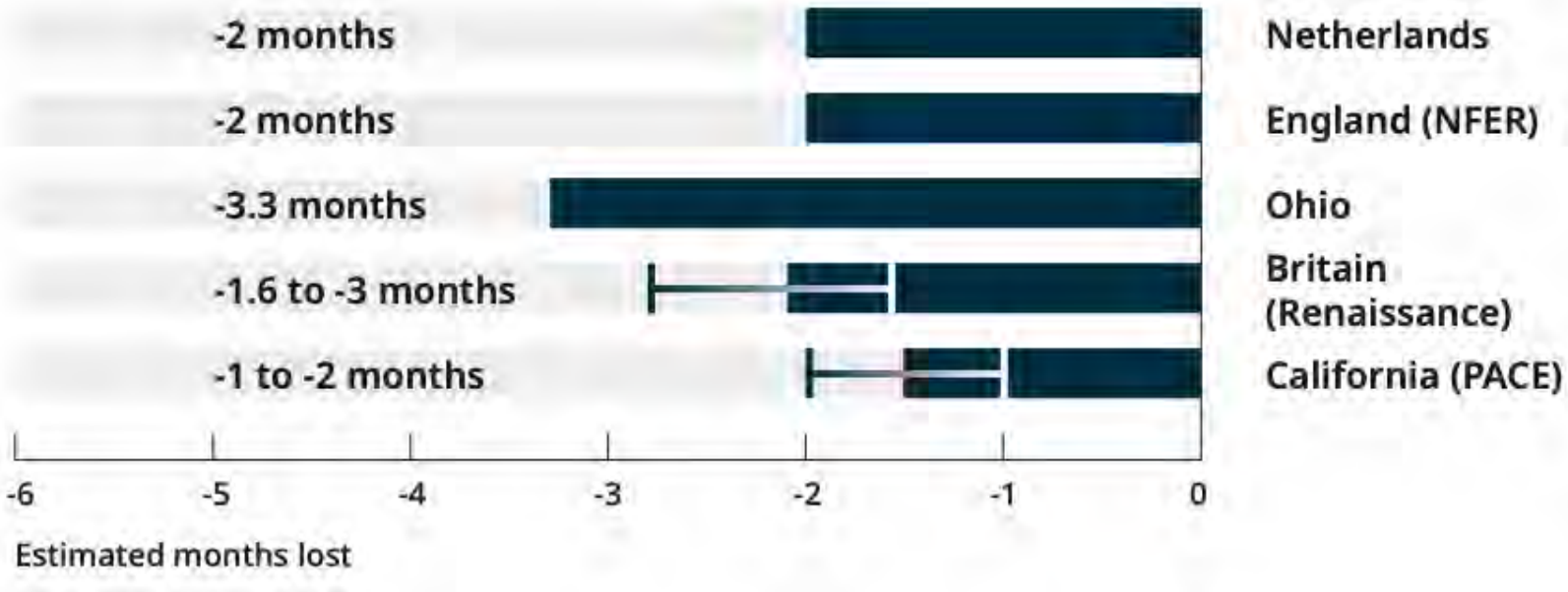
- A ~3% drop in lifetime earnings for these cohorts;
- Lost GDP for Canada estimated at 1.6 trillion dollars

Non-COVID health risks include:

- Loneliness & social isolation,
- Loss of structure affecting physical activity, sleep and mental health, and
- Decreased ability to detect neglect or abuse.

All negative impacts are highly inequitable with greater learning loss for students facing greater disadvantage

Figure 1:
Evidence from International Assessments Reporting Average Learning Loss in Months
Fall 2020



Source: Kelly Gallagher-Mackay, Elizabeth Dhuey, Lisa Hawke, Lance McCready, Sarah Oates, Prachi Srivastava, and Kathryn Underwood

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- School disruptions have a significant and highly inequitable **impact** on students, parents and society. Further disruptions should be minimized.
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- **MOHLTC**: Michael Hillmer, Kamil Malikov, Qing Huang, Jagadish Rangrej, Nam Bains, Jennifer Bridge
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- **PHO:** Sarah Buchan, Kevin Brown
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Content provided by Modelling Consensus and Scientific Advisory Table members and secretariat

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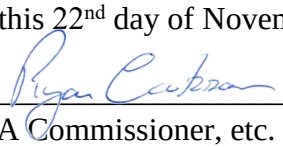
* Chairs of Scientific Advisory, Evidence Synthesis, and Modelling Consensus Tables

For table membership and profiles, please visit the About and Partners pages on the Science Advisory Table website.

This is **"Exhibit W"**
to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022



A Commissioner, etc.

Update on COVID-19 Projections

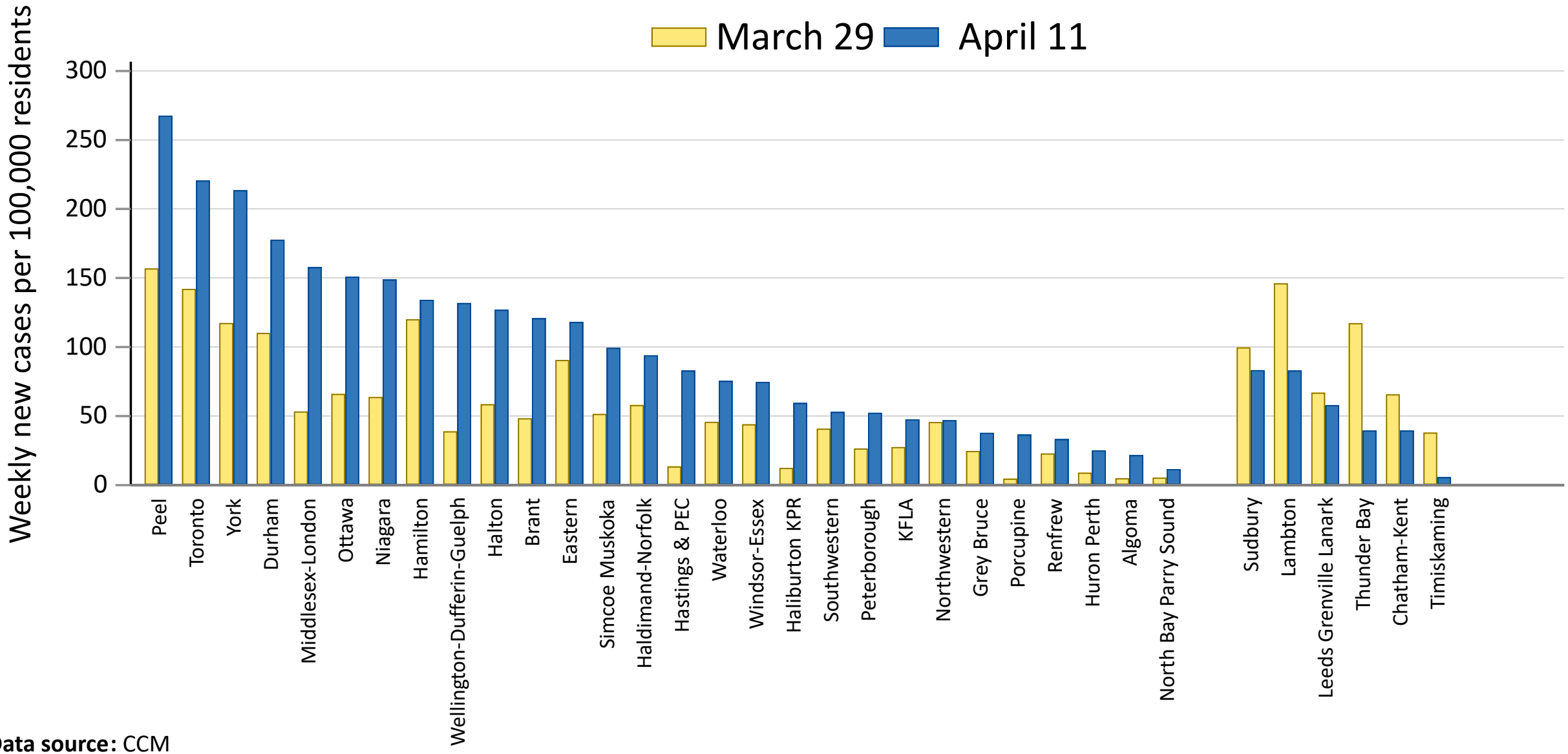
Science Advisory and Modelling Consensus Tables

April 16, 2021

Key Findings

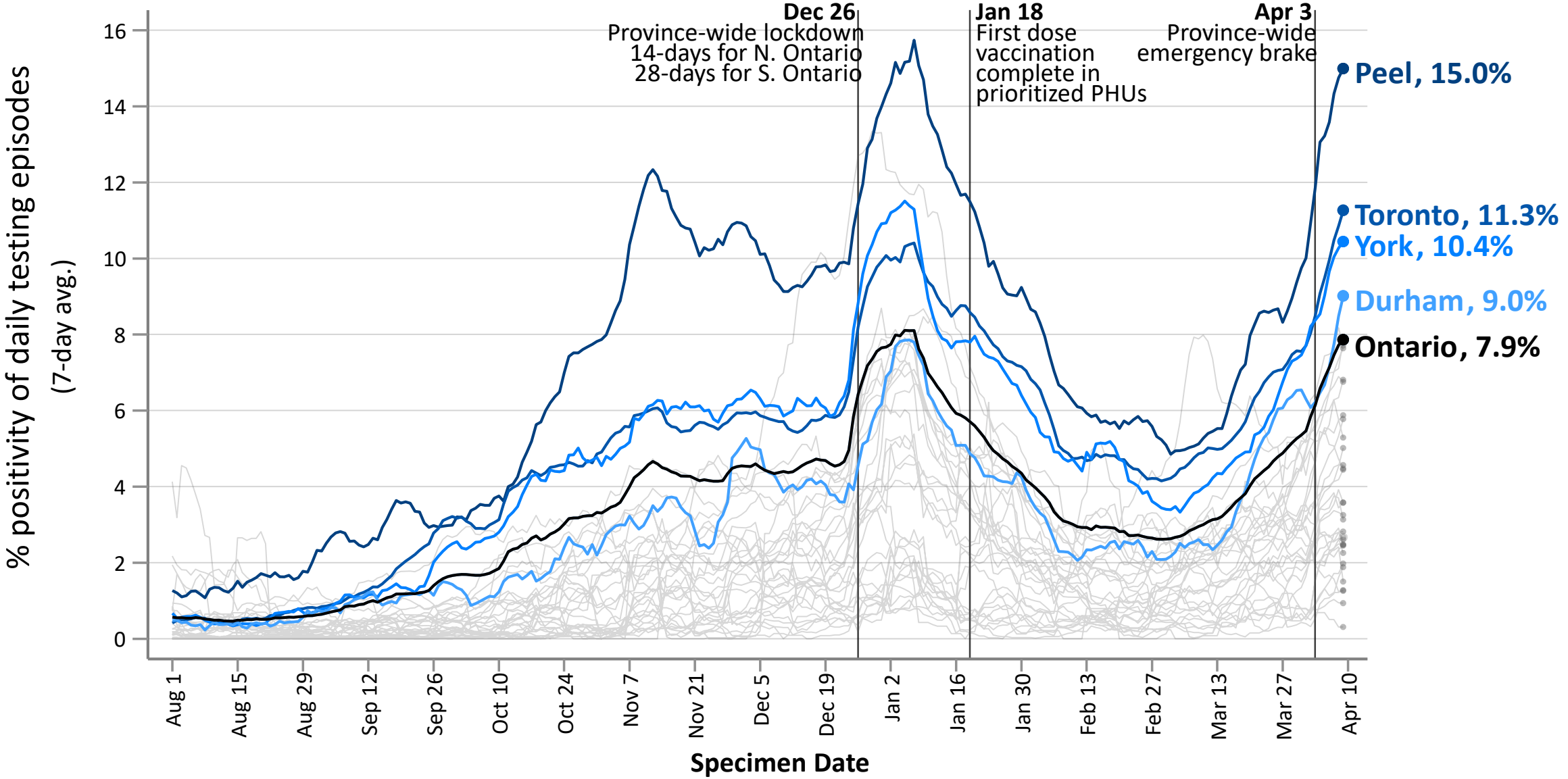
- COVID-19 cases, hospitalizations and ICU occupancy are **at their highest levels since March 2020** and variant cases continue to rise sharply.
- ICU occupancy is **compromising care for all patients.**
- Ontarians can help themselves and others by limiting mobility to truly necessary trips and **always wearing a mask and keeping 6 feet distant** when in contact with anyone outside their household.
- Although improving, vaccination is not reaching people at high-risk fast enough to overcome the level of serious illness in our communities and our hospitals.
- Without stronger system-level measures and immediate support for essential workers and high-risk communities, **high case rates will persist through the summer.**

Cases are **rapidly** increasing in most Public Health Units



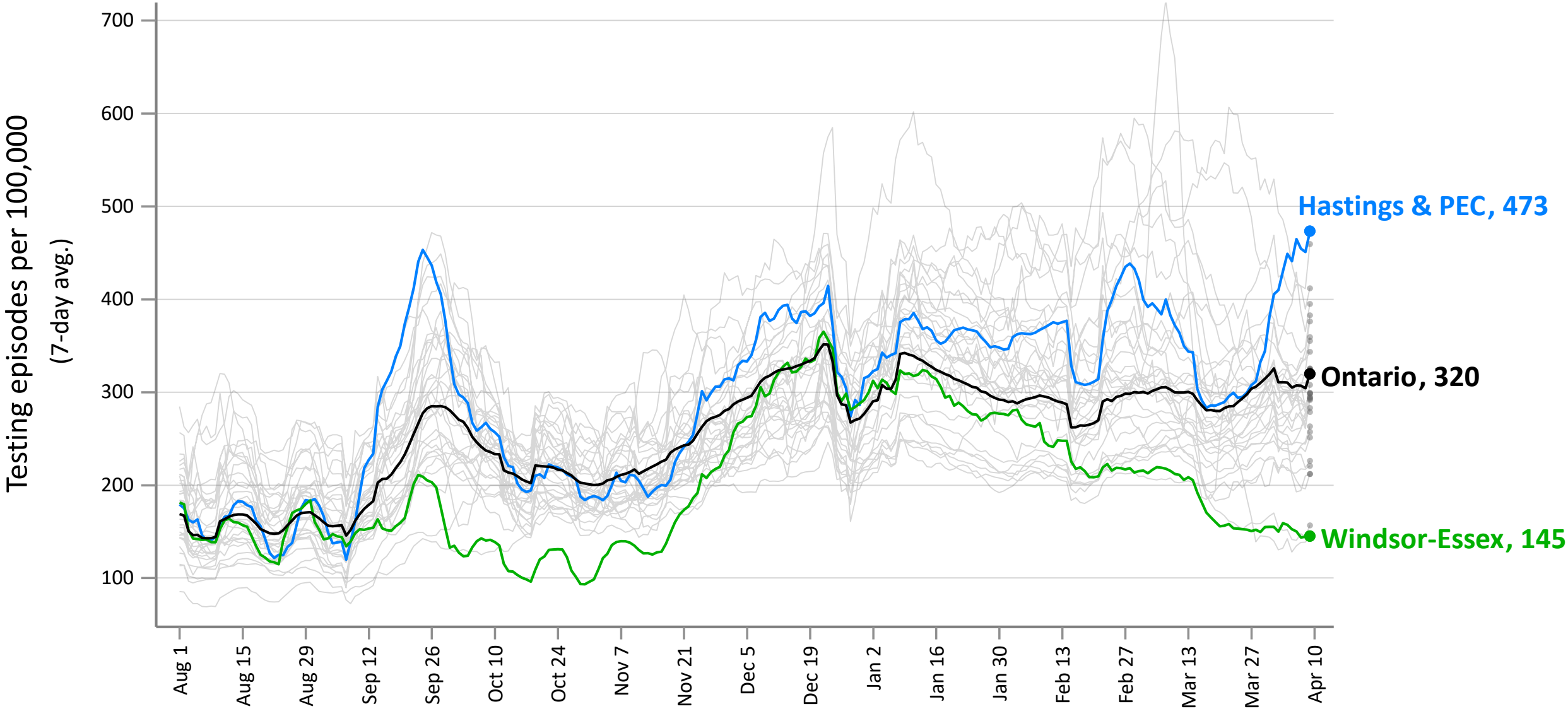
Data source: CCM
Data note: Data for the most recent day have been censored to account for reporting delays

Test positivity rates are increasing across Ontario



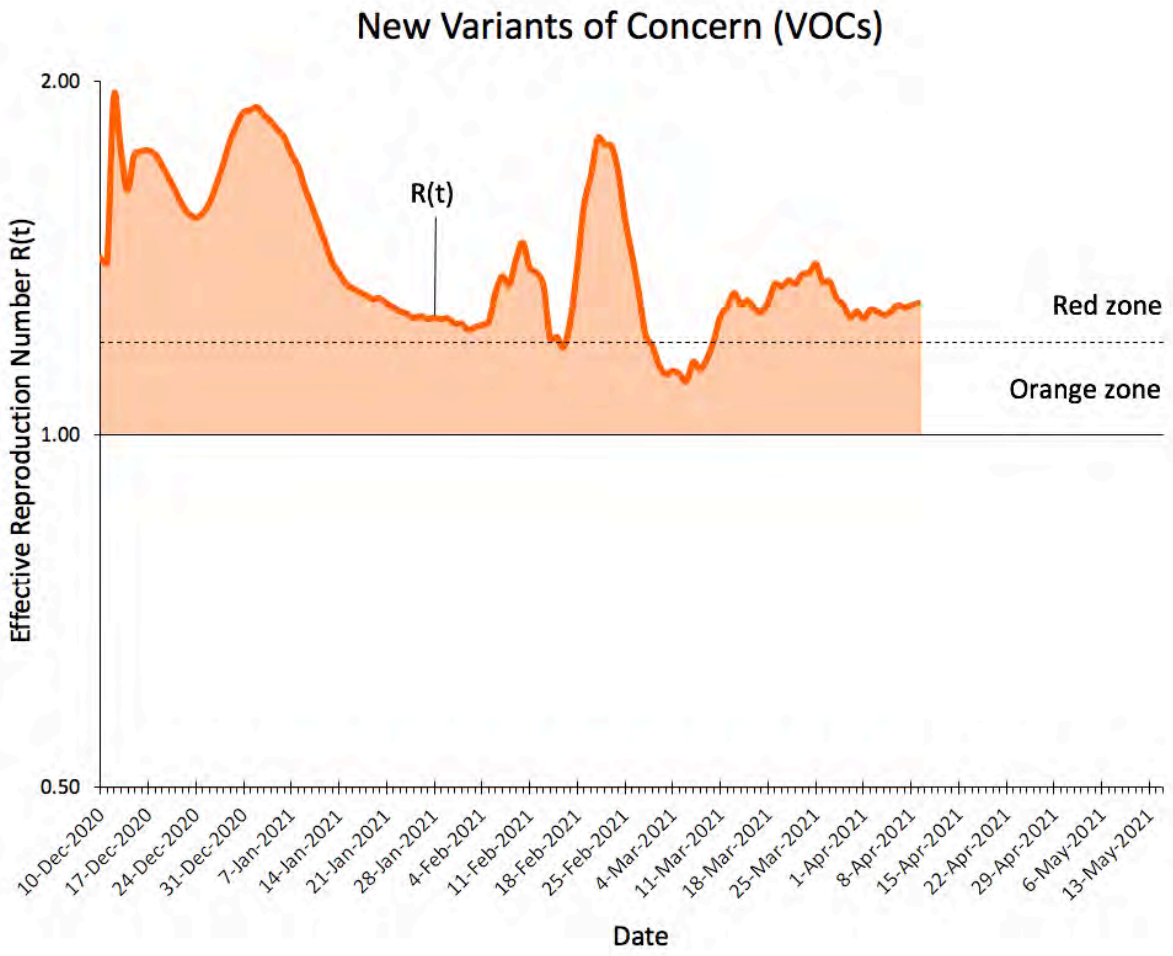
Data source: Ontario Laboratory Information System (OLIS), data up to April 9

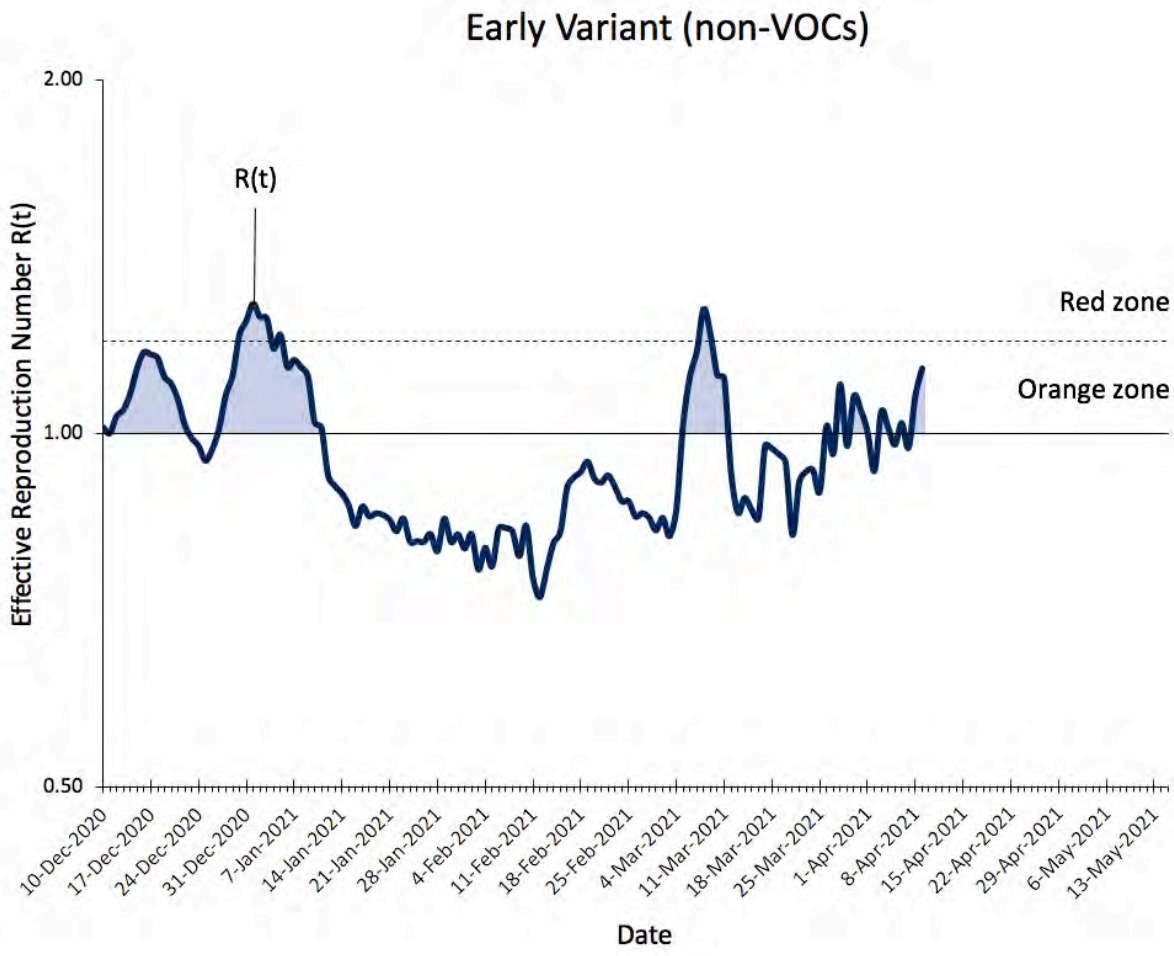
Ontario testing rates are flat – the increase in cases is because there are more cases, not more tests being done



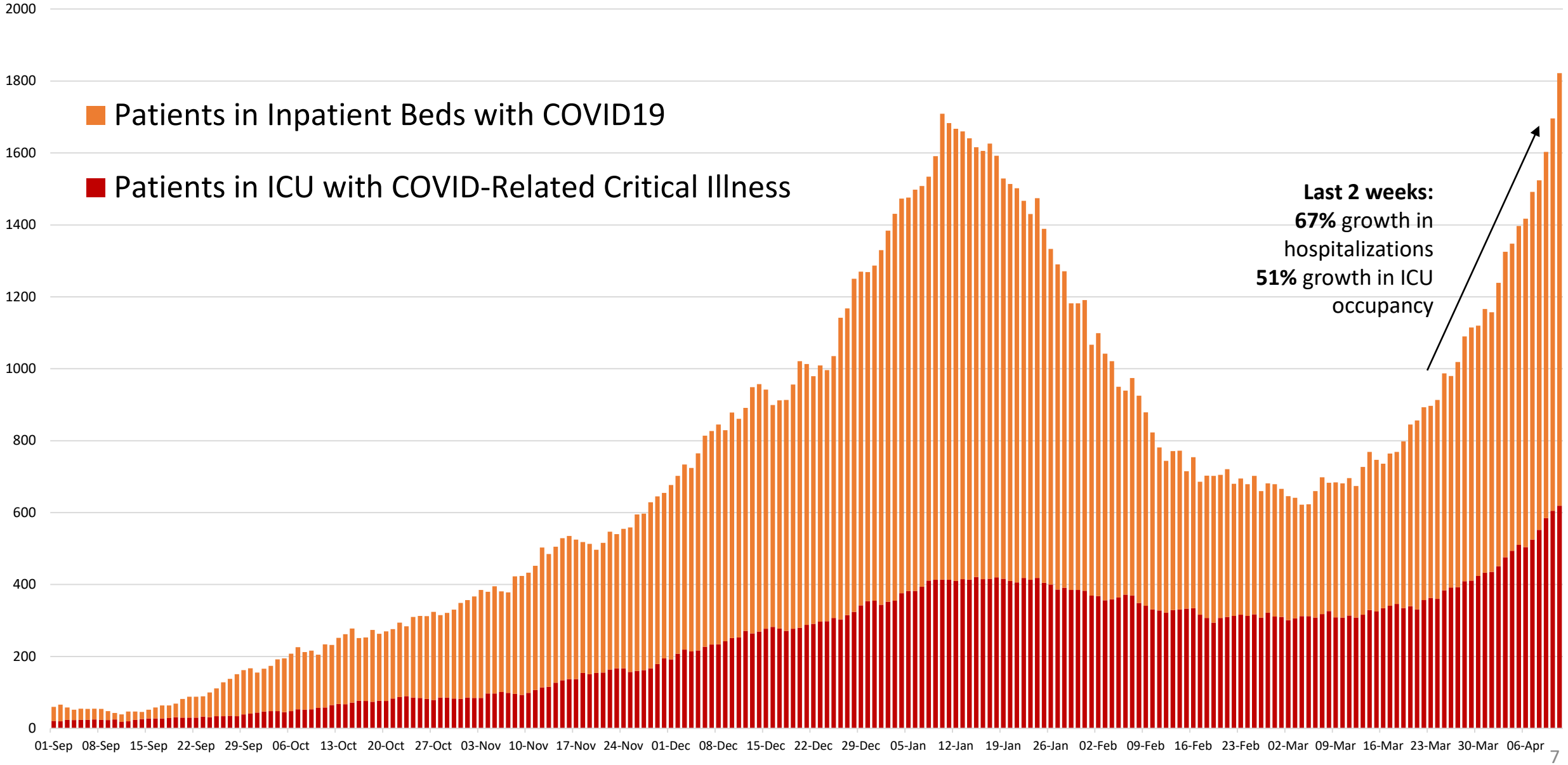
Data source: Ontario Laboratory Information System (OLIS), data up to April 9

The number of variant cases continues to rise and variants now dominate, but even the original strain is rising.





A record number of Ontarians are in hospital due to COVID-19



Data Sources: MOH COVID Inpatient Census and Critical Care Information System

A 6 week stay-at-home order with a vaccination rate of at least 100K doses per day is the only way to flatten the curve.

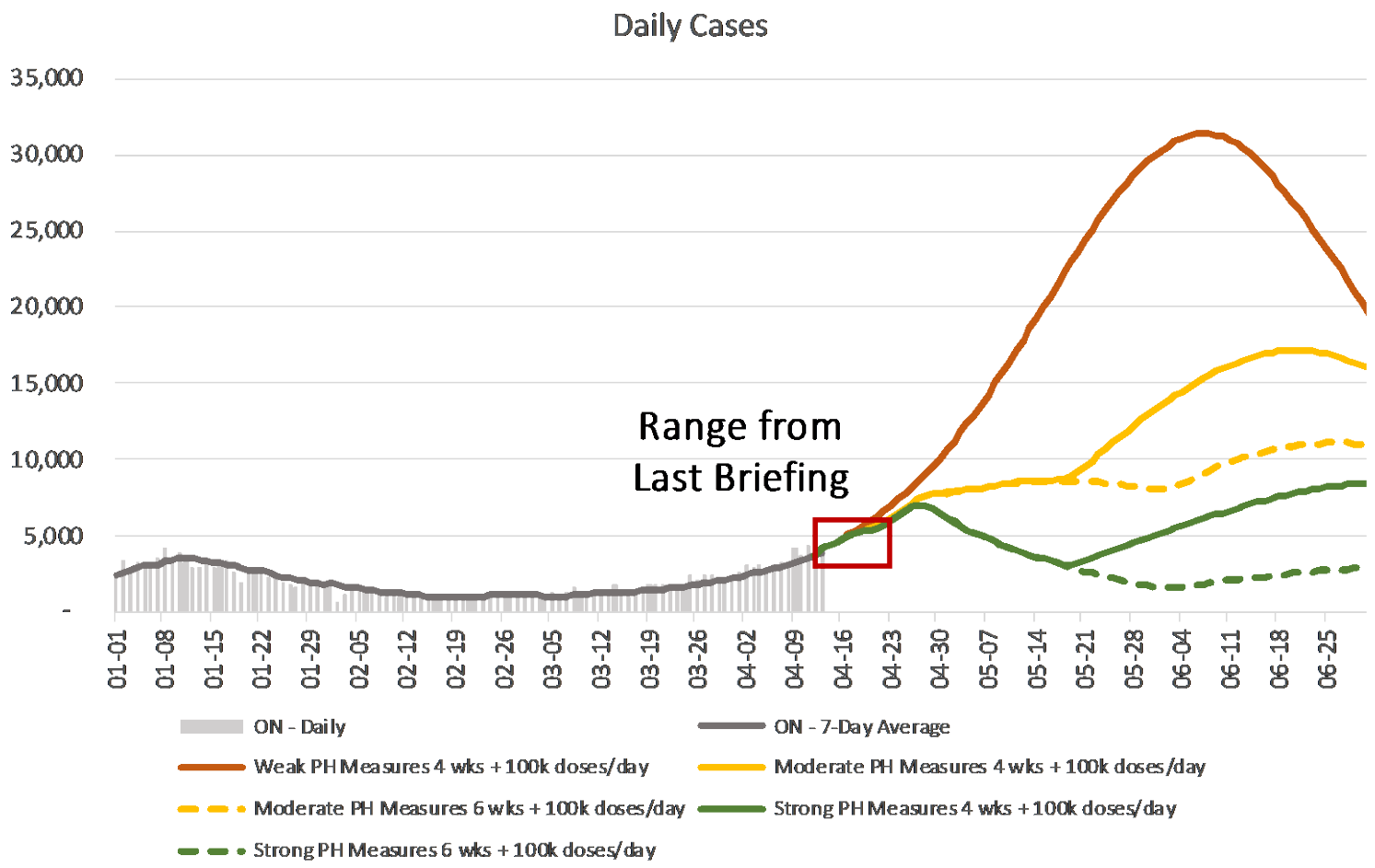
Figure summarizes predictions across 4 models with many scenarios.

Stay-at-home order assumptions:

- 4 or 6 weeks starting Apr 8
- Weak to strong effect on transmission

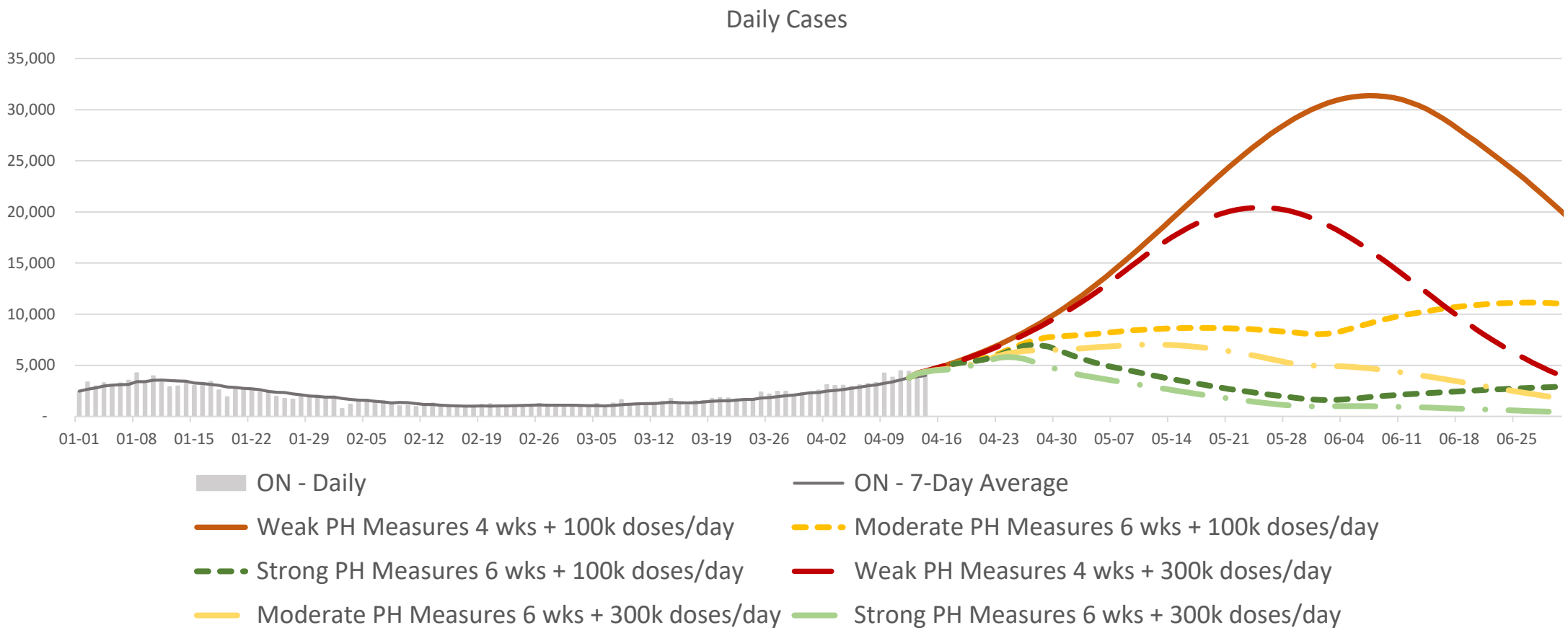
Vaccine assumptions:

- 60% effective in preventing infection
- 100,000 doses/day
- Administered at random

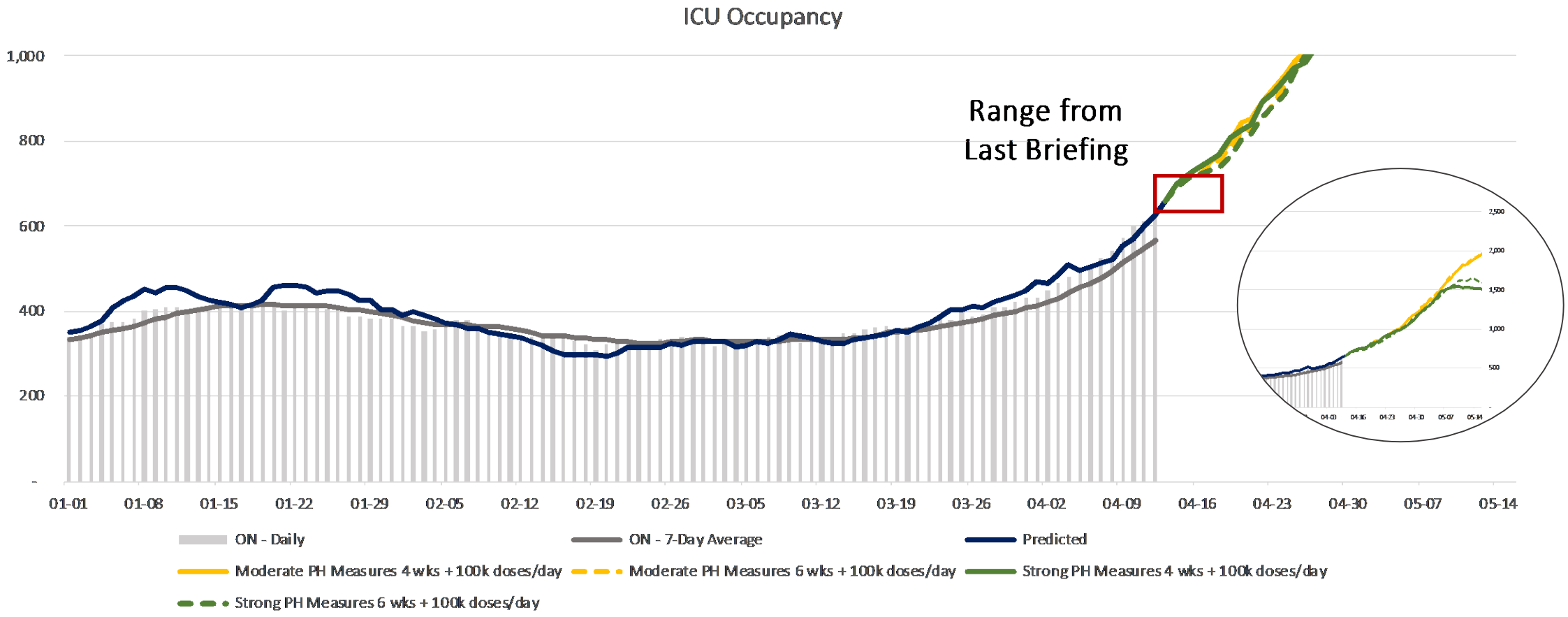


Predictions informed by modeling from COVID-19 ModCollab, Fields Institute, McMasterU, PHO, YorkU
Data (Observed Cases): covid-19.ontario.ca

Under every scenario, more vaccines mean a faster resolution in the long-run

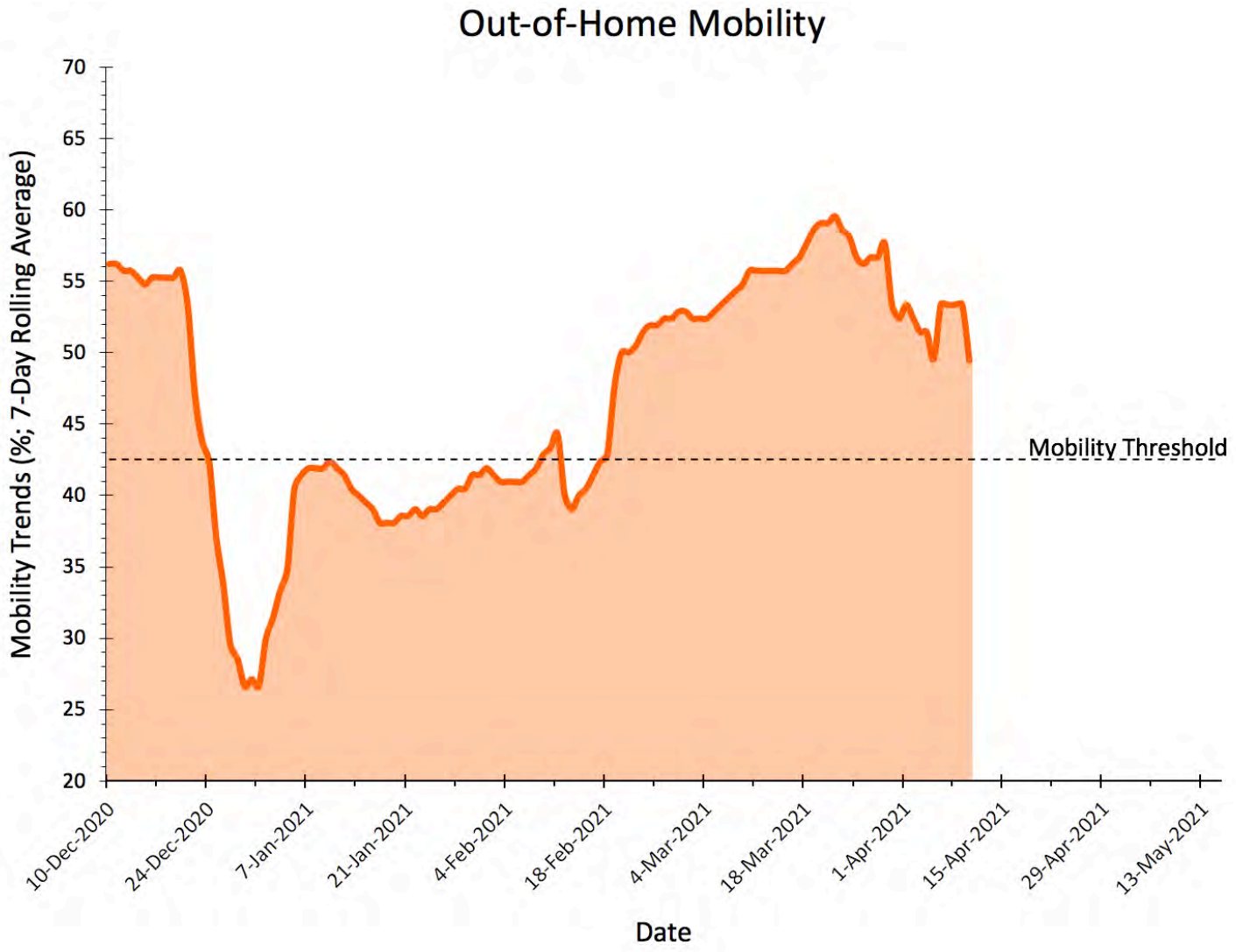


As predicted, ICU occupancy is rising dramatically. System-level public health measures will help blunt some of the impact.



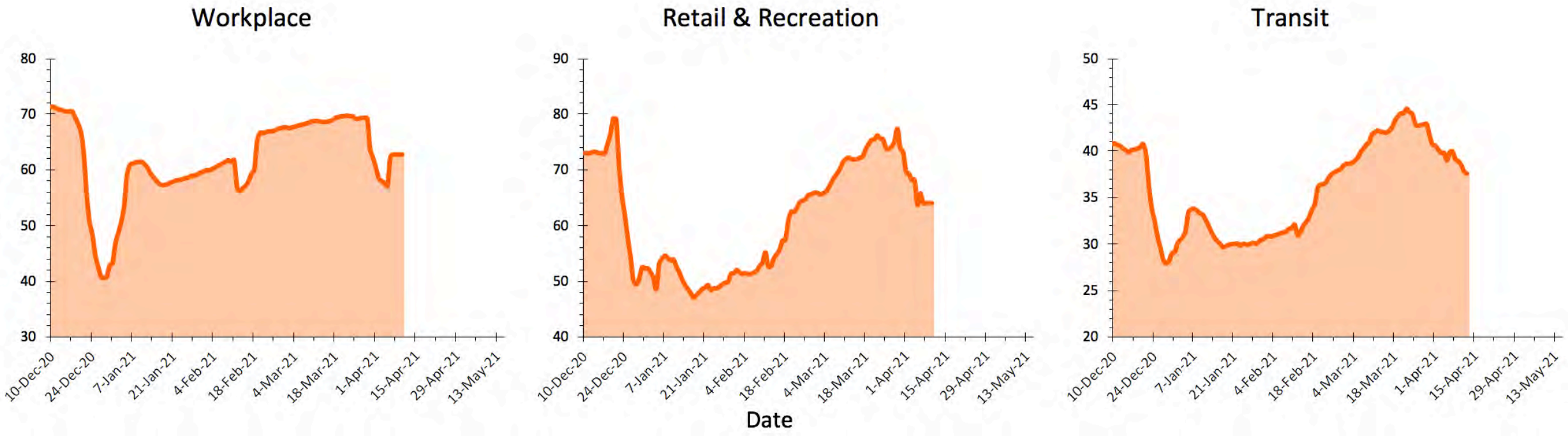
Predictions: COVID-19 ModCollab.
Data (Observed ICU Occupancy): CCSO

Mobility has declined slightly but not enough to bring current growth under control.



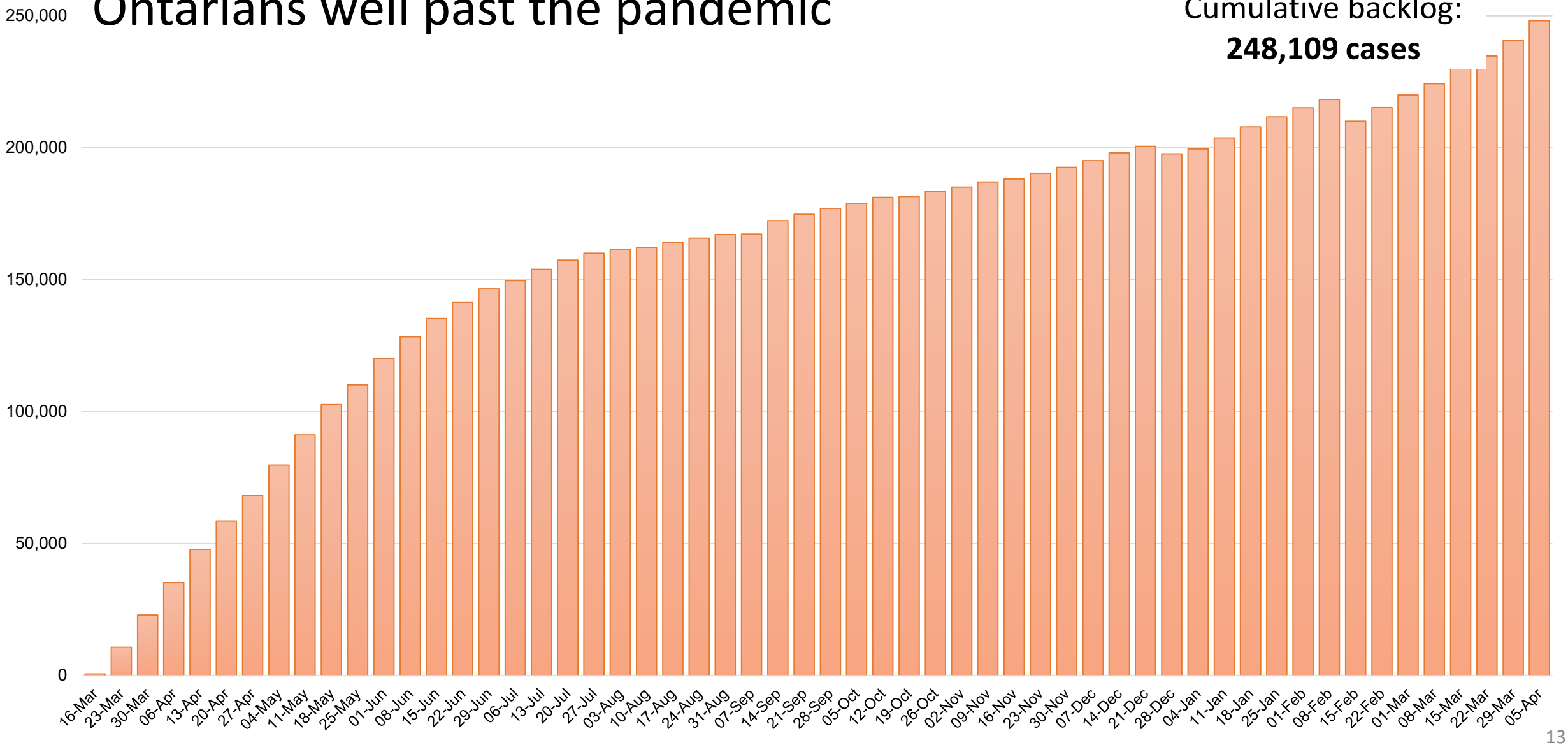
Predictions: COVID-19 SAT.
Data Google and Apple Mobility data

Mobility has declined slightly across settings. Further reducing mobility and always wearing a mask and distancing is how Ontarians help reduce cases.



Predictions: COVID-19 SAT.
Data Google and Apple Mobility data

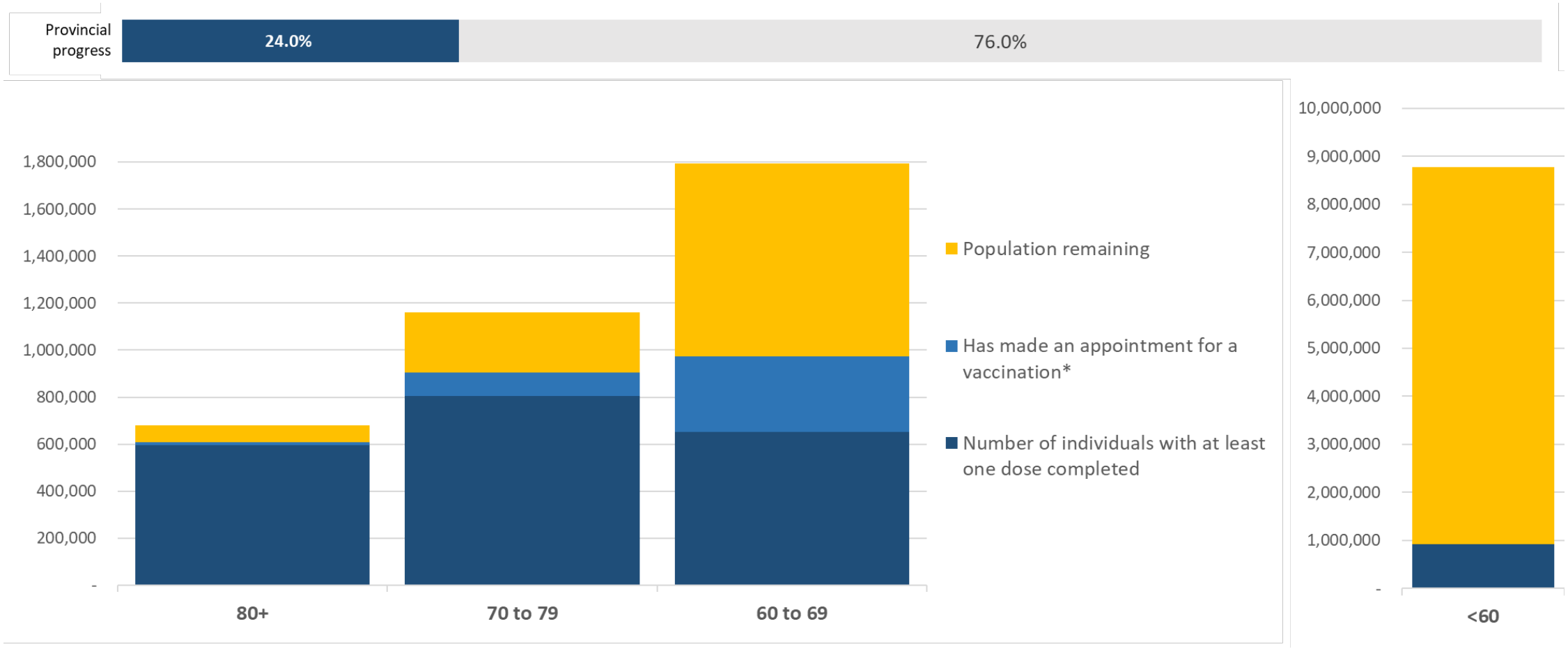
The access to care deficit is building which will be felt by Ontarians well past the pandemic



Data Source: Wait Times Information System. Backlog estimated based on comparison of 2020/21 with 2019/20 surgical volumes

First dose vaccine coverage expanding but remains incomplete

More than 3m doses administered

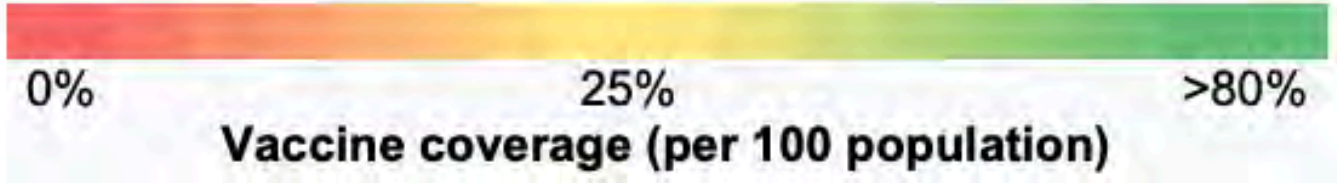


Data Sources
MOF Population Projections
COVAX analytical file, extracted, 8:00 pm Apr 12 2021, CPAD, MOH
COVAX Skedulo, extracted 6:00pm Apr 12 2021

Vaccination by risk is improving but remains a key to controlling spread

Figure excludes long-term care vaccination – at least 1 dose as of April 12, 2021

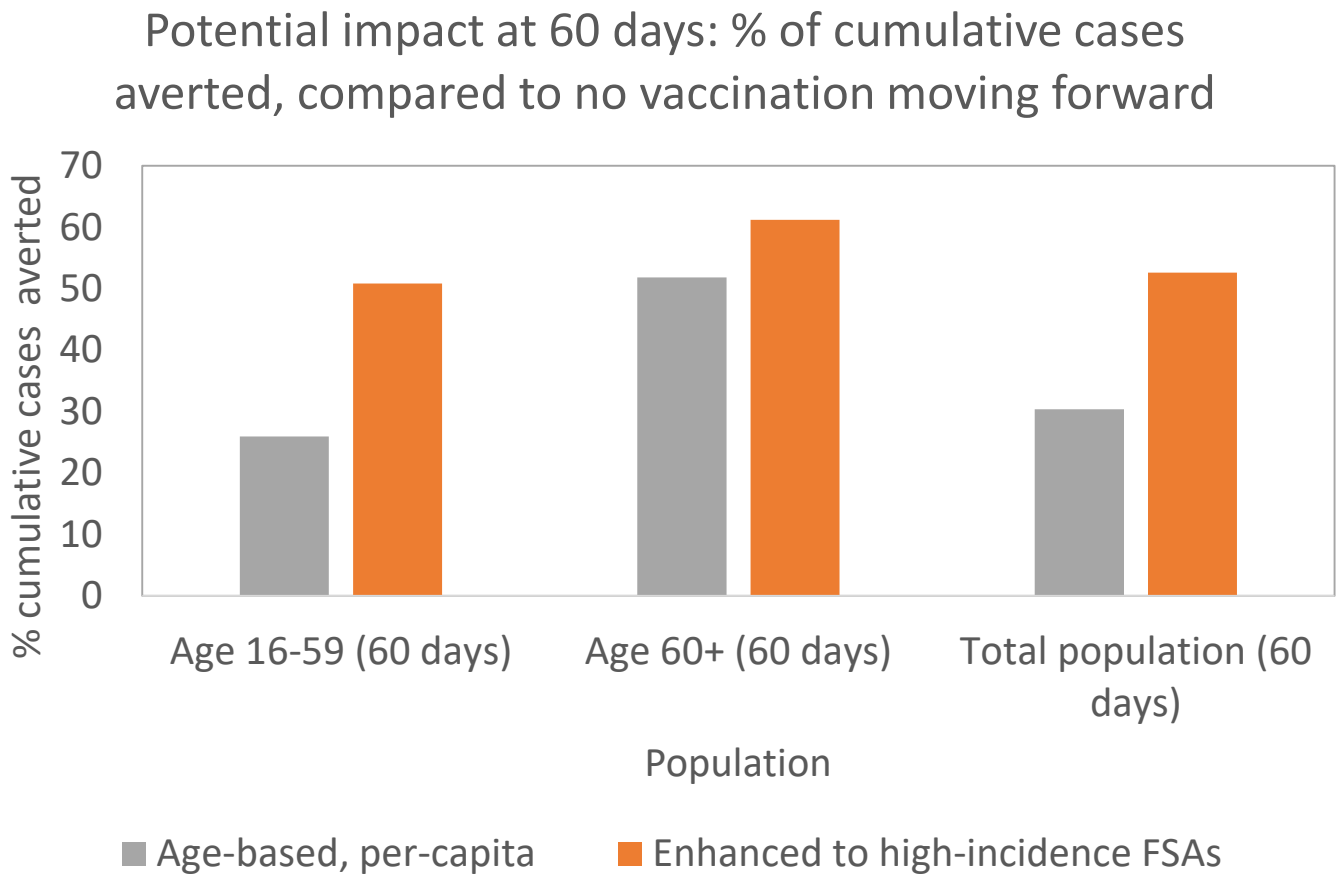
	Neighbourhood Risk‡										
	1 = high incidence of COVID-19 infections →									**10 =** low incidence of COVID-19 infections	
Age group	1	2	3	4	5	6	7	8	9	10	**Overall**
80+	65%	68%	70%	75%	77%	77%	79%	81%	82%	82%	**76%**
75-79	63%	68%	70%	73%	75%	74%	75%	77%	74%	71%	**72%**
70-74	57%	64%	62%	66%	65%	64%	63%	62%	51%	39%	**58%**
65-69	42%	48%	44%	39%	41%	38%	36%	34%	22%	19%	**35%**
60-64	40%	42%	38%	36%	35%	34%	30%	27%	23%	27%	**33%**
55-59	20%	25%	21%	20%	21%	22%	20%	20%	17%	17%	**20%**
50-54	14%	18%	13%	13%	13%	13%	13%	13%	13%	14%	**14%**
45-49	9%	14%	9%	11%	11%	11%	11%	11%	13%	14%	**11%**
40-44	7%	9%	9%	10%	10%	11%	10%	11%	12%	13%	**10%**
16-39	5%	7%	6%	8%	8%	8%	8%	8%	10%	10%	**8%**
Overall	**15%**	**20%**	**18%**	**19%**	**20%**	**20%**	**19%**	**19%**	**20%**	**20%**	**23%**



Source: ICES

What happens if we vaccinate 3 million adults over the next 30 days?

100,000 vaccinations per day, top 20% highest incidence neighbourhoods



Number vaccines per case averted

Analysis: COVID Heterogeneity Research Group, COVID-19 ModCollab, PHO.
Data: CCM

Key Findings

- COVID-19 cases, hospitalizations and ICU occupancy are **at their highest levels since March 2020** and variant cases continue to rise sharply.
- ICU occupancy is **compromising care for all patients.**
- Ontarians can help themselves and others by limiting mobility to truly necessary trips and **always wearing a mask and keeping 6 feet distant** when in contact with anyone outside their household.
- Although improving, vaccination is not reaching people at high-risk fast enough to overcome the level of serious illness in our communities and our hospitals.
- Without stronger system-level measures and immediate support for essential workers and high-risk communities, **high case rates will persist through the summer.**

Contributors

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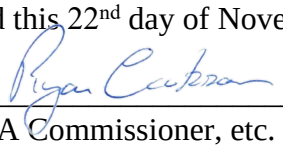
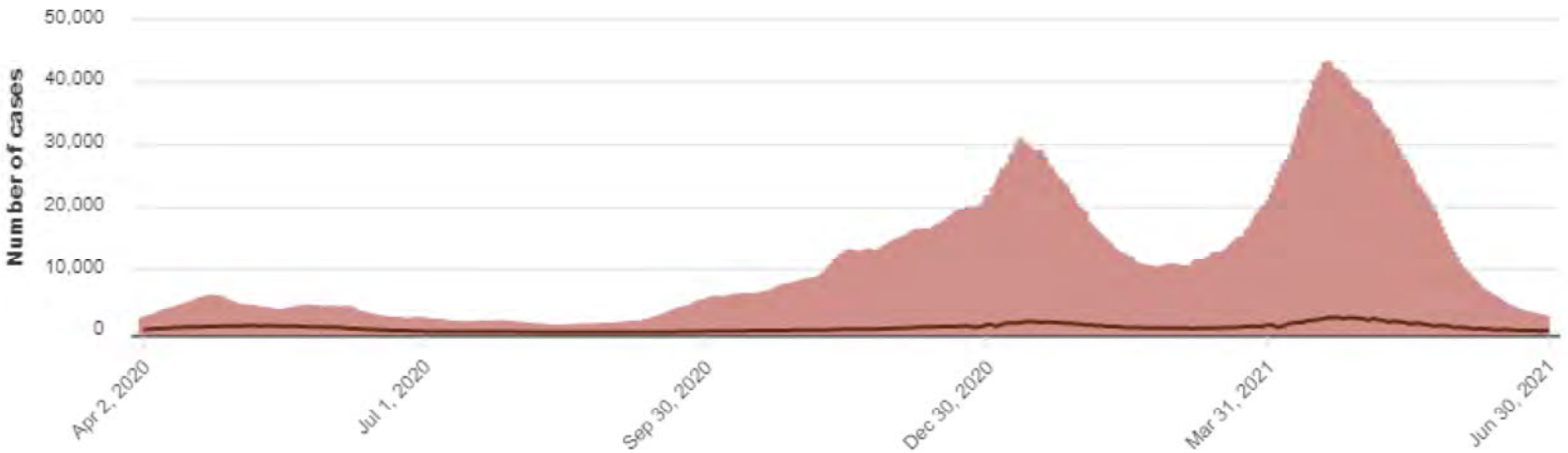
* Chairs of Scientific Advisory, Evidence Synthesis, and Modelling Consensus Tables

For table membership and profiles, please visit the About and Partners pages on the Science Advisory Table website.

This is **"Exhibit X"**
to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022



A Commissioner, etc.


Number of cases
50,000
40,000
30,000
20,000
10,000
0
Apr 2, 2020
Jul 1, 2020
Sep 30, 2020
Dec 30, 2020
Mar 31, 2021
Jun 30, 2021

This is **"Exhibit Y"**
to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022

A Commissioner, etc.

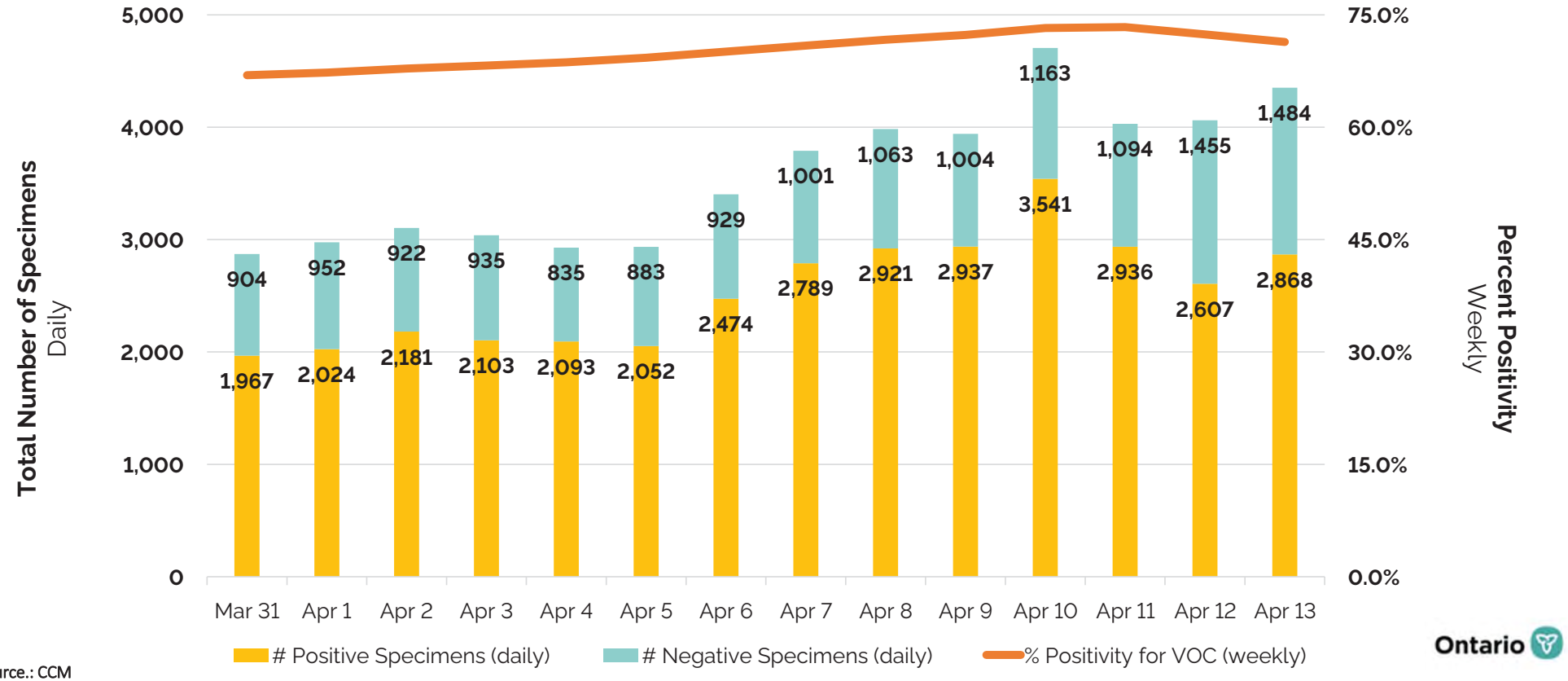
Variant COVID-19 Cases

As of April 19, 2021

The % positivity for VOCs (weekly) is leveling out around 70%.

64,643
cases with a mutation or VOC detected

71.4% Weekly Percent Positivity (April 13)
70.1 % Previous week (April 6)



Source.: CCM

This is **"Exhibit Z"**
to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022

A Commissioner, etc.

Public Health Ontario | Santé publique Ontario

DAILY EPIDEMIOLOGICAL SUMMARY

COVID-19 in Ontario: January 15, 2020 to July 3, 2021

This report includes the most current information available from CCM as of **July 3, 2021**.

Please visit the interactive Ontario COVID-19 Data Tool to explore recent COVID-19 data by public health unit, age group, sex, and trends over time.

A weekly summary report is available with additional information to complement the daily report.

This **daily** report provides an epidemiologic summary of recent COVID-19 activity in Ontario. The change in cases is determined by taking the cumulative difference between the current day and the previous day.

Highlights

- There are a total of 545,803 confirmed cases of COVID-19 in Ontario reported to date.
- Compared to the previous day, this represents:
    - An increase of 213 confirmed cases (percent change of +1.9%)
    - An increase of 9 deaths (percent change of 0.0%)
    - An increase of 286 resolved cases (percent change of +9.2%)

In this document, the term 'change in cases' refers to cases publicly reported by the province for a given day. Data corrections or updates can result in case records being removed and or updated from past reports and may result in subset totals for updated case counts (i.e., age group, gender) differing from the overall updated case counts.

The term public health unit reported date in this document refers to the date local public health units were first notified of the case.

Case Characteristics

Table 1a. Summary of recent confirmed cases of COVID-19: Ontario

	Change in cases July 2, 2021	Change in cases July 3, 2021	Percentage change July 3, 2021 compared to July 2, 2021	Cumulative case count as of July 3, 2021
Total number of cases	209	213	+1.9%	545,803
Number of deaths	9	9	0.0%	9,214
Number resolved	262	286	+9.2%	534,558

Note: The number of cases publicly reported by the province each day may not align with case counts reported to public health on a given day; public health unit reported date refers to the date local public health was first notified of the case. Data corrections or updates can result in case records being removed and or updated from past reports.
Data Source: CCM

Table 1b. Summary of recent confirmed cases of COVID-19 by age group and gender: Ontario

	Change in cases July 2, 2021	Change in cases July 3, 2021	Cumulative case count as of July 3, 2021
Gender: Male	109	111	271,959
Gender: Female	96	95	270,054
Ages: 19 and under	57	51	87,920
Ages: 20-39	83	64	204,406
Ages: 40-59	42	53	155,746
Ages: 60-79	19	37	72,521
Ages: 80 and over	7	8	25,110

Note: Not all cases have a reported age or gender reported. Data corrections or updates can result in case records being removed and or updated from past reports and may result in subset totals (i.e., age group, gender) differing from past publicly reported case counts.
Data Source: CCM

Table 2. Summary of recent confirmed cases of COVID-19 in school aged children by age group, August 30, 2020 to July 3, 2021: Ontario

	Change in cases July 2, 2021	Change in cases July 3, 2021	Cumulative case count from August 30, 2020 to July 3, 2021
Ages: 4 to 8	18	11	16,260
Ages: 9 to 13	8	14	20,360
Ages: 14 to 17	8	10	20,720

Note: Includes all confirmed cases of COVID-19 for specified ages, regardless of school attendance. Data corrections or updates can result in case records being removed and or updated from past reports and may result in subset totals (i.e., age group) differing from past publicly reported case counts.
Data Source: CCM

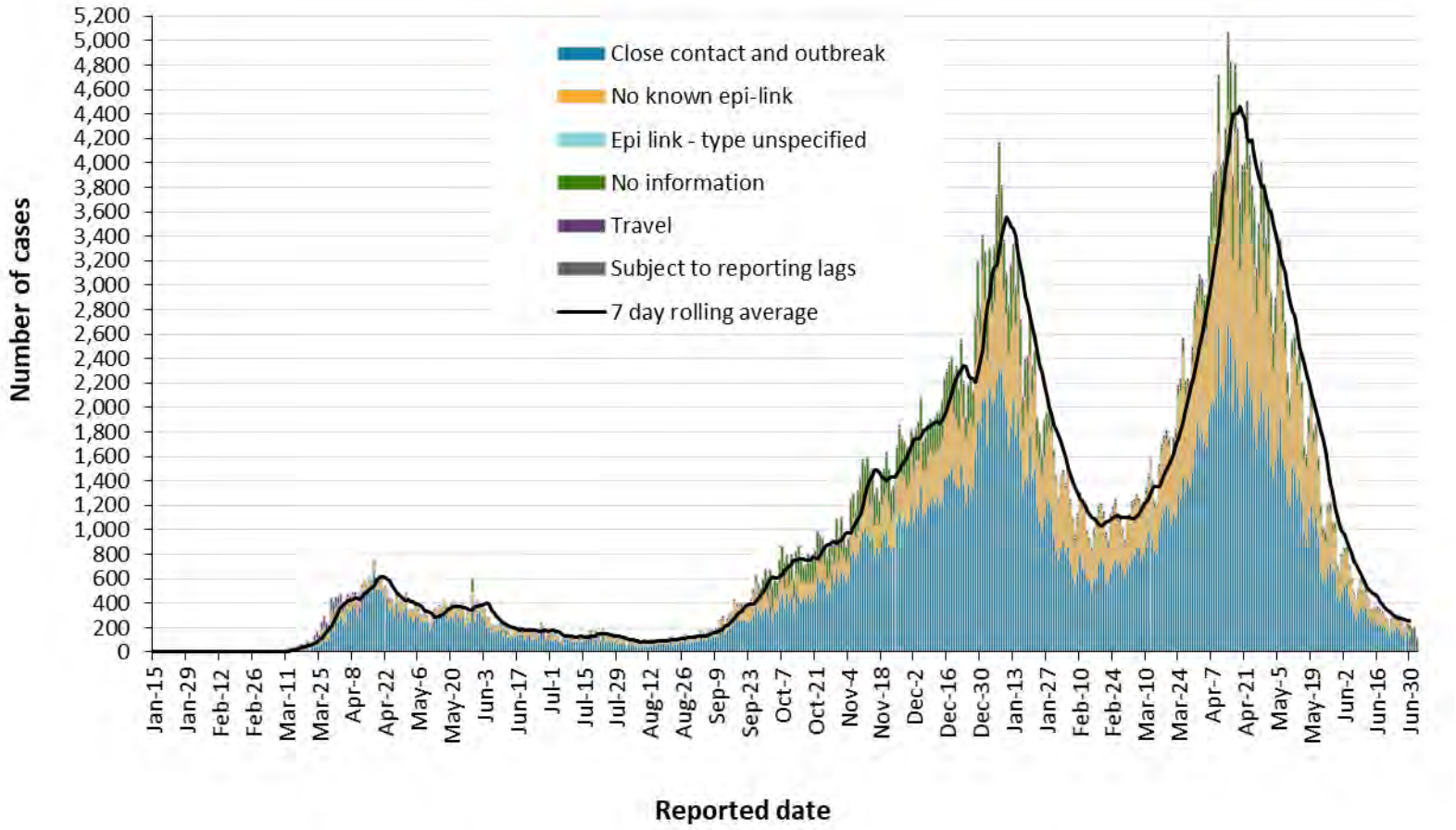
Table 3. Summary of recent confirmed cases of COVID-19 in long-term care homes: Ontario

Long-term care home cases	Change in cases July 2, 2021	Change in cases July 3, 2021	Cumulative case count as of July 3, 2021
Residents	1	1	15,400
Health care workers	1	0	7,195
Deaths among residents	0	1	3,971
Deaths among health care workers	0	0	10

Note: Information on how long-term care home residents and health care workers are identified is available in the technical notes. Also, the change in cases in these categories may represent existing case records that have been updated.
Data Source: CCM

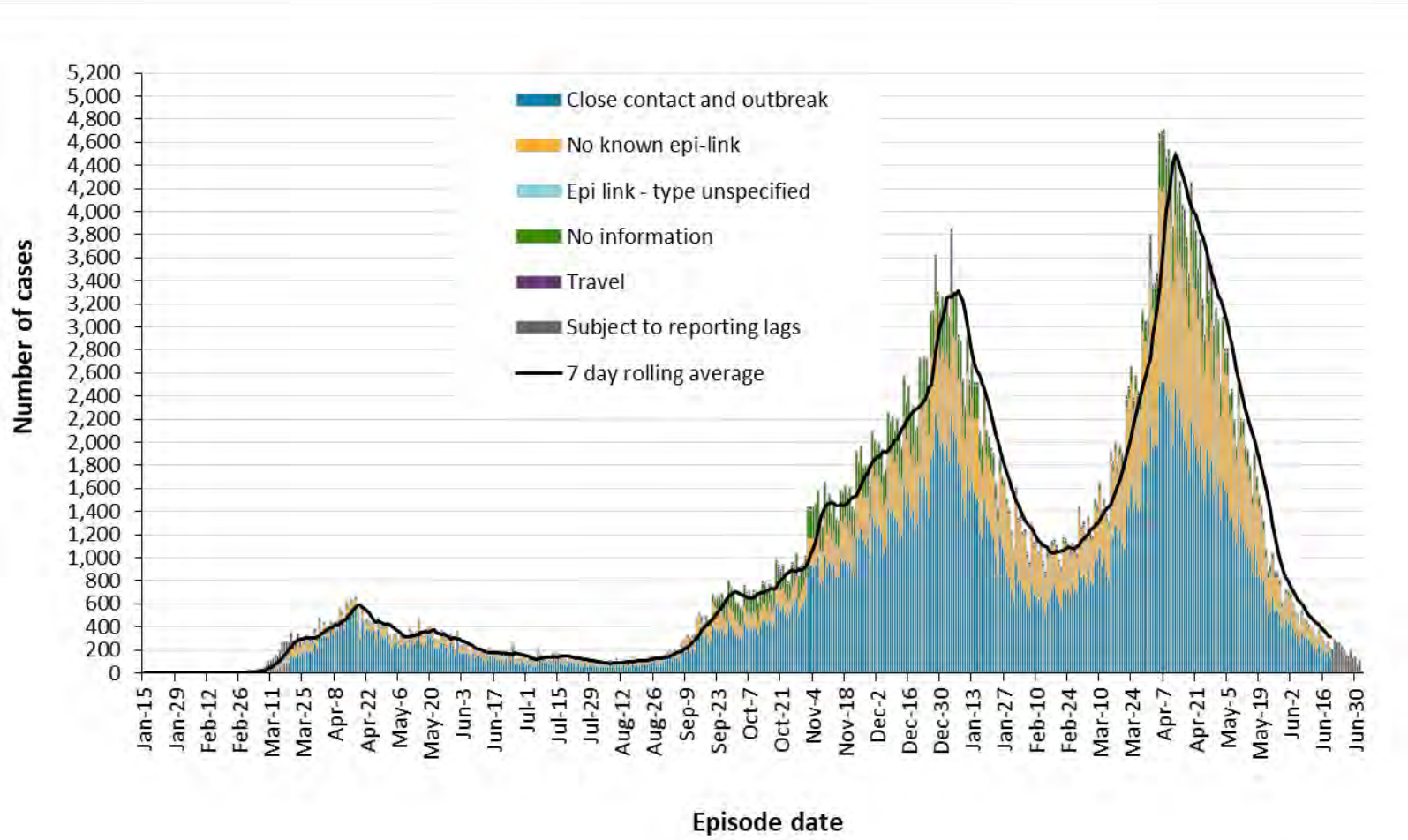
Time

Figure 1. Confirmed cases of COVID-19 by likely acquisition and public health unit reported date: Ontario, January 15, 2020 to July 3, 2021



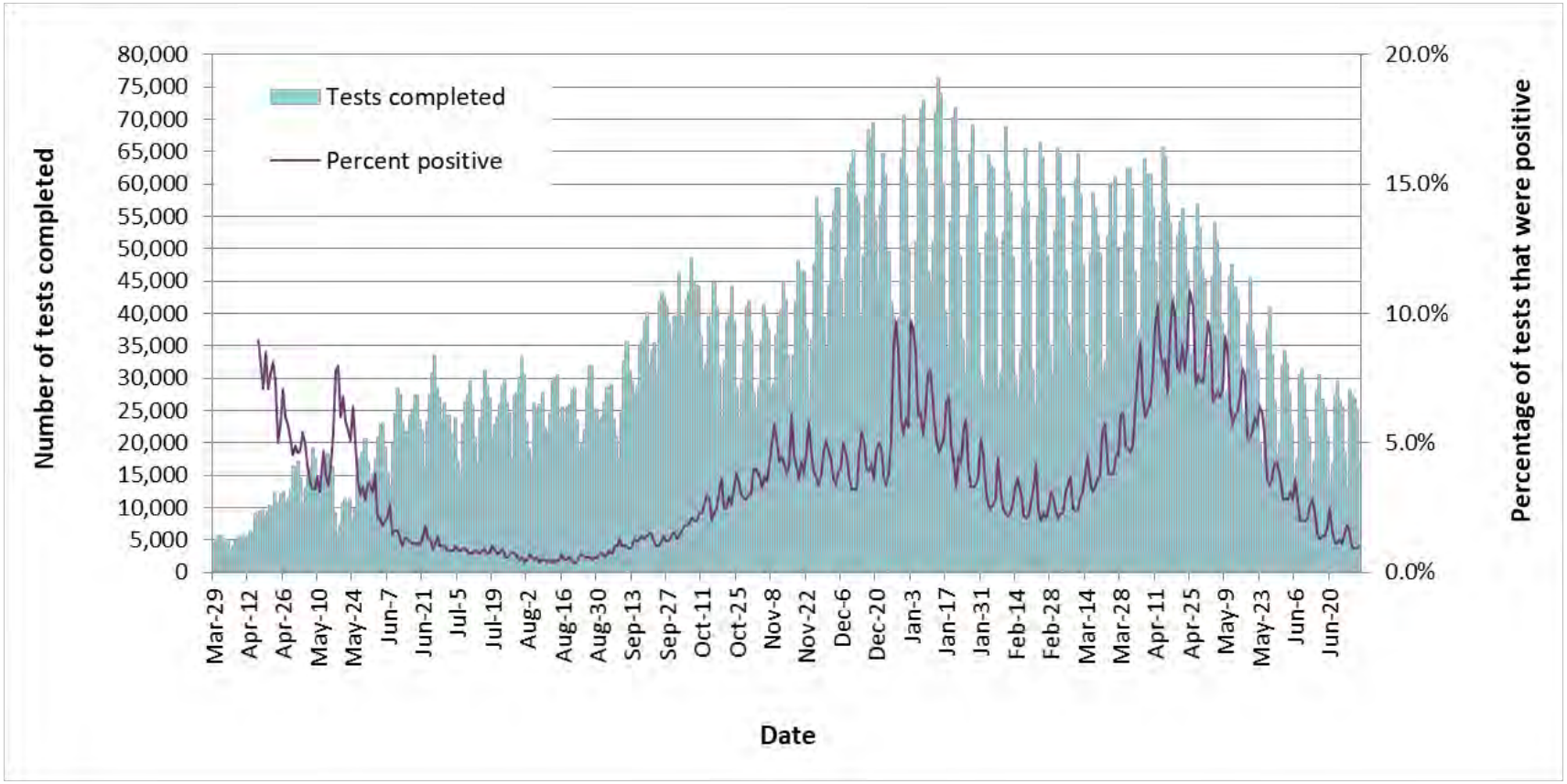
Data Source: CCM

Figure 2. Confirmed cases of COVID-19 by likely acquisition and approximation of symptom onset date: Ontario, January 15, 2020 to July 3, 2021



Note: Not all cases may have an episode date and those without one are not included in the figure. Episode date is defined and available in the technical notes.
Data Source: CCM

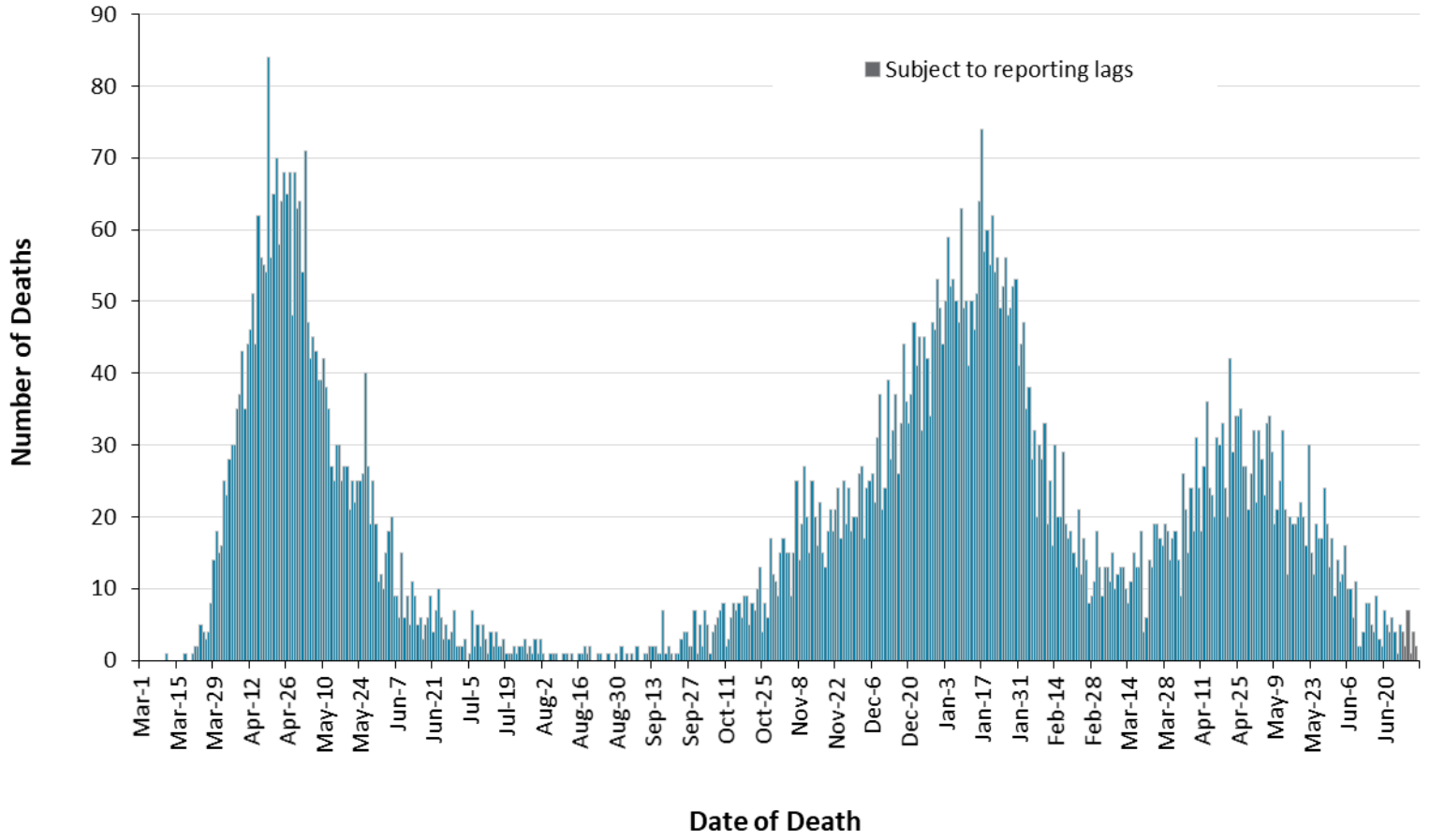
Figure 3. Number of COVID-19 tests completed and percent positivity: Ontario, March 29, 2020 to July 2, 2021



Note: The number of tests performed does not reflect the number of specimens or persons tested. More than one test may be performed per specimen or per person. As such, the percentage of tests that were positive does not necessarily translate to the number of specimens or persons testing positive.
Data Source: The Provincial COVID-19 Diagnostics Network, data reported by member microbiology laboratories.

Severity

Figure 4. Confirmed deaths among COVID-19 cases by date of death: Ontario, March 1, 2020 to July 3, 2021



Note: Cases without a death date are not included in the figure.
Data Source: CCM

Table 4. Confirmed cases of COVID-19 by severity: Ontario

	Cumulative case count as of July 3, 2021	Percentage of all cases
Cumulative deaths reported (please note there may be a reporting delay for deaths)	9,214	1.7%
Deaths reported in ages: 19 and under	4	<0.1%
Deaths reported in ages: 20-39	82	<0.1%
Deaths reported in ages: 40-59	581	0.4%
Deaths reported in ages: 60-79	2,937	4.0%
Deaths reported in ages: 80 and over	5,609	22.3%
Ever in ICU	5,378	1.0%
Ever hospitalized	27,962	5.1%

Note: Not all cases have an age reported. Data corrections or updates can result in case records being removed and/or updated and may result in totals differing from past publicly reported case counts.
Data Source: CCM

Geography

Table 5. Summary of recent confirmed cases of COVID-19 by public health unit and region: Ontario

Public Health Unit Name	Change in cases July 2, 2021	Change in cases July 3, 2021	Cumulative case count	Cumulative rate per 100,000 population
Northwestern Health Unit	0	0	1,091	1,244.4
Thunder Bay District Health Unit	-2	0	3,337	2,225.3
TOTAL NORTH WEST	-2	0	4,428	1,863.4
Algoma Public Health	0	0	400	349.5
North Bay Parry Sound District Health Unit	1	1	607	467.8
Porcupine Health Unit	5	6	2,080	2,492.8
Public Health Sudbury & Districts	2	2	2,150	1,080.3
Timiskaming Health Unit	0	0	208	636.3
TOTAL NORTH EAST	8	9	5,445	973.5
Ottawa Public Health	11	9	27,682	2,624.7
Eastern Ontario Health Unit	-7	0	4,610	2,208.8
Hastings Prince Edward Public Health	0	0	1,133	672.4
Kingston, Frontenac and Lennox & Addington Public Health	-1	2	1,551	729.1
Leeds, Grenville & Lanark District Health Unit	0	0	1,752	1,011.7
Renfrew County and District Health Unit	1	0	744	684.9
TOTAL EASTERN	4	11	37,472	1,945.2

Public Health Unit Name	Change in cases July 2, 2021	Change in cases July 3, 2021	Cumulative case count	Cumulative rate per 100,000 population
Durham Region Health Department	6	6	25,237	3,542.5
Haliburton, Kawartha, Pine Ridge District Health Unit	5	1	2,171	1,149.1
Peel Public Health	12	17	109,517	6,819.4
Peterborough Public Health	1	1	1,593	1,076.5
Simcoe Muskoka District Health Unit	6	3	12,384	2,065.4
York Region Public Health	4	4	52,625	4,293.1
TOTAL CENTRAL EAST	34	32	203,527	4,542.4
Toronto Public Health	20	42	165,100	5,291.1
TOTAL TORONTO	20	42	165,100	5,291.1
Chatham-Kent Public Health	0	0	1,884	1,772.1
Grey Bruce Health Unit	20	25	1,658	976.0
Huron Perth Public Health	2	5	1,936	1,385.3
Lambton Public Health	3	0	3,605	2,752.7
Middlesex-London Health Unit	2	9	12,585	2,479.7
Southwestern Public Health	1	1	3,884	1,836.4
Windsor-Essex County Health Unit	11	-4	16,862	3,969.1
TOTAL SOUTH WEST	39	36	42,414	2,508.6
Brant County Health Unit	-1	0	3,854	2,483.2
City of Hamilton Public Health Services	8	10	21,284	3,594.3
Haldimand-Norfolk Health Unit	1	1	2,681	2,350.1

Public Health Unit Name	Change in cases July 2, 2021	Change in cases July 3, 2021	Cumulative case count	Cumulative rate per 100,000 population
Halton Region Public Health	22	12	17,421	2,814.0
Niagara Region Public Health	20	6	16,247	3,438.6
Region of Waterloo Public Health and Emergency Services	47	49	17,726	3,033.4
Wellington-Dufferin-Guelph Public Health	9	5	8,204	2,630.3
TOTAL CENTRAL WEST	106	83	87,417	3,068.0
TOTAL ONTARIO	**209**	**213**	**545,803**	**3,671.9**

Notes: Health units with data corrections or updates could result in records being removed from totals, leading to negative or zero counts.
Data Source: CCM

Outbreaks

Table 6. Summary of recent confirmed COVID-19 outbreaks reported in long-term care homes, retirement homes and hospitals by status: Ontario

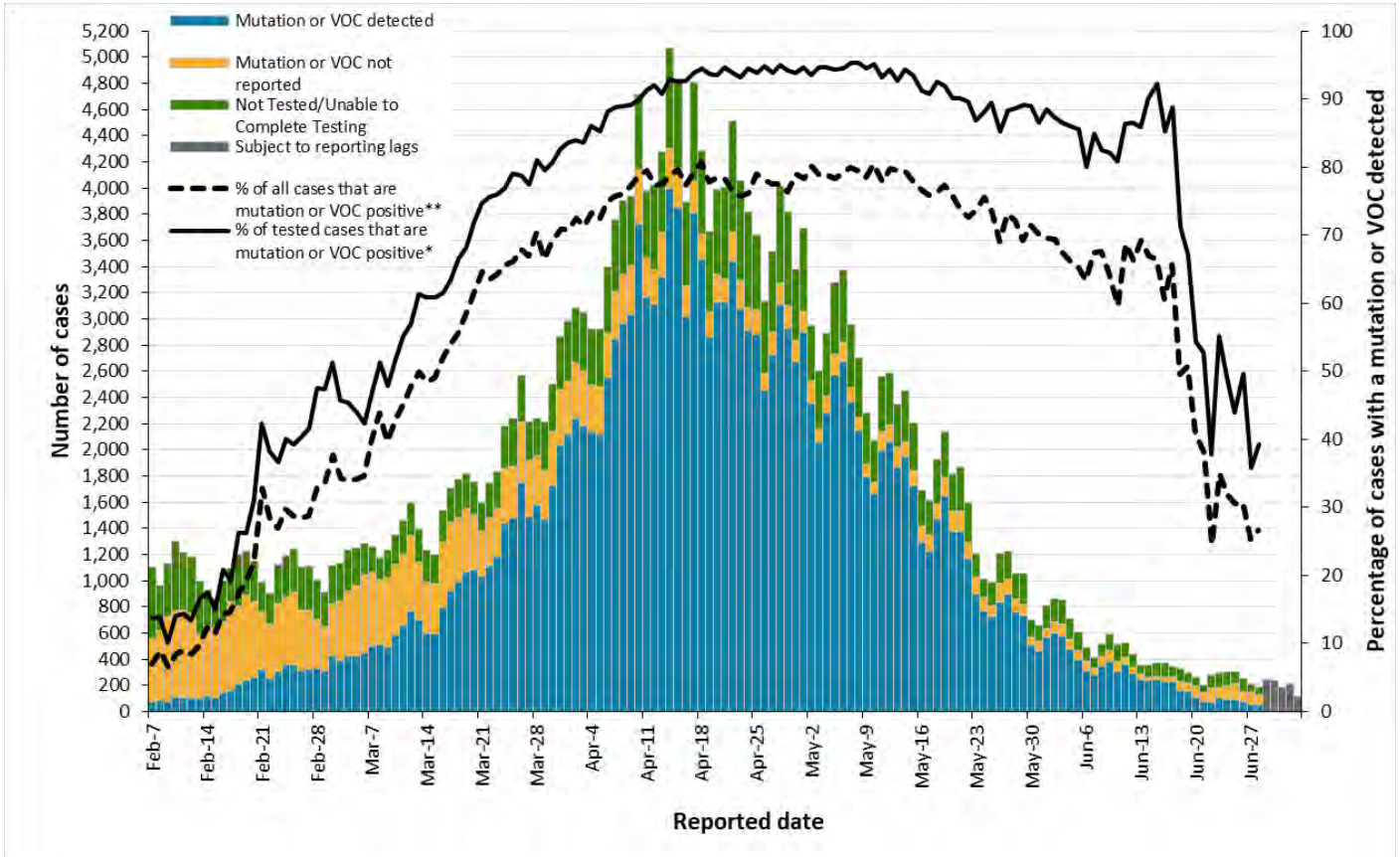
Institution type	Change in outbreaks July 2, 2021	Change in outbreaks July 3, 2021	Number of ongoing outbreaks	Cumulative number of outbreaks reported
Long-term care homes	0	1	4	1,486
Retirement homes	0	0	3	871
Hospitals	2	0	7	575

Note: Ongoing outbreaks include all outbreaks that are 'Open' in CCM without a 'Declared Over Date' recorded, or where the outbreak started more than five months ago, even for outbreaks where the Outbreak Status value selected in CCM is 'OPEN'. The start of the outbreak is determined by the onset date of first case, or if missing the outbreak reported date, or else if that is also missing, then the outbreak created date.
Data Source: CCM

Variant COVID-19 Cases

The laboratory detection of a variant of concern (VOC) is a multi-step process. Samples that test positive for SARS-CoV-2 and have a cycle threshold (Ct) value ≤ 35 can be tested for mutations common to variants of concern. If positive for the mutation of interest with a Ct value of ≤ 30, these samples may then undergo genomic analyses to identify the VOC lineage. VOC lineages may still be confirmed using genomic analysis despite specific S gene mutation(s) being documented as 'unable to complete' due to poor sequence quality at the genome position. For more information about whole genome sequencing, please see the SARS CoV-2 Whole Genome Sequencing in Ontario report.

Figure 5. Number of confirmed COVID-19 cases and percent positive for mutations or VOCs: Ontario, February 7, 2021 to July 3, 2021



Note: Data used to calculate the number of cases tested for mutations common to VOCs or lineages using genomic analyses are obtained using information from the Laboratory object in CCM in addition to the data from the Investigation Subtype field. Therefore, comparisons to counts using only information from the Investigation Subtype field may not align. The percent of cases due to a VOC may be higher than described in this report.
*The denominator includes only confirmed COVID-19 cases that were able to be tested for VOCs (e.g. those identified as 'Detected' or 'Not Detected'). Mutations tested for routinely are the N501Y and E484K mutations. Mutations common to the B.1.617.2 lineage are not included in the current VOC mutation test. However, cases identified as B.1.617.2 after whole genome sequencing is completed are included in the VOC detected category.
**The denominator includes all confirmed COVID-19 cases, including those that were unable to be tested for VOCs (e.g. those identified as 'Detected', 'Not Detected' and 'Not Tested/Unable to Complete Testing').
Data Source: CCM

Table 7. Summary of confirmed COVID-19 cases with a mutation or VOC detected: Ontario

	Change in cases July 2, 2021	Change in cases July 3, 2021	Cumulative case count up to July 3, 2021
Variant of Concern			
Lineage B.1.1.7 (Alpha)*	34	32	143,899
Lineage B.1.351 (Beta)**	0	0	1,415
Lineage P.1 (Gamma) ***	3	0	4,631
Lineage B.1.617.2 (Delta)†	32	14	2,041
Mutations			
N501Y and E484K	-1	4	4,709
N501Y (E484K unknown)‡	-4	3	13,957
E484K (N501Y negative)	5	3	5,810
E484K (N501Y unknown)	-3	-4	452
Mutation not detected§	19	7	11,693

Note: Interpret the VOC and mutation trends with caution due to the varying time required to complete VOC testing and/or genomic analysis following the initial positive test for SARS-CoV-2. Due to the nature of the genomic analysis, test results may be completed in batches. Data corrections or updates can result in case records being removed and/or updated and may result in totals differing from past publicly reported case counts. Data for calculating the change in cases and the cumulative case counts uses data from the Investigation Subtype field only. Changes to the VOC testing algorithm may impact counts and trends. Further details can be found in the data caveats section.

*Includes all confirmed COVID-19 cases where lineage B.1.1.7 was identified by genomic analysis and those presumed to be B.1.1.7 based on positive N501Y and negative E484K mutation in the Investigation Subtype field

**Includes B.1.351 cases identified by genomic analysis and those presumed to be B.1.351 based on 'Mutation K417N+ and N501Y+ and E484K+' in the Investigation Subtype field

***Includes P.1 cases identified by genomic analysis and those presumed to be P.1 based on 'Mutation K417T+ and N501Y+ and E484K+' in the Investigation Subtype field

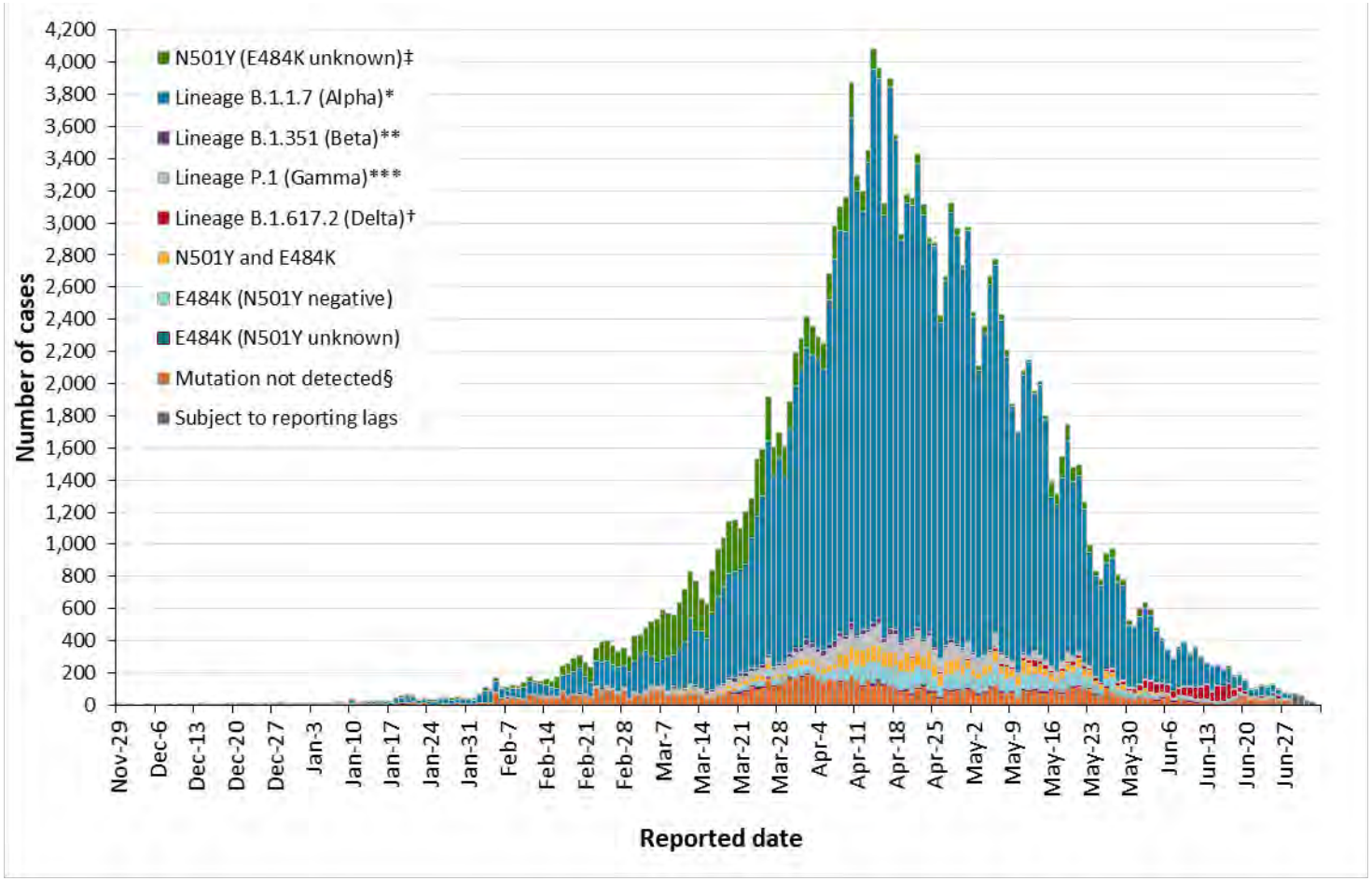
†Includes B.1.617.2 cases identified by genomic analysis. Mutations common to B.1.617.2 are not included in the current VOC mutation test.

‡The category 'N501Y (E484K unknown)' mainly consists of results from before the introduction of the E484K test. Counts will shift from this category into a VOC lineage category as E484K tests or genomic analysis are completed.

§Includes cases identified as 'Mutation not detected' or 'Mutation N501Y- and E484K-' in the Investigation Subtype field only.

Data Source: CCM

Figure 6. Confirmed COVID-19 cases with a mutation or VOC detected by public health unit reported date: Ontario, November 29, 2020 to July 3, 2021



Note: Reported date is based on the date the case was reported, not the date that the VOC or mutation was identified. Further details on testing for variants of concern can be found in the technical notes. Interpret the VOC and mutation trends with caution due to the varying time required to complete testing and/or genomic analysis following the initial positive test for SARS-CoV-2. Data for calculating the change in cases and the cumulative case count uses data from the Investigation Subtype field only. Data for cases with a B.1.1.7, B.1.351, P.1 and B.1.617.2 lineage detected or any of the mutations listed above are determined using the

Investigation Subtype field only. Changes to the VOC testing algorithm may impact counts and trends. Further details can be found in the data caveats section. As of March 22, 2021, positive specimens with a Ct ≤ 35 are tested for both the N501Y and E484K mutation, with all E484K positive specimens with a Ct ≤ 30 forwarded for further genomic analysis. If found to be positive for the N501Y mutation only, no further genomic analysis are performed as these are presumed to be B.1.1.7. As of May 26, 2021, cases where an E484K mutation is detected will no longer be reflexed for sequencing as VOC testing labs switched to a representative sampling method where only a proportion of all positives with a Ct ≤ 30 are forwarded for further genomic analysis.

*Includes all confirmed COVID-19 cases where lineage B.1.1.7 was identified by genomic analysis and those presumed to be B.1.1.7 based on positive N501Y and negative E484K mutation in the Investigation Subtype field

**Includes B.1.351 cases identified by genomic analysis and those presumed to be B.1.351 based on 'Mutation K417N+ and N501Y+ and E484K+' in the Investigation Subtype field

***Includes P.1 cases identified by genomic analysis and those presumed to be P.1 based on 'Mutation K417T+ and N501Y+ and E484K+' in the Investigation Subtype field

†Includes B.1.617.2 cases identified by genomic analysis. Mutations common to B.1.617.2 are not included in the current VOC mutation test.

‡The category 'N501Y (E484K unknown)' mainly consists of results from before the introduction of the E484K test. Counts will shift from this category into a VOC lineage category as E484K tests or genomic analysis are completed.

§Includes cases identified as 'Mutation not detected' or 'Mutation N501Y- and E484K-' in the Investigation Subtype field only.

Data Source: CCM

Technical Notes

Data Sources

- The data for this report were based on information successfully extracted from the Public Health Case and Contact Management Solution (CCM) for all PHUs by PHO as of **July 3, 2021 at 1 p.m**. for cases reported from February 1, 2021 onwards and as of **July 2, 2021 at 9 a.m.** for cases reported up to January 31, 2021.

- VOC data for this report were based on information successfully extracted from CCM for all PHUs by PHO as of **July 3, 2021 at 1 p.m.** for cases reported from April 1, 2021 onwards and as of **July 2, 2021 at 9 a.m.** for cases reported up to March 31, 2021.

- CCM is a dynamic disease reporting system, which allows ongoing updates to data previously entered. As a result, data extracted from CCM represent a snapshot at the time of extraction and may differ from previous or subsequent reports.

- Ontario population projection data for 2020 were sourced from Ministry, IntelliHEALTH Ontario. Data were extracted on November 26, 2019.

- COVID-19 test data were based on information from The Provincial COVID-19 Diagnostics Network, reported by member microbiology laboratories.

Data Caveats

- The data only represent cases reported to public health units and recorded in CCM. As a result, all counts will be subject to varying degrees of underreporting due to a variety of factors, such as disease awareness and medical care seeking behaviours, which may depend on severity of illness, clinical practice, changes in laboratory testing, and reporting behaviours.

- Data cleaning for older cases is incorporated on Mondays and may impact the case count published on Tuesdays

- Lags in CCM data entry due to weekend staffing may result in lower case counts than would otherwise be recorded.

- Only cases meeting the confirmed case classification as listed in the MOH Case Definition – Coronavirus Disease (COVID-19) document are included in the report counts from CCM

- Cases of confirmed reinfection, as defined in the provincial case definitions, are counted as unique investigations.

- Case classification information may be updated for individuals with a positive result issued from a point-of-care assays.

- The number of tests performed does not reflect the number of specimens or persons tested. More than one test may be performed per specimen or per person. As such, the percentage of tests that were positive does not necessarily translate to the number of specimens or persons testing positive.

- Reported date is the date the case was reported to the public health unit.

- Case episode date represents an estimate of disease onset. This date is calculated based on the earliest date of symptom onset, specimen collection/test date, or the date reported to the public health unit.

- Resolved cases are determined only for COVID-19 cases that have not died. Cases that have died are considered fatal and not resolved. The following cases are classified as resolved:

    - Cases that are reported as 'recovered' in CCM

    - Cases that are not hospitalized and are 14 days past their episode date

    - Cases that are currently hospitalized (no hospital end date entered) and have a status of 'closed' in CCM (indicating public health unit follow-up is complete) and are 14 days past their symptom onset date or specimen collection date

- Hospitalization includes all cases for which a hospital admission date was reported or hospitalization/ICU was reported as 'Yes' at the time of data extraction. It includes cases that have been discharged from hospital as well as cases that are currently hospitalized. Emergency room visits are not included in the number of reported hospitalizations.

- ICU admission includes all cases for which an ICU admission date was reported at the time of data extraction. It is a subset of the count of hospitalized cases. It includes cases that have been treated or that are currently being treated in an ICU.

- Orientation of case counts by geography is based on the diagnosing health unit (DHU). DHU refers to the case's public health unit of residence at the time of illness onset and not necessarily the location of exposure. Cases for which the DHU was reported as MOH-PHO (to signify a case that is not a resident of Ontario) have been excluded from the analyses.

- Likely source of acquisition is determined by examining the epidemiologic link and epidemiologic link status fields in CCM. If no epidemiologic link is identified in those fields the risk factor fields are examined to determine whether a case travelled, was associated with a confirmed outbreak, was a contact of a case, had no known epidemiological link (sporadic community transmission) or was reported to have an unknown source/no information was reported. Some cases may have no information reported if the case is untraceable, was lost to follow-up or referred to FNIHB. Cases with multiple risk factors were assigned to a single likely acquisition source group which was determined hierarchically in the following order:

    - For cases with an episode date *on or after* April 1, 2020: Outbreak-associated > close contact of a confirmed case > travel > no known epidemiological link > information missing or unknown

    - For cases with an episode date *before* April 1, 2020: Travel > outbreak-associated > close contact of a confirmed case > no known epidemiological link > information missing or unknown

- Deaths are determined by using the outcome field in CCM. Any case marked 'Fatal' is included in the deaths data. The CCM field Type of Death is not used to further categorize the data.

    - The date of death is determined using the outcome date field for cases marked as 'Fatal' in the outcome field.

- COVID-19 cases from CCM for which the Classification and/or Disposition was reported as ENTERED IN ERROR, DOES NOT MEET DEFINITION, IGNORE, DUPLICATE or any variation on these values have been excluded. The provincial case count for COVID-19 may include some duplicate records, if these records were not identified and resolved.

- Ongoing outbreaks include all outbreaks that are 'Open' in CCM without a 'Declared Over Date' recorded, or where the outbreak started more than five months ago, even for outbreaks where the Outbreak Status value selected in CCM is 'OPEN'. The start of the outbreak is determined by the onset date of first case, or if missing the outbreak reported date, or else if that is also missing, then the outbreak created date.

- 'Long-term care home residents' includes cases that reported 'Yes' to the risk factor 'Resident of a long-term care home'; or 'Yes' to the risk factor 'Resident of nursing home or other chronic care facility' and reported to be part of an outbreak assigned as a long-term care home (via the Outbreak number or case comments field); or were reported to be part of an outbreak assigned as a long-term care home (via the outbreak number or case comments field) with an age over 70 years and did not report 'No' to the risk factors 'Resident of long-term care home' or 'Resident of nursing home or other chronic care facility'. 'Long-term care home residents' excludes cases that reported 'Yes' to any of the health care worker occupational risk factors.

- The 'health care workers' variable includes cases that reported 'Yes' to any of the occupation of health care worker, doctor, nurse, dentist, dental hygienist, midwife, other medical technicians, personal support worker, respiratory therapist, first responder.

- 'Health care workers associated with long-term care outbreaks' includes 'health care workers' reported to be part of an outbreak assigned as a long-term care home (via the outbreak number or case comments field). Excludes cases that reported 'Yes' to risk factors 'Resident of long-term care home' or 'Resident of nursing home or other chronic care facility' and 'Yes' to the calculated 'health care workers' variable.

- Percent change is calculated by taking the difference between the current period (i.e., daily count or sum of the daily count over a 7-day period) and previous period (i.e., daily count or sum of the daily count over a 7-day period), divided by the previous period.

- Public Health Ontario conducts testing and genomic analyses for SARS-CoV-2 positive specimens using the criteria outlined here: https://www.publichealthontario.ca/en/laboratory-services/test-information-index/covid-19-voc

- Lineage nomenclature is dynamic. PANGO lineage naming and assignment may change as more samples are sequenced and analyzed.

- Variant status may be updated based on scientific evidence. Variants designated as a VOC in Canada is available on the Public Health Agency of Canada's SARS-CoV-2 Variants webpage.

- Changes to the VOC testing algorithm may occur over time and trends should be interpreted with caution. Since February 3, 2021 all PCR positive SARS-Co-V-2 specimens with Ct values ≤ 35 are tested for a N501Y mutation. As of March 22, 2021, positive specimens with a Ct ≤ 35 are tested for both the N501Y and E484K mutation, with all E484K positive specimens with a Ct ≤ 30 forwarded for further genomic analysis. If found to be positive for the N501Y mutation only, no further genomic analysis are performed as these are presumed to be B.1.1.7. As of May 26, 2021, cases where a E484K mutation is detected will no longer be reflexed for sequencing as

VOC testing labs switched to a representative sampling method where only a proportion of all positives with a Ct ≤ 30 are forwarded for further genomic analysis.

- The laboratory detection of a variant of concern is a multi-step process. Samples that test positive for SARS-CoV-2 and have a cycle threshold (Ct) value ≤ 35 can be tested for mutations common to variants of concern. If positive for the mutation of interest with a Ct value of ≤30, these samples may then undergo genomic analyses to identify the VOC lineage. VOC lineages may still be confirmed using genomic analysis despite specific S gene mutation(s) being documented as 'unable to complete' due to poor sequence quality at the genome position.

- VOC testing data are analyzed for cases with a reported date on or after February 07, 2021. VOC testing data are based on CCM information reported within the laboratory object for select Logical Observation Identifiers Names and Codes (LOINC) and supplemented with information from the Investigation Subtype field. A confirmed Case Investigation is assigned a VOC test value (e.g., VOC test detected, VOC test not detected) based on the following hierarchy:

    - If multiple laboratory results are identified, a VOC test value is assigned based on the following hierarchy: Detected > Not Detected > Unable to complete

    - If a laboratory result is 'Not Detected' or 'Unable to complete', but data on the Investigation Subtype field is listed as a lineage or mutation common to a VOC, then the VOC test value is set to 'Detected'

- If a VOC is identified through genomic analysis cases initially classified as a mutation may be updated and moved to the appropriate lineage (B.1.1.7, B.1.351, P.1 and B.1.617.2)

- LOINCs are a set of internationally used result description codes. In the absence of a standard LOINC, Ontario Health can create local result codes, which are identified with an 'XON' prefix. LOINCs incorporate details of the result value (e.g. test method, target detected - such as IgG, DNA, isolate etc.) and are unique to each result.

- VOC testing data in this report are assigned on a per case basis. Multiple laboratory results may be associated to a single case investigation, but for analysis purposes are only counted once.

    - The percent of cases that test VOC positive is calculated by taking the number of VOC test positive, divided by the total number of confirmed COVID-19 cases for a given reported date.

- The VOC percent positive may be higher than described in this report. As testing algorithms change, the VOC percent positivity may not be reflective of the exact number of COVID-19 cases due to VOCs

- Only CCM case investigations with a CONFIRMED classification have their laboratory records with VOC testing information included in the percent positivity calculations

Appendix A

Table A1. Weekly rates of confirmed COVID-19 cases per 100,000 population over recent rolling 7-day periods, by reported date and public health unit: Ontario, June 18 to June 30, 2021

Public Health Unit Name	June 18 to June 24	June 19 to June 25	June 20 to June 26	June 21 to June 27	June 22 to June 28	June 23 to June 29	June 24 to June 30	% change from June 18 – June 24 to June 24 - June 30
NORTH WEST								
Northwestern Health Unit	8.0	6.8	6.8	9.1	8.0	8.0	5.7	-28.8%
Thunder Bay District Health Unit	4.7	4.7	4.7	4.7	4.7	4.0	2.0	-57.4%
NORTH EAST								
Algoma Public Health	1.7	0.9	0.9	0.9	0.0	0.0	0.0	-100.0%
North Bay Parry Sound District Health Unit	43.9	43.2	47.0	45.5	37.8	32.4	30.8	-29.8%
Porcupine Health Unit	91.1	98.3	87.5	87.5	91.1	95.9	82.7	-9.2%
Public Health Sudbury & Districts	15.6	17.1	12.1	10.6	9.5	9.0	4.0	-74.4%
Timiskaming Health Unit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N/A
EASTERN								
Ottawa Public Health	9.8	8.0	7.1	7.2	6.1	5.6	4.6	-53.1%
Eastern Ontario Health Unit	2.4	1.4	1.9	1.9	1.9	1.9	1.0	-58.3%
Hastings Prince Edward Public Health	0.6	0.6	0.6	1.2	1.2	1.8	1.8	+200.0%
Kingston, Frontenac and Lennox & Addington Public Health	4.7	3.8	1.4	1.4	0.9	0.9	1.4	-70.2%

Public Health Unit Name	June 18 to June 24	June 19 to June 25	June 20 to June 26	June 21 to June 27	June 22 to June 28	June 23 to June 29	June 24 to June 30	% change from June 18 – June 24 to June 24 - June 30
Leeds, Grenville & Lanark District Health Unit	1.2	1.7	1.7	2.3	2.3	2.9	3.5	+191.7%
Renfrew County and District Health Unit	2.8	3.7	3.7	2.8	3.7	3.7	2.8	0.0%
CENTRAL EAST								
Durham Region Health Department	10.0	8.7	8.1	8.3	9.4	8.7	8.0	-20.0%
Haliburton, Kawartha, Pine Ridge District Health Unit	7.4	6.4	6.9	4.8	5.3	5.3	4.8	-35.1%
Peel Public Health	13.9	12.8	11.8	10.2	10.2	10.3	9.5	-31.7%
Peterborough Public Health	8.1	7.4	6.1	4.1	2.7	4.1	6.1	-24.7%
Simcoe Muskoka District Health Unit	6.7	6.2	6.0	6.3	6.2	6.7	6.2	-7.5%
York Region Public Health	6.9	6.3	5.7	5.1	4.9	4.4	4.2	-39.1%
TORONTO								
Toronto Public Health	10.2	10.3	10.1	9.6	9.3	8.5	8.5	-16.7%
SOUTH WEST								
Chatham-Kent Public Health	1.9	1.9	2.8	3.8	3.8	4.7	5.6	+194.7%
Grey Bruce Health Unit	46.5	71.2	77.1	82.4	84.8	97.1	106.5	+129.0%
Huron Perth Public Health	7.9	7.2	7.9	7.2	6.4	9.3	8.6	+8.9%
Lambton Public Health	29.0	32.1	30.5	27.5	26.0	24.4	17.6	-39.3%
Middlesex-London Health Unit	6.5	5.9	6.5	6.9	8.3	8.9	9.7	+49.2%

Public Health Unit Name	June 18 to June 24	June 19 to June 25	June 20 to June 26	June 21 to June 27	June 22 to June 28	June 23 to June 29	June 24 to June 30	% change from June 18 – June 24 to June 24 - June 30
Southwestern Public Health	7.6	8.0	5.7	7.1	5.2	5.7	6.6	-13.2%
Windsor-Essex County Health Unit	10.1	8.7	8.7	9.7	9.2	8.0	8.0	-20.8%
CENTRAL WEST								
Brant County Health Unit	7.1	7.7	9.0	7.7	7.7	7.7	7.1	0.0%
City of Hamilton Public Health Services	18.6	16.4	16.7	16.0	18.2	16.5	15.4	-17.2%
Haldimand-Norfolk Health Unit	7.0	7.0	7.0	7.0	7.9	9.6	7.0	0.0%
Halton Region Public Health	7.4	7.8	7.6	7.3	6.6	7.3	9.7	+31.1%
Niagara Region Public Health	14.4	15.0	14.0	14.2	14.4	12.5	12.9	-10.4%
Region of Waterloo Public Health and Emergency Services	66.1	64.2	66.1	65.5	65.4	63.8	61.3	-7.3%
Wellington-Dufferin-Guelph Public Health	12.8	14.4	16.0	15.7	17.0	18.0	18.3	+43.0%
TOTAL ONTARIO	**13.2**	**13.0**	**12.7**	**12.4**	**12.3**	**12.1**	**11.7**	**-11.4%**

Note: Rates are based on the sum of the daily case counts during the date ranges specified in each column.
Data Source: CCM

Table A2. Summary of confirmed COVID-19 cases with a mutation or VOC by public health unit: Ontario as of July 3, 2021

Public Health Unit Name	Cumulative count for Lineage B.1.1.7 (Alpha)*	Cumulative count for Lineage B.1.351 (Beta)**	Cumulative count for Lineage P.1 (Gamma)***	Cumulative count for Lineage B.1.617.2 (Delta)†	Cumulative count for mutations‡
Algoma Public Health	68	0	12	2	28
Brant County Health Unit	665	2	88	28	495
Chatham-Kent Public Health	113	5	14	0	110
City of Hamilton Public Health Services	4,964	65	101	66	2,100
Durham Region Health Department	9,500	65	261	56	1,207
Eastern Ontario Health Unit	648	44	17	2	273
Grey Bruce Health Unit	306	0	5	52	56
Haldimand-Norfolk Health Unit	368	3	22	8	402
Haliburton, Kawartha, Pine Ridge District Health Unit	443	0	17	33	313
Halton Region Public Health	5,075	29	159	72	606
Hastings Prince Edward Public Health	77	0	8	2	406
Huron Perth Public Health	234	0	11	17	67
Kingston, Frontenac and Lennox & Addington Public Health	439	2	35	3	129
Lambton Public Health	433	0	17	13	129
Leeds, Grenville & Lanark District Health Unit	293	18	0	0	42
Middlesex-London Health Unit	3,358	2	96	20	187

Public Health Unit Name	Cumulative count for Lineage B.1.1.7 (Alpha)*	Cumulative count for Lineage B.1.351 (Beta)**	Cumulative count for Lineage P.1 (Gamma)***	Cumulative count for Lineage B.1.617.2 (Delta)†	Cumulative count for mutations‡
Niagara Region Public Health	4,233	4	17	17	1,084
North Bay Parry Sound District Health Unit	230	28	2	7	13
Northwestern Health Unit	56	0	1	0	16
Ottawa Public Health	6,647	488	50	21	478
Peel Public Health	30,574	132	1,405	504	3,580
Peterborough Public Health	613	4	7	8	161
Porcupine Health Unit	1,065	2	0	35	8
Public Health Sudbury & Districts	615	11	5	1	341
Region of Waterloo Public Health and Emergency Services	3,094	11	71	437	302
Renfrew County and District Health Unit	224	8	6	1	12
Simcoe Muskoka District Health Unit	3,848	31	159	61	831
Southwestern Public Health	659	2	14	15	165
Thunder Bay District Health Unit	104	0	2	5	74
Timiskaming Health Unit	83	1	0	0	0
Toronto Public Health	45,108	373	1,483	429	8,296
Wellington-Dufferin-Guelph Public Health	2,074	1	61	53	192
Windsor-Essex County Health Unit	1,826	5	17	3	130

Public Health Unit Name	Cumulative count for Lineage B.1.1.7 (Alpha)*	Cumulative count for Lineage B.1.351 (Beta)**	Cumulative count for Lineage P.1 (Gamma)***	Cumulative count for Lineage B.1.617.2 (Delta)†	Cumulative count for mutations‡
York Region Public Health	15,862	79	468	70	2,695
TOTAL ONTARIO	**143,899**	**1,415**	**4,631**	**2,041**	**24,928**

Note: Interpret the VOC and mutation trends with caution due to the varying time required to complete VOC testing and/or genomic analysis following the initial positive test for SARS-CoV-2. Due to the nature of the genomic analysis, test results may be completed in batches. Data corrections or updates can result in case records being removed and/or updated and may result in totals differing from past publicly reported case counts. Data for calculating the change in cases and the cumulative case count uses data from the Investigation Subtype field only. Changes to the VOC testing algorithm may impact counts and trends. Further details can be found in the data caveats section.

*Includes all confirmed COVID-19 cases where lineage B.1.1.7 was identified by genomic analysis and those presumed to be B.1.1.7 based on positive N501Y and negative E484K mutation.

**Includes B.1.351 cases identified by genomic analysis and those presumed to be B.1.351 based on 'Mutation K417N+ and N501Y+ and E484K+' in the Investigation Subtype field

***Includes P.1 cases identified by genomic analysis and those presumed to be P.1 based on 'Mutation K417T+ and N501Y+ and E484K+' in the Investigation Subtype field

†Includes B.1.617.2 cases identified by genomic analysis. Mutations common to B.1.617.2 are not included in the current VOC mutation test.

‡Mutations includes all confirmed COVID-19 cases with the following mutations detected, reported from the Investigation Subtype field: N501Y and E484K, N501Y (E484K unknown), E484K (N501Y negative), E484K (N501Y unknown).

If a VOC is identified through genomic analysis, the change in cases and/or cumulative case counts for mutations will fluctuate as the case is moved to one of the listed lineages.

Data Source: CCM

Table A3. Weekly percent positivity for cases positive for mutations or VOCs over recent rolling 7-day periods using all confirmed cases as the denominator, by reported date and public health unit: Ontario, June 16 to June 28, 2021

Public Health Unit Name	June 16 to June 22	June 17 to June 23	June 18 to June 24	June 19 to June 25	June 20 to June 26	June 21 to June 27	June 22 to June 28
Algoma Public Health	50.0	50.0	50.0	100.0	100.0	100.0	0.0
Brant County Health Unit	91.7	85.7	63.6	66.7	42.9	41.7	33.3
Chatham-Kent Public Health	0.0	0.0	0.0	0.0	33.3	25.0	25.0
City of Hamilton Public Health Services	36.8	36.3	29.1	26.8	26.3	23.2	23.1
Durham Region Health Department	63.9	59.5	52.1	50.0	39.7	42.4	35.8
Eastern Ontario Health Unit	50.0	60.0	60.0	66.7	50.0	50.0	50.0
Grey Bruce Health Unit	20.0	12.1	11.4	13.2	21.4	20.7	19.4
Haldimand-Norfolk Health Unit	42.9	62.5	37.5	50.0	50.0	62.5	55.6
Haliburton, Kawartha, Pine Ridge District Health Unit	46.7	71.4	57.1	50.0	30.8	33.3	40.0
Halton Region Public Health	54.5	50.9	50.0	47.9	36.2	33.3	26.8
Hastings Prince Edward Public Health	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Huron Perth Public Health	57.1	44.4	36.4	30.0	18.2	20.0	22.2
Kingston, Frontenac and Lennox & Addington Public Health	70.0	63.6	70.0	75.0	66.7	33.3	0.0
Lambton Public Health	36.8	33.3	26.3	28.6	30.0	27.8	26.5

Public Health Unit Name	June 16 to June 22	June 17 to June 23	June 18 to June 24	June 19 to June 25	June 20 to June 26	June 21 to June 27	June 22 to June 28
Leeds, Grenville & Lanark District Health Unit	100.0	100.0	100.0	66.7	66.7	75.0	75.0
Middlesex-London Health Unit	65.9	59.4	48.5	36.7	36.4	34.3	38.1
Niagara Region Public Health	18.1	13.8	5.9	7.0	4.5	4.5	5.9
North Bay Parry Sound District Health Unit	73.7	73.3	77.2	76.8	73.8	71.2	69.4
Northwestern Health Unit	16.7	14.3	14.3	0.0	0.0	0.0	0.0
Ottawa Public Health	64.6	59.8	61.2	54.8	50.7	48.7	43.8
Peel Public Health	62.4	60.1	57.4	54.9	52.1	47.0	48.8
Peterborough Public Health	75.0	71.4	66.7	63.6	55.6	66.7	50.0
Porcupine Health Unit	61.6	59.5	56.6	52.4	46.6	47.9	48.7
Public Health Sudbury & Districts	81.8	90.0	90.3	88.2	83.3	81.0	78.9
Region of Waterloo Public Health and Emergency Services	24.2	15.0	5.2	2.7	3.1	3.4	3.7
Renfrew County and District Health Unit	66.7	33.3	33.3	25.0	25.0	0.0	25.0
Simcoe Muskoka District Health Unit	61.5	51.5	37.5	35.1	27.8	26.3	27.0
Southwestern Public Health	50.0	55.6	75.0	76.5	83.3	80.0	72.7
Thunder Bay District Health Unit	20.0	28.6	14.3	14.3	14.3	14.3	14.3
Timiskaming Health Unit	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Public Health Unit Name	June 16 to June 22	June 17 to June 23	June 18 to June 24	June 19 to June 25	June 20 to June 26	June 21 to June 27	June 22 to June 28
Toronto Public Health	61.2	59.1	55.5	52.6	52.2	48.2	47.8
Wellington-Dufferin-Guelph Public Health	23.7	14.3	15.0	17.8	16.0	16.3	15.1
Windsor-Essex County Health Unit	41.7	38.3	30.2	24.3	18.9	22.0	20.5
York Region Public Health	52.1	50.5	44.0	37.7	30.0	28.6	30.0
TOTAL ONTARIO	**48.9**	**44.7**	**39.0**	**35.8**	**32.8**	**30.8**	**29.6**

Note: Data for calculating the number of cases tested for mutations common to VOCs or lineages using genomic analyses are obtained using information from the Laboratory object in CCM in addition to the data from the Investigation subtype field. Therefore, comparisons to counts using only information from the Investigation Subtype field may not align. The percent of cases due to a VOC may be higher than described in this report. While all confirmed COVID-19 cases are included in the denominator, not all cases were able to be tested for VOCs. Percent positivity is based on the sum of the daily cases that test positive divided by the number of cases reported during the date ranges specified in each column.
Data Source: CCM

Table A4. Weekly percent positivity for cases positive for mutations or VOCs over recent rolling 7-day periods using cases tested for mutations or VOCs as the denominator, by reported date and public health unit: Ontario, June 16 to June 28, 2021

Public Health Unit Name	June 16 to June 22	June 17 to June 23	June 18 to June 24	June 19 to June 25	June 20 to June 26	June 21 to June 27	June 22 to June 28
Algoma Public Health	100.0	100.0	100.0	100.0	100.0	100.0	0.0
Brant County Health Unit	100.0	92.3	70.0	72.7	54.5	50.0	44.4
Chatham-Kent Public Health	0.0	0.0	0.0	0.0	50.0	33.3	33.3
City of Hamilton Public Health Services	61.4	62.1	53.3	54.2	52.0	46.8	41.7
Durham Region Health Department	86.8	83.0	74.0	72.1	65.7	64.1	57.1
Eastern Ontario Health Unit	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Grey Bruce Health Unit	21.4	13.5	13.0	15.5	25.7	24.8	23.3
Haldimand-Norfolk Health Unit	75.0	83.3	75.0	80.0	80.0	100.0	83.3
Haliburton, Kawartha, Pine Ridge District Health Unit	53.8	71.4	57.1	50.0	36.4	42.9	50.0
Halton Region Public Health	65.2	63.6	63.9	63.9	50.0	50.0	40.7
Hastings Prince Edward Public Health	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Huron Perth Public Health	80.0	66.7	50.0	42.9	33.3	33.3	40.0
Kingston, Frontenac and Lennox & Addington Public Health	87.5	77.8	77.8	85.7	66.7	50.0	0.0
Lambton Public Health	100.0	90.9	90.9	80.0	80.0	76.9	75.0

Public Health Unit Name	June 16 to June 22	June 17 to June 23	June 18 to June 24	June 19 to June 25	June 20 to June 26	June 21 to June 27	June 22 to June 28
Leeds, Grenville & Lanark District Health Unit	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Middlesex-London Health Unit	84.4	70.4	57.1	47.8	50.0	44.4	51.6
Niagara Region Public Health	68.4	60.0	28.6	29.4	23.1	23.1	26.7
North Bay Parry Sound District Health Unit	91.3	91.7	95.7	95.6	95.7	97.7	97.1
Northwestern Health Unit	50.0	50.0	50.0	0.0	0.0	0.0	0.0
Ottawa Public Health	93.6	92.8	94.0	90.2	88.4	84.1	84.8
Peel Public Health	84.3	79.9	75.7	73.4	71.7	68.1	67.8
Peterborough Public Health	85.7	83.3	80.0	77.8	62.5	66.7	50.0
Porcupine Health Unit	97.8	97.8	97.7	97.7	97.1	100.0	100.0
Public Health Sudbury & Districts	94.7	96.4	96.6	96.8	95.2	94.4	93.8
Region of Waterloo Public Health and Emergency Services	31.5	20.3	7.1	3.6	4.3	4.6	5.0
Renfrew County and District Health Unit	100.0	100.0	100.0	100.0	100.0	0.0	100.0
Simcoe Muskoka District Health Unit	70.6	58.6	45.5	41.9	38.5	37.0	41.7
Southwestern Public Health	61.1	66.7	80.0	81.3	90.9	85.7	80.0
Thunder Bay District Health Unit	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Timiskaming Health Unit	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Public Health Unit Name	June 16 to June 22	June 17 to June 23	June 18 to June 24	June 19 to June 25	June 20 to June 26	June 21 to June 27	June 22 to June 28
Toronto Public Health	81.9	78.8	74.9	69.8	68.9	64.7	65.4
Wellington-Dufferin-Guelph Public Health	31.0	20.0	22.2	22.9	20.5	22.2	21.1
Windsor-Essex County Health Unit	87.0	90.0	81.3	75.0	77.8	75.0	66.7
York Region Public Health	70.4	70.8	63.8	53.7	44.7	43.9	45.0
TOTAL ONTARIO	**68.1**	**63.2**	**56.3**	**51.7**	**48.8**	**46.3**	**44.8**

Note: Data for calculating the number of cases tested for mutations common to VOCs or lineages using genomic analyses are obtained using information from the Laboratory object in CCM in addition to the data from the Investigation subtype field. Therefore, comparisons to counts using only information from the Investigation Subtype field may not align. The percent of cases due to a VOC may be higher than described in this report.
Percent positivity is based on the sum of the daily cases that test positive divided by the number of cases that were tested for mutations common to VOCs or lineages (e.g. those identified as 'Detected' or 'Not Detected') during the date ranges specified in each column.
Data Source: CCM

Citation

Ontario Agency for Health Protection and Promotion (Public Health Ontario). Epidemiologic summary: COVID-19 in Ontario – January 15, 2020 to July 3, 2021. Toronto, ON: Queen's Printer for Ontario; 2021.

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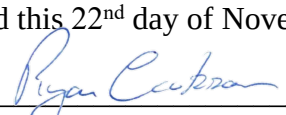
Ontario

This is **"Exhibit AA"**
to the Affidavit of David McKeown
affirmed this 22nd day of November, 2022



A Commissioner, etc.

Early release, published at www.cmaj.ca on April 7, 2021. Subject to revision.

RESEARCH

The mobility gap: estimating mobility thresholds required to control SARS-CoV-2 in Canada

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ABSTRACT

BACKGROUND: Nonpharmaceutical interventions remain the primary means of controlling severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) until vaccination coverage is sufficient to achieve herd immunity. We used anonymized smartphone mobility measures to quantify the mobility level needed to control SARS-CoV-2 (i.e., mobility threshold), and the difference relative to the observed mobility level (i.e., mobility gap).

METHODS: We conducted a time-series study of the weekly incidence of SARS-CoV-2 in Canada from Mar. 15, 2020, to Mar. 6, 2021. The outcome was weekly growth rate, defined as the ratio of cases in a given week versus the previous week. We evaluated the effects of average time spent outside the home in the previous 3 weeks using a log-normal regression model, accounting for province, week and mean temperature. We calculated the SARS-CoV-2 mobility threshold and gap.

RESULTS: Across the 51-week study period, a total of 888 751 people were infected with SARS-CoV-2. Each 10% increase in the mobility gap was associated with a 25% increase in the SARS-COV-2 weekly case growth rate (ratio 1.25, 95% confidence interval 1.20–1.29). Compared to the prepandemic baseline mobility of 100%, the mobility threshold was highest in the summer (69%; interquartile range [IQR] 67%–70%), and dropped to 54% in winter 2021 (IQR 52%–55%); a mobility gap was present in Canada from July 2020 until the last week of December 2020.

INTERPRETATION: Mobility strongly and consistently predicts weekly case growth, and low levels of mobility are needed to control SARS-CoV-2 through spring 2021. Mobility measures from anonymized smartphone data can be used to guide provincial and regional loosening and tightening of physical distancing measures.

The global toll of coronavirus disease 2019 (COVID-19) continues to grow, despite the promise of recently approved vaccines. A surge is occurring in many countries in the Northern Hemisphere, including Canada, that may take a considerable toll before vaccination is sufficiently widespread to achieve herd immunity. Nonpharmaceutical public health interventions, including physical distancing, remain the primary population-based means of controlling COVID-19.[1] Since early in the second wave, which started in September 2020, polling has suggested that most people in Canada have supported and adhered to government-directed restrictions,[2] and many favour strengthened measures to control community transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the causative viral agent of COVID-19.[3]

SARS-CoV-2 is spread primarily through close contact with people who are infected.[4] As with any infectious disease, contact rates are a primary driver of SARS-CoV-2 transmission.[5] Mobility measures capturing human activity through anonymized tracking of smartphones are believed to be reasonable proxies of contact rates outside of one's own home; these measures can provide more timely and reliable sources of information on contact rates compared with time-use surveys or contact tracing.[6–8]

Aggregated smartphone mobility data are provided by a number of software developers and have been used to quantify the impact of policy on mobility in Canada,[9] the effectiveness of lockdowns aiming to reduce the spread of SARS-CoV-2[10–12] and loopholes from excessively localized measures.[13] Mobility metrics are helpful for gauging the effect of restrictions on behaviour, but do

not, on their own, show decision-makers whether restrictions in place at the time are sufficient to curtail the spread of SARS-CoV-2. In this study, we evaluated the association between smartphone mobility measures and the spread of SARS-CoV-2 in Canada, both nationally and provincially, between March 2020 and March 2021. We also sought to quantify the mobility level needed to control COVID-19 (i.e., the mobility threshold), and the difference between observed mobility levels and the threshold (i.e., the mobility gap). We hypothesized that lower mobility levels may be needed in provinces with larger urban populations in the winter compared with more rural provinces in the summer.[14]

Methods

Study design

We conducted a time-series study of the impact of mobility on weekly SARS-CoV-2 incidence in Canada between Mar. 15, 2020, and Mar. 6, 2021. The study was conducted at both the national and provincial levels. For analyses at the provincial level, only weeks with an incidence greater than 20 cases in the previous week were included, because incidence rates during weeks with small case counts are likely to be considerably affected by importation and sporadic outbreaks. Based on visual inspection of model fit, we included only provinces or territories for which at least 50% of weeks were eligible for inclusion in the province-level analyses, to ensure that province-specific estimates were accurate. When several disjoint segments of eligible weeks from the same province were eligible, we included the longest segment.

Outcome

We measured the weekly case counts and test positivity for SARS-CoV-2 in each province using data from the COVID-19 Canada Open Data Working Group[15] in the 51-week period from Mar. 15, 2020, to Mar. 6, 2021. Outcomes were aggregated by week in order to control for daily patterns evident in Canadian case reporting data.[16] The Open Data Working Group obtains and compiles daily case counts reported across the country by provincial public health agencies, accredited news media and official social media accounts. Weeks were defined as starting on Sunday and ending on Saturday.

Because we hypothesized that mobility would impact SARS-CoV-2 dynamics in terms of changes in rates, rather than absolute levels of infection, our outcome was the weekly growth rate, measured as the ratio of SARS-CoV-2 cases in a given week divided by the number of SARS-CoV-2 cases in the previous week. A weekly growth rate equal to 1 meant that incidence was stable relative to the previous week, and a weekly growth rate greater than 1 meant that cases increased. Because surveillance data are subject to time-varying underdetection, we developed a corrected growth rate, equal to the weekly growth rate of cases multiplied by the weekly growth rate of test positivity.

Mobility measures

Province-level smartphone mobility data were drawn from open-source Google Community Mobility Reports,[17] which are updated daily. These data are collected from select users of Google Maps who have enabled the location history setting, which is turned off by default. The primary exposure of interest was the average time spent outside of home in the previous 3-week period, which has been validated and is a strong indicator of the introduction and lifting of nonpharmaceutical public health interventions.[18] This lag period was chosen based on a 10-day buffer around the known peak correlation between mobility and case growth rate at 11 days.[12]

We defined the baseline level of the mobility measure as its median value during the 5-week period from Jan. 3 to Feb. 6, 2020, namely the 1-month period before the first confirmed case of community transmission in Canada (Mar. 5 in British Columbia) and before the first school closures in Canada (Mar. 15 in Ontario). We rescaled the Google residential mobility values (formula: $100 \times [1 - X/30]$; estimating that, in winter, Canadians spend 30% of time outside the home) so that levels in the baseline period represented 100%, with a range from 0% (no out-of-home mobility) to values greater than 100%.[8,9] For the purposes of plotting out-of-home mobility, we smoothed the index values using a penalized spline with a knot for each 2-week period,[19] and also superimposed a 7-day rolling average.

Covariates

In addition to mobility, we controlled for week and average temperature (degrees centigrade) in a 3-week lag period of the most populous city of each province, based on Environment Canada data.[20] For descriptive purposes, we grouped weeks in the same quarter together: March 2020, April–June 2020, July–September 2020, October–December 2020 and January–March 2021.

Analysis

We described the weekly case growth rates, positivity and nonresidential mobility levels across provinces and quarters with the median and interquartile range (IQR). We modelled the logarithm of weekly SARS-CoV-2 growth using a Gaussian regression model. Covariate coefficients from this model were exponentiated and represented growth rate ratios (GRRs). Factors with GRR values greater than 1 were associated with accelerating growth; factors with GRR values less than 1 were associated with decelerating growth. For the primary (uncorrected for test positivity) and secondary (corrected for test positivity) outcomes, we developed 2 regression models: an unadjusted model that included out-of-home mobility in the previous 3-week period and penalized spline for the week (with a knot for every 2-month period), and an adjusted model that also accounted for mean temperature in the previous 3 weeks as a linear covariate. All models were fit using the mgcv package in R (model details in Appendix 1, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.210132/tab-related-content).[19,21]

Using the adjusted model of the association between SARS-CoV-2 growth rate and mobility, we estimated the mobility threshold at which SARS-CoV-2 growth would cease to occur. The calculation of the mobility threshold is detailed in Appendix 1. We defined the mobility gap as the difference between the observed mobility and the mobility threshold. The mobility gap can be interpreted as the estimated incremental reduction in mobility that would have been needed to achieve control of SARS-CoV-2 growth rate in a given province in a given week.

Table 1: Weekly SARS-CoV-2 test positivity, case growth rates and mobility in Canada, Mar. 15, 2020, to Mar. 6, 2021

Level of analysis	No. of weeks	No. of cases	Median (IQR)			
			Test positivity, %*	Case growth rate	Positivity-corrected growth rate	Out-of-home mobility, % of baseline
Canada	51	888 751	3.7 (1.2–6.1)	1.0 (0.9–1.2)	1.1 (0.7–1.5)	61 (48–73)
Period						
March 2020	3	14 149	4.1 (2.7–5.6)	4.0 (3.0–4.7)	8.7 (6.1–11.3)	82 (71–89)
April–June 2020	13	92 650	3.9 (1.4–6.0)	1.0 (0.8–1.1)	0.8 (0.5–1.1)	40 (31–52)
July–September 2020	13	59 643	0.9 (0.8–1.1)	1.2 (1.0–1.3)	1.3 (1.0–1.7)	75 (73–77)
October–December 2020	13	423 081	5.9 (4.0–6.3)	1.1 (1.0–1.2)	1.3 (1.1–1.4)	65 (60–67)
January–March 2021	9	299 228	4.5 (3.7–6.2)	0.9 (0.8–1.0)	0.8 (0.7–0.9)	48 (45–50)
Provinces						
Alberta	51	135 498	2.1 (1.1–4.6)	1.1 (0.9–1.4)	1.0 (0.7–1.9)	63 (52–78)
British Columbia	51	83 034	2.3 (1.2–5.6)	1.0 (0.9–1.3)	1.0 (0.9–1.5)	62 (56–73)
Manitoba	32	31 785	5.7 (2.1–9.4)	1.0 (0.8–1.4)	1.1 (0.7–1.8)	64 (52–82)
Ontario	51	311 810	2.3 (0.9–3.8)	1.1 (0.9–1.2)	1.1 (0.7–1.4)	57 (40–66)
Quebec	50	289 583	9.1 (2.3–14.7)	1.0 (0.8–1.2)	1.0 (0.6–1.6)	60 (45–73)

Note: IQR = interquartile range, SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2.
*Two missing weeks for test positivity at the national level (n = 49) and 10 missing weeks at the provincial level (n = 269).

To enable model comparison, we measured several model diagnostics, including the Pearson residual autocorrelation at 1 week of lag, the model R^2 (1 – $\text{deviance}_{\text{model}}/\text{deviance}_{\text{null}}$), the estimated model degrees of freedom (taking penalties into consideration) and the model Akaikes' Information Criterion (AIC; equal to the sum of the model deviance plus the model degrees of freedom), a measure of model fit where smaller values indicate more parsimonious and better-fitting models.

Ethics approval

All data used in this study were in the public domain; therefore the study was exempt from review by the University of Toronto Research Ethics Board.

Results

Across the 51-week period (Mar. 15, 2020, to Mar. 6, 2021), there were 888 751 cases of SARS-CoV-2 in Canada (Table 1). All cases were included in the national analysis, and 881 009 (99.1%) were included in the province-level analyses, which included 279 eligible province-weeks. Ontario (n = 311 810) and Quebec (n = 289 583) had the highest number of eligible SARS-CoV-2 cases.

Across Canada, out-of-home mobility dropped rapidly in March 2020 to reach a low of 23% in the week of April 5 (Figure 1). Mobility increased through the summer of 2020 and reached levels approaching baseline in the week of August 23 (78%), and then decreased slowly through the fall months and rapidly in December 2020. Manitoba was unique, with mobility levels dropping comparatively more than other provinces during the fall of 2020.

Mobility and SARS-CoV-2 growth rate

In the national model, adjusting for both date and temperature effects, each 10% increase in mobility was associated with a 25% increase in the weekly growth rate (adjusted GRR 1.25 per 10% increase in mobility, 95% confidence interval [CI] 1.20–1.29) (Table 2 and Figure 2). Increases in mean weekly temperature were significantly associated with decreased SARS-CoV-2 growth rates (GRR 0.83 per 5°C increase, 95% CI 0.75–0.93). Model diagnostics indicated low levels of residual autocorrelation (Pearson correlation, adjusted model = 0.15), and that model fit was strong (R^2, adjusted model = 81.6%). The positivity-corrected outcome was missing for 2 weeks, leaving 49 weeks in the analysis. Results were similar with this outcome (adjusted GRR 1.35 per 10% increase in mobility, 95% CI 1.17–1.55), though overall model fit was worse (R^2 = 56.2%)

In provincial-level analyses, adjusting for both date and temperature effects, each 10% increase in mobility was associated with a 20% increase in the weekly growth rate (adjusted GRR 1.20, 95% CI 1.16–1.24), and increasing temperature was associated with lower growth rates (GRR 0.88 per 5°C increase in temperature, 95% CI 0.86–0.91). Model fit for the provincial level models was weaker (R^2, adjusted model = 38.2%). The positivity-corrected outcome was missing for 10 weeks, leaving 269 province-weeks in the analysis. A strong association between mobility and the positivity-corrected growth rate was also apparent (adjusted GRR 1.29 per 10% increase in mobility, 95% CI 1.21–1.38).

Mobility threshold and mobility gap

We used the adjusted national and provincial models to measure the mobility threshold (Figure 3). The national mobility threshold

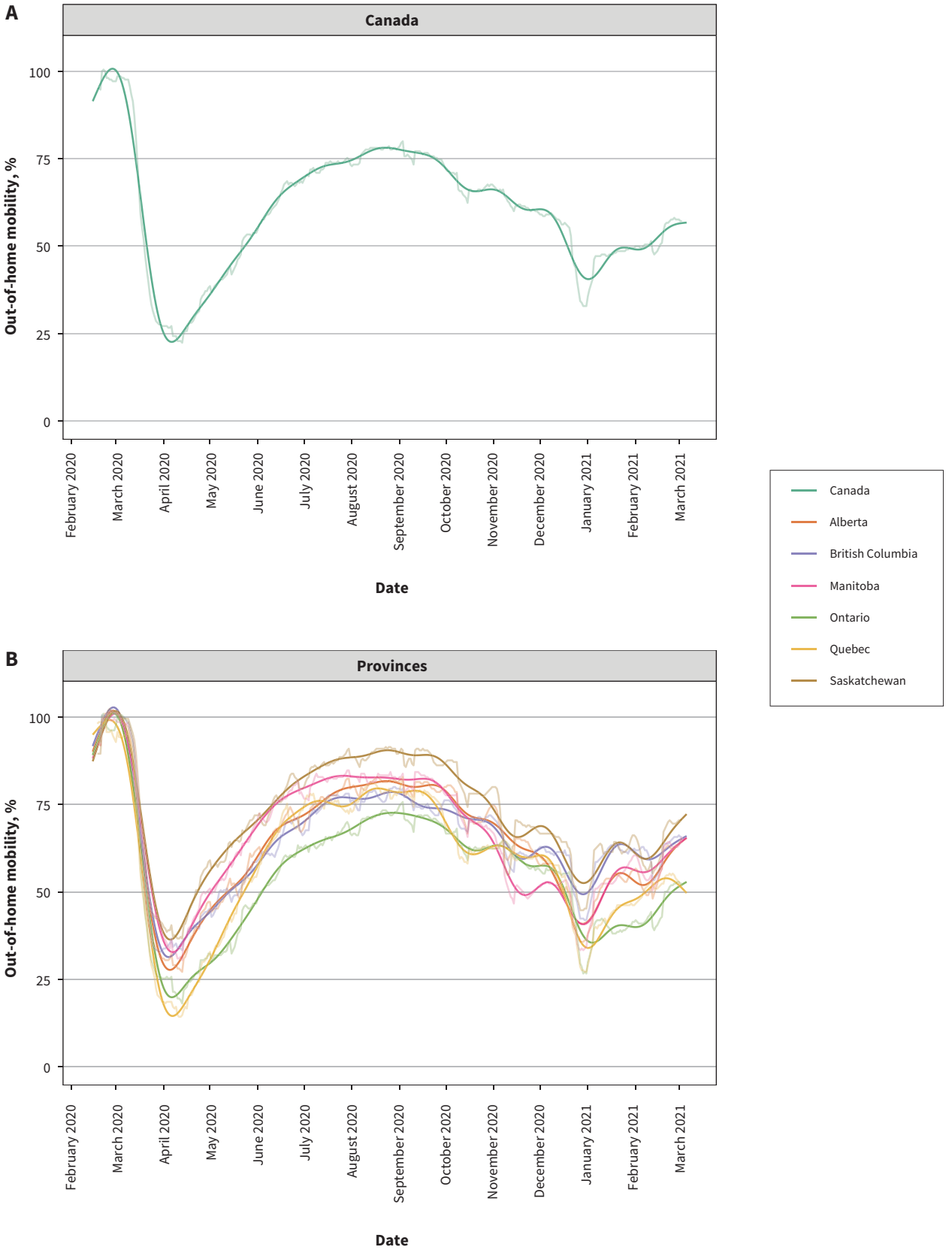

Figure 1: Out-of-home mobility (A) across Canada and (B) in 6 Canadian provinces, Feb. 5, 2020, to Mar. 6, 2021. Note: The out-of-home mobility index is a measure of the average amount of time spent outside the home, based on smartphone mobility data (the index is scaled so that levels in the baseline period from Jan. 3 to Feb. 6, 2020, represent 100%). The index values are smoothed using a penalized spline with a knot for each 2-week period (bold line) and are superposed with a 7-day rolling average (pale line).

Table 2: Factors influencing SARS-CoV-2 weekly growth rates and positivity-corrected growth-rates, across Canada, Mar. 15, 2020, to Mar. 6, 2021

	National level* *n* = 51		Provincial level* *n* = 279	
Variable	**Unadjusted†**	**Adjusted‡**	**Unadjusted†**	**Adjusted‡**
Weekly growth rate				
Coefficients, GRR (95% CI)				
Mean out-of-home mobility in previous 3-week period, per 10% increase	1.19 (1.13–1.24)	1.25 (1.20–1.29)	1.16 (1.12–1.20)	1.20 (1.16–1.24)
Temperature, per 5°C increase		0.83 (0.75–0.93)		0.88 (0.86–0.91)
Model characteristics				
Residual autocorrelation	0.14	0.15	0.20	0.09
Model complexity (degrees of freedom)	7.8	7.5	23.9	15.6
Goodness-of-fit, R^2 (%)	81.8	81.6	33.3	38.2
Model fit criterion (AIC)	−28.8	−28.9	242.1	204.1
Positivity-corrected weekly growth rate				
Coefficients, GRR (95% CI)				
Mean out-of-home mobility in previous 3-week period, per 10% increase	1.27 (1.10–1.47)	1.35 (1.17–1.55)	1.13 (1.08–1.19)	1.29 (1.21–1.38)
Temperature, per 5°C increase		0.73 (0.56–0.94)		0.89 (0.84–0.94)
Model characteristics				
Residual autocorrelation	0.04	0.03	0.15	0.10
Model complexity (degrees of freedom)	7.8	8.2	3.0	15.0
Goodness-of-fit, R^2 (%)	54.4	56.2	9.7	15.6
Model fit criterion (AIC)	34.6	33.3	509.0	490.5

Note: AIC = Akaike's Information Criterion (lower is better), CI = confidence interval, GRR = growth rate ratio, SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2.
*Positivity-corrected weekly growth models are missing 2 weeks for test positivity at the national level (*n* = 49) and missing 10 weeks at the provincial level (*n* = 269).
†The unadjusted model included out-of-home mobility in the previous 3 weeks and a penalized spline for the week.
‡The adjusted model included out-of-home mobility in the previous 3 weeks, a penalized spline for the week and mean temperature in the previous 3 weeks.

varied markedly through the pandemic period and was highest in the summer (median 71%, IQR 69%–72%), and dropped throughout the fall to 54% (IQR 52%–55%) in the winter. Variations across provinces in the estimated mobility threshold were also apparent; Ontario (50%, IQR 46%–59%) and Quebec (54%, IQR 52%–63%) had the lowest thresholds.

The mobility gap in Canadian provinces passed through distinct phases over the course of the pandemic (Figure 3). At the onset of the pandemic in March 2020, out-of-home mobility was in excess of the mobility threshold. Strict lockdown measures led to rapid declines in mobility below the threshold and control of the SARS-CoV-2 growth rate (April–May). Easing of lockdown measures in the late spring coincided with increasing mobility thresholds, but mobility soon increased to exceed the threshold needed to control SARS-CoV-2 in the summer of 2020. Mobility thresholds decreased throughout the fall and mobility remained above the threshold, coinciding with surging case counts. In November 2020, Manitoba markedly reduced mobility to levels below the mobility threshold, but mobility in Canada dropped below the threshold only in the last week of December.

Interpretation

Our evaluation of predictors of weekly SARS-CoV-2 growth rates across Canada shows that reductions in mobility strongly predict future control of SARS-CoV-2 growth rates in the subsequent 3-week period, and suggests that more substantial reductions in mobility were required to control transmission of SARS-CoV-2 through the fall of 2020. We developed measures of the estimated mobility level required to achieve SARS-CoV-2 control in Canada (the mobility threshold), and the estimated mobility reduction required to control SARS-CoV-2 growth (the mobility gap).

This study builds on work showing strong associations between physical distancing measures and the incidence of SARS-CoV-2.[11,22,23] Studies using smartphone mobility measures show that changes in mobility specifically predict SARS-CoV-2 incidence in the subsequent 1–3 weeks.[12] More detailed mobility data suggest that dine-in restaurants, take-out services (likely representing risk for workers more than customers), gyms and cafés are particularly important drivers of SARS-CoV-2 incidence in the United States.[24] A mobility threshold necessary to control

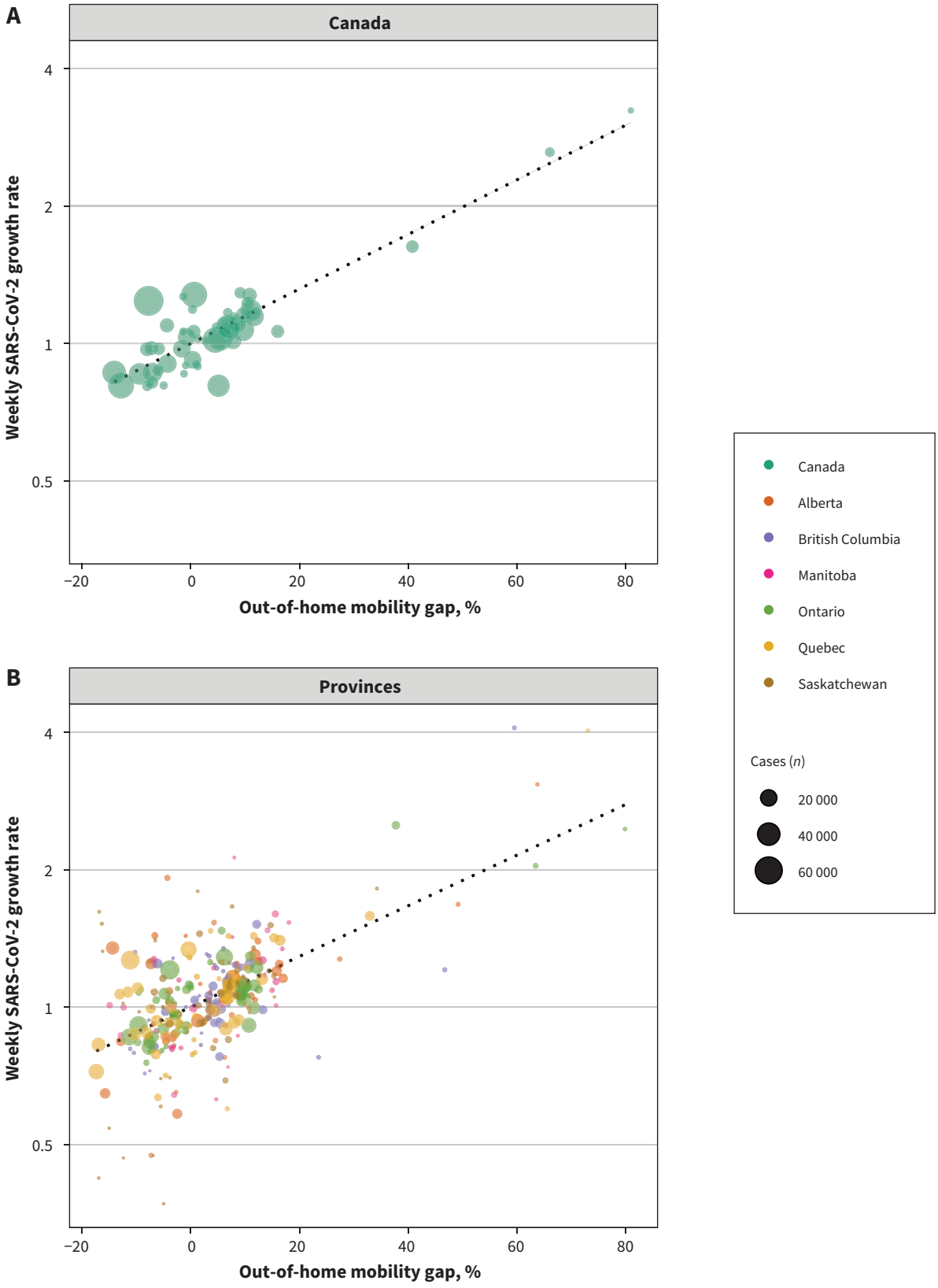

Figure 2: Adjusted-association between out-of-home mobility and severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) growth rate across 6 Canadian provinces, Mar. 15, 2020, to Mar. 6, 2021. Weekly SARS-CoV-2 growth rate (cases in given week/cases in previous week) is strongly associated with the out-of-home mobility in the prior 3-week period. In the adjusted Canada-level analysis, each 10% increase in out-of-home mobility was associated with a 25% increase in the growth rate (growth rate ratio [GRR] 1.25, 95% confidence interval [CI] 1.20–1.29). In the adjusted province-level analysis, each 10% increase in mobility was associated with a 20% increase in the growth rate ratio (GRR 1.20, 95% CI 1.16–1.24). These associations are represented by the dotted lines.

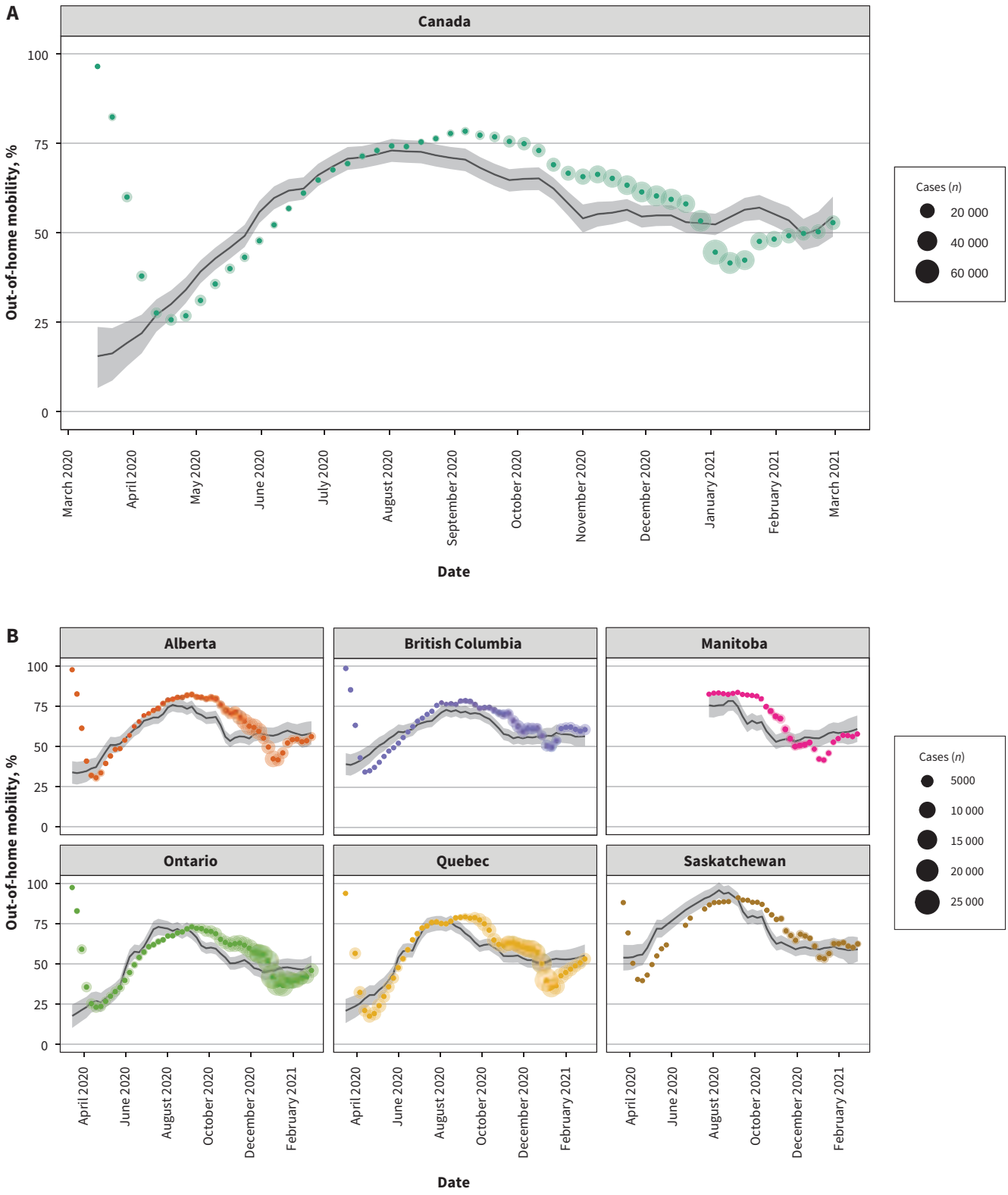

Figure 3: Variation in 3-week rolling average of mobility (coloured points) and the estimated mobility threshold (black line) and 80% confidence intervals (shaded region) for (A) Canada and (B) 6 Canadian provinces. Size of circles is proportional to the number of cases in a given week. Note: The mobility threshold is the estimated level of mobility needed to control severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) case growth. This threshold is highest in summer and is lowest in the most populated provinces, particularly in Ontario (median 50%) and Quebec (median 54%). When mobility decreased below the mobility threshold in spring 2020 and winter 2021, weekly SARS-CoV-2 case counts decreased. In late November 2020, Manitoba was the only province that successfully crossed the mobility threshold, which led to reductions in SARS-CoV-2 case growth. Other provinces attained this only in late December 2020 or early January 2021.

SARS-CoV-2 spread can be measured.[25] We have shown that the mobility reductions required are seasonally dependent — relatively small reductions were required to control SARS-CoV-2 in the summer of 2020, but larger mobility reductions have been needed since the fall.

As with several respiratory pathogens,[26,27] we observed substantial seasonal variation in the risk of SARS-CoV-2 infection. Substantial controversy remains as to the underlying drivers of the increased incidence in the winter. Hypotheses include human behavioural factors, particularly the increased time spent in poorly ventilated indoor environments, increased virus survival in winter climatic conditions (in particular, decreased absolute humidity)[28] and factors related to the immune system.[26]

Our work suggests that if governments and public health agencies wish to suppress community transmission of SARS-CoV-2 through the spring of 2021, before vaccination is widespread, stringent nonpharmaceutical interventions may be necessary. Manitoba, which lowered mobility sufficiently to achieve control of SARS-CoV-2 in the fall, did so by moving the entire province into the most stringent lockdown level on Nov. 12, 2020. Measures included restricting private gatherings to 5 persons, closing nonessential businesses and in-restaurant dining[29] and increasing enforcement (almost $1 million in fines given out by early January 2021).[30,31]

Limitations

We did not examine granular patterns of mobility within provinces, limiting potential insights into the effectiveness of the regional approaches pursued in some provinces. We used comparative measures of mobility relative to levels in January 2020 rather than absolute counts, which added to the complexity of interprovincial comparisons. Further, the Google Community Mobility Reports may not be representative of the Ontario population as a whole, and the data compiled by the Canadian Open Data Working Group have not been formally validated. The SARS-CoV-2 growth rates that we observed may be temporally dependent, which could lead to underestimation of coefficient standard errors; model diagnostics suggested that autocorrelation was weak. Weather was crudely measured based on the most populous city of the province. We considered only a limited number of potential confounding variables and did not control for SARS-CoV-2 vaccination levels. Vaccines were first administered in Canada on Dec. 14, 2020, and remain well below herd immunity levels as of March 2021. As vaccination rates increase, this could be embedded into models of the predicted mobility threshold. Meanwhile, the rapidly spreading variants arising from the United Kingdom and South Africa[32] may need a lower mobility threshold to control the spread of SARS-CoV-2.

Conclusion

This study shows that mobility strongly predicts the growth rate of SARS-CoV-2 up to 3 weeks in the future, and that stringent measures will continue to be necessary through spring 2021 in Canada. The mobility threshold and mobility gap can be used by public health officials and governments to estimate the level of restrictions needed to control the spread of SARS-CoV-2 and guide, in real-time, the implementation and intensity of nonpharmaceutical public health interventions to control the COVID-19 pandemic.

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Competing interests: Kevin Brown, Nathan Stall and Peter Jüni are affiliated with the Ontario COVID-19 Science Advisory Table. Peter Jüni serves as an upaid member of the steering group of trials funded by Appili Therapeutics, AstraZeneca, Biotronik, Biosensors, Eli Lilly, St. Jude Medical and The Medicines Company, and has participated in advisory boards or consulted with Amgen, Ava and Fresenius, outside the submitted work. No other competing interests were declared.

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Contributors: Kevin Brown conceived and designed the work. Kevin Brown, Jean-Paul Soucy and Isha Berry acquired the data, which Kevin Brown analyzed and interpreted. Kevin Brown drafted the manuscript, which all authors revised critically for important intellectual content, gave final approval of the version to be published and agreed to be accountable for all aspects of the work.

Data sharing: All data used in this study are in the public domain. Mobility data are available at https://www.google.com/covid19/mobility/. Incidence data are available at https://opencovid.ca/. Data are also available upon request.

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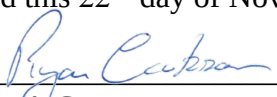

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NEWS RELEASE

Ontario Implements Provincewide Emergency Brake

All 34 Public Health Unit Regions to Move into Shutdown

April 01, 2021
Office of the Premier

TORONTO —The Ontario government, in consultation with the Chief Medical Officer of Health and other health experts, is imposing a provincewide emergency brake as a result of an alarming surge in case numbers and COVID-19 hospitalizations across the province. The provincewide emergency brake will be effective Saturday, April 3, 2021, at 12:01 a.m. and the government intends to keep this in place for at least four weeks.

Details were provided today by Premier Doug Ford, Christine Elliott, Deputy Premier and Minister of Health, Dr. David Williams, Chief Medical Officer of Health, and Dr. Adalsteinn (Steini) Brown, Co-Chair of the Ontario COVID-19 Science Advisory Table.

"We are facing a serious situation and drastic measures are required to contain the rapid spread of the virus, especially the new variants of concern," said Premier Ford. "I know pulling the emergency brake will be difficult on many people across the province, but we must try and prevent more people from getting infected and overwhelming our hospitals. Our vaccine rollout is steadily increasing, and I encourage everyone who is eligible to get vaccinated. That is our best protection against this deadly virus."

Ontario's key indicators and latest modelling show that additional measures must be taken. From March 26 to 28, 2021, provincial case rates have increased by 7.7 per cent to 101.1 cases per 100,000 people. Current COVID-19 related ICU admissions are already over the peak of wave two and hospitals in regional hotspots will need to further ramp down scheduled surgeries. COVID-19 related ICU admissions are projected to exceed 650 beds in a few weeks. These increases are being driven by COVID-19 variants, which are transmitted easily and result in a higher risk of death and hospitalization, including in younger populations.

The provincewide emergency brake would put in place time-limited public health and workplace safety measures to help to stop the rapid transmission of COVID-19 variants in communities, protect hospital capacity and save lives. Measures include, but are not limited to:

- Prohibiting indoor organized public events and social gatherings and limiting the capacity for outdoor organized public events or social gatherings to a 5-person maximum, except for gatherings with members of the same household (the people you live with) or gatherings of members of one household and one other person from another household who lives alone.
- Restricting in-person shopping in all retail settings, including a 50 per cent capacity limit for supermarkets, grocery stores, convenience stores, indoor farmers' markets, other stores that primarily sell food and pharmacies, and 25 per cent for all other retail including big box stores, along with other public health and workplace safety measures;
- Prohibiting personal care services;
- Prohibiting indoor and outdoor dining. Restaurants, bars and other food or drink establishments will be permitted to operate by take-out, drive-through, and delivery only;
- Prohibiting the use of facilities for indoor or outdoor sports and recreational fitness (e.g., gyms) with very limited exceptions;
- Requiring day camps to close; and,
- Limiting capacity at weddings, funerals, and religious services, rites or ceremonies to 15 per cent occupancy per room indoors, and to the number of individuals that can maintain two metres of physical distance outdoors. This does not include social gatherings associated with these services such as receptions, which are not permitted indoors and are limited to five people outdoors.

On the advice of the Chief Medical Officer of Health, all Ontarians are asked to limit trips outside the home to necessities such as food, medication, medical appointments, supporting vulnerable community members, or exercising outdoors with members of their household. Employers in all industries should make every effort to allow employees to work from home.

"Ontario, like many other provinces and jurisdictions around the world, is in the third wave of the COVID-19 pandemic and immediate action is required to help turn the tide," said Christine Elliott, Deputy Premier and Minister of Health. "Implementing a provincewide emergency brake was not an easy decision to make and is not one we take lightly. As we continue to vaccinate more Ontarians, the end is in sight, but right now these necessary measures will help to stop the spread of variants in our communities, protect capacity in our health care system, and save lives."

The current *COVID-19 Response Framework: Keeping Ontario Safe and Open*, will be paused when the provincewide emergency brake comes into effect. The impacts of these time-limited measures will be evaluated throughout the next four weeks to determine if it is safe to lift any restrictions or if they need to be extended. With more than $1.6 billion invested to protect against COVID-19, schools remain safe for students and staff. Keeping schools open is critical to the mental health and well-being of Ontario youth. During the emergency shutdown, schools will remain open for in-person learning with strict safety measures in place. The spring break will continue as planned for the week of April 12. In order to support working families, child care will remain open during the shutdown. Child care settings will continue to adhere to stringent health and safety measures so that they remain safe places for children and staff.

"In the last few weeks a significant increase in COVID-19 cases and variants of concern has been observed across Ontario which has put considerable strain on our public health and health care systems," said Dr. David Williams, Chief Medical Officer of Health. "Implementing a provincewide shutdown is needed to bring the third wave of this pandemic under control so that we can save lives, keep our education system open and allow our vaccination program to take hold."

Quick Facts

- Based on the latest modelling data, variants of concern are continuing to grip the province and drive this third wave of the pandemic. Case rates are rising, younger Ontarians are becoming sicker and ICU capacity is at risk of becoming overwhelmed without stronger public health and workplace safety measures in place.
- The 2021 Budget, *Ontario's Action Plan: Protecting People's Health and Our Economy*, brings the government's total investments to protect the economy to $23.3 billion. This includes an estimated $3.4 billion to support approximately 120,000 small businesses across Ontario via two rounds of the Ontario Small Business Support Grant. Applications for the Ontario Small Business Support Grant have been extended for one week through April 7 and all eligible businesses are encouraged to apply.
- Additionally, the new Ontario Tourism and Hospitality Small Business Support Grant will provide an estimated $100 million in one-time payments of $10,000 to $20,000 to eligible small businesses in the tourism and hospitality sector. Businesses required to close or significantly restrict services due to provincial public health measures can continue to apply for property tax and energy cost rebates. Visit Ontario.ca/COVIDsupport for more information on Ontario's supports for businesses.
- To ensure that every person who requires care in a hospital can access a bed, the government has invested more than $5.1 billion to support hospitals since the start of the pandemic, creating more than 3,100 additional hospital beds and 500 critical care and high intensity medicine beds. This includes $1.8 billion in 2021–22 to continue providing care for COVID-19 patients, addressing surgical backlogs and keeping pace with patient needs through its *Ontario's Action Plan: Protecting People's Health and Our Economy.*
- The province continues to deploy rapid testing in workplaces, including up to 300,000 COVID-19 tests per week for asymptomatic staff in key sectors such as manufacturing, warehousing, supply chain, mining, construction and food processing. More than 4.7 million rapid antigen tests have been sent to over 1,150 workplaces, including 89 essential industry sites, under the Provincial Antigen Screening Program.
- The Ontario government continues to implement its High Priority Communities Strategy to provide targeted supports to communities hardest hit by COVID-19. In these communities 1,000 Community Ambassadors have been mobilized, 30 community testing sites have been opened and nearly 36,000 PPE kits have been distributed to community members.
- Get tested if you have COVID-19 symptoms, or if you have been advised of exposure by your local public health unit or through the COVID Alert App. Visit Ontario.ca/covidtest to find the nearest testing location.
- Emergency orders O. Reg. 55/21 (Compliance Orders for Retirement Homes) and O. Reg. 8/21 (Enforcement of COVID-19 Measures) currently in force, under the Emergency Management and Civil Protection Act, have been extended until April 19, 2021, as the province continues to deal with the impacts of COVID-19.

Additional Resources

- 2021 Budget - Ontario's Action Plan: Protecting People's Health and Our Economy

- The Digital Main Street program helps main street businesses build their online presence and reach more customers.
- Property Tax and Energy Cost Rebates
- Visit Ontario's COVID-19 vaccine web page to view the latest provincial data and information on COVID-19 vaccines.
- Visit Ontario's COVID-19 information website to learn more about how the province continues to protect the people of Ontario from the virus.
- For public inquiries call ServiceOntario, INFOline at 1-866-532-3161 (Toll-free in Ontario only)

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This is **"Exhibit CC"**
to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022

A Commissioner, etc.

NEWS RELEASE

Ontario Enacts Provincial Emergency and Stay-at-Home Order

Additional measures needed to protect health system capacity and save lives during third wave of COVID-19

April 07, 2021
Office of the Premier

TORONTO — The Ontario government, in consultation with the Chief Medical Officer of Health and other health experts, is immediately declaring a third provincial emergency under s 7.0.1 (1) of the *Emergency Management and Civil Protection Act* (EMPCA). These measures are being taken in response to the rapid increase in COVID-19 transmission, the threat on the province's hospital system capacity, and the increasing risks posed to the public by COVID-19 variants.

Details were provided today by Premier Doug Ford, Christine Elliott, Deputy Premier and Minister of Health, Solicitor General Sylvia Jones, and Dr. David Williams, Chief Medical Officer of Health.

"The COVID-19 situation is at a critical stage and we must act quickly and decisively to stay ahead of these deadly new variants," said Premier Ford. "By imposing these strict new measures we will keep people safe while allowing our vaccination program to reach more people, starting with our high risk population and identified hot spots. Although this is difficult, I urge everyone to follow these public health measures and together we will defeat this deadly virus."

Case rates, hospitalizations, and ICU occupancy are increasing rapidly, threatening to overwhelm the health care system. The number of COVID-19 hospitalizations in the province have increased by 28.2 per cent between the period of March 28 and April 5, 2021. In addition, between March 28 and April 5, 2021, Ontario has seen the number of COVID-19 patients in intensive care escalate by 25 per cent. While every action possible is being taken to increase capacity and continue daily surgeries and procedures, the province is reaching a tipping point.

Effective Thursday, April 8, 2021 at 12:01 a.m., the government is issuing a province-wide Stay-at-Home order requiring everyone to remain at home except for essential purposes, such as going to the grocery store or pharmacy, accessing health care services (including getting vaccinated), for outdoor exercise , or for work that cannot be done remotely. As Ontario's health care capacity is threatened, the Stay-at-Home order, and other new and existing public health and workplace safety measures will work to preserve public health system capacity, safeguard vulnerable populations, allow for progress to be made with vaccinations and save lives.

Retail

In addition, the province is also strengthening public health and workplace safety measures for non-essential retail under the provincewide emergency brake. Measures include, but are not limited to:

- Limiting the majority of non-essential retailers to only operate for curbside pick-up and delivery, via appointment, between the hours of 7 a.m. and 8 p.m., with delivery of goods to patrons permitted between 6:00 am and 9:00 pm, and other restrictions;
- Restricting access to shopping malls to limited specified purposes, including access for curbside pick-up and delivery, via appointment, with one single designated location inside the shopping mall, and any number of designated locations outside the shopping mall, along with other restrictions;
- Restricting discount and big box stores in-person retail sales to grocery items, pet care supplies, household cleaning supplies, pharmaceutical items, health care items, and personal care items only;
- Permitting the following stores to operate for in-person retail by appointment only and subject to a 25 per cent capacity limit and restricting allowable hours of operation to between 7 a.m. and 8 p.m. with the delivery of goods to patrons permitted between 6 a.m. and 9 p.m.:
    - Safety supply stores;
    - Businesses that primarily sell, rent or repair assistive devices, aids or supplies, mobility devices, aids or supplies or medical devices, aids or supplies;

    - Rental and leasing services including automobile, commercial and light industrial machinery and equipment rental;
    - Optical stores that sell prescription eyewear to the public;
    - Businesses that sell motor vehicles, boats and other watercraft;
    - Vehicle and equipment repair and essential maintenance and vehicle and equipment rental services; and
    - Retail stores operated by a telecommunications provider or service, which may only permit members of the public to enter the premises to purchase a cellphone or for repairs or technical support.
- Permitting outdoor garden centres and plant nurseries, and indoor greenhouses that engage in sales to the public, to operate with a 25 per cent capacity limit and a restriction on hours of operation to between 7 a.m. and 8 p.m.

These additional and strengthened public health and workplace safety measures will be in effect as of Thursday, April 8, 2021 at 12:01 a.m.

Education

Keeping schools and child care open is critical to the mental health and well-being of Ontario children and youth. Schools and child care will remain open for in-person care and learning in public health regions where it is permitted, with strict safety measures in place.

In addition, beginning next week, education workers who provide direct support to students with special education needs across the province, and all education workers in select hot spot areas, will be eligible to register for vaccination. Vaccinations will commence during the April break starting with priority neighborhoods in Toronto and Peel, then rolling out to priority neighborhoods in other hot spot regions, including York, Ottawa, Hamilton, Halton and Durham. This will be followed by a rollout across the province as supply allows.

"While our government took decisive action by implementing the provincewide emergency brake, more needs to be done to protect against the threats to our health system resources and the continued health and safety of individuals and families across the province," said Christine Elliott, Deputy Premier and Minister of Health. "By further strengthening public health and workplace safety measures, we can work to reduce transmission of the virus while we work to rollout Phase 2 of our vaccine distribution plan, and put more needles in the arms of Ontarians."

"The rapid and increasing spread of COVID-19 and the variants of concern pose significant threats to our health care system and the well-being of Ontarians, requiring immediate and decisive action," said Solicitor General Sylvia Jones. "The declaration of a third provincial emergency is necessary to provide the government with the tools needed to help protect the public, reduce the spread of the virus and save lives."

Vaccinations

As part of Phase Two of its COVID-19 vaccine distribution plan, people living in regions with the highest rates of transmission will be prioritized to receive a vaccine, starting with the most at-risk in the Peel and Toronto public health regions. This initiative will be expanded to additional "hot spot" regions based on established patterns of transmission, severe illness, and mortality.

To support this expanded vaccination effort, mobile teams are being organized to administer vaccines in high-risk congregate settings, residential buildings, faith-based locations, and locations occupied by large employers in hot spot neighbourhoods to individuals aged 18 or over. Pop-up clinics will also be set-up in highly impacted neighborhoods, including at faith-based locations and community centres in those hot spots, in collaboration with public health units and community organizations within those communities. The province will provide additional resources to support these mobile and pop-up clinics in the hardest-hit neighbourhoods.

The government will also extend booking for COVID-19 vaccination appointments to more age groups through its provincial booking system, for public health regions with highly impacted neighbourhoods, on Friday, April 9, 2021. Booking eligibility will be extended to include individuals aged 50 and over for COVID-19 vaccination appointments at mass immunization clinics in high-risk areas as identified by postal code, using the provincial booking system.

Workplace Inspections

Health and safety inspectors and provincial offenses officers will increase inspections and enforcement at essential businesses in regional hot zones to continue protecting essential workers while on the job. There have been 19,500 COVID-related workplace inspections and investigations across the province since the beginning of 2021. During those visits, over 450 COVID-19 related tickets have been issued and OHS inspectors have issued over 14,446 OHS orders and stopped unsafe work related to COVID-19 a total of 24 times.

Rapid Testing

Rapid testing continues to be deployed in workplaces for asymptomatic staff in key sectors such as manufacturing, warehousing, supply chain, mining, construction and food processing. Approximately 5.4 million rapid antigen tests have been sent to over 1,150 workplaces, including 100 essential industry sites, under the Provincial Antigen Screening Program. To encourage the use of these tests under the program, additional outreach will occur to employers in regions with highest rates of transmission to increase access to testing, and the process for enrollment in the screening program will be streamlined to allow for quick access to these supports.

"As we continue to see COVID-19 variants of concern drive this third wave of COVID-19, it is evident stronger public health and workplace measures are needed to help interrupt the spread of the virus," said Dr. David Williams, Chief Medical Officer of Health. "By all of us staying at home, while still taking some time to enjoy the outdoors with the people we live with in our local neighbourhoods and maintaining two metres physical distance from others, we can reduce our mobility, minimize transmission, protect our loved ones and our communities, safeguard health system capacity, and save lives."

Quick Facts

- Over the past week, the province's positivity rate is 5.1 per cent, well above the high-alert threshold of 2.5 per cent, and as of April 6, 2021, there has been a total of 2,483 cases with one of the three variants of concern (VoC). The percent of cases in the last week that tested positive for a mutation or VOC was 63.1 per cent.
- On Saturday April 3, 2021, in response to an alarming surge in case numbers and COVID-19 hospitalizations across the province and in consultation with the Chief Medical Officer of Health, the government imposed a provincewide emergency brake, implementing additional time-limited public health and workplace safety measures, including encouraging remote work in all industries to the greatest extent possible and the closure of additional workplaces, further capacity limits on some essential businesses which are able to remain open, and strengthened advice on limiting trips outside of the home for essential reasons.
- On the advice of the Chief Medical Officer of Health, all Ontarians are asked to limit trips outside the home to necessities such as food, medication, medical appointments, supporting vulnerable community members, or exercising outdoors with members of their household in our their communities. Individuals should remain in their local communities and avoid all non-essential travel – even within the province – and to stay home when ill even with mild symptoms. Employers in all industries should make every effort to allow employees to work from home.
- To ensure that every person who requires care in a hospital can access a bed, the government has invested more than $5.1 billion to support hospitals since the start of the pandemic, creating more than 3,100 additional hospital beds and 500 critical care and high intensity medicine beds. This includes $1.8 billion in 2021–22 to continue providing care for COVID-19 patients, addressing surgical backlogs and keeping pace with patient needs through its Ontario's Action Plan: Protecting People's Health and Our Economy.
- The Ontario government continues to implement its High Priority Communities Strategy to provide targeted supports to communities hardest hit by COVID-19. In these communities 1,000 Community Ambassadors have been mobilized, 30 community testing sites have been opened and nearly 36,000 PPE kits have been distributed to community members.
- Get tested if you have COVID-19 symptoms, or if you have been advised of exposure by your local public health unit or through the COVID Alert App. Visit Ontario.ca/covidtest to find the nearest testing location.

Additional Resources

- Ontario Implements Provincewide Emergency Brake
- Ontario Moving to Phase Two of COVID-19 Vaccine Distribution Plan
- 2021 Budget - Ontario's Action Plan: Protecting People's Health and Our Economy
- The Digital Main Street program helps main street businesses build their online presence and reach more customers.
- Property Tax and Energy Cost Rebates
- Visit Ontario's COVID-19 communications resources web page for resources in multiple languages to help local communication efforts.
- Visit Ontario's COVID-19 vaccine web page to view the latest provincial data and information on COVID-19 vaccines.
- Visit Ontario's COVID-19 information website to learn more about how the province continues to protect the people of Ontario from the virus.
- For public inquiries call ServiceOntario, INFOline at 1-866-532-3161 (Toll-free in Ontario only).

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NEWS RELEASE

Ontario Releases COVID-19 Response Framework to Help Keep the Province Safe and Open

Government Provides Additional Details on $300 Million to Support Eligible Businesses

November 3, 2020
Office of the Premier

TORONTO — In consultation with the Chief Medical Officer of Health and other health experts, the Ontario government has developed the *Keeping Ontario Safe and Open Framework*. It ensures that public health measures are targeted, incremental and responsive to help limit the spread of COVID-19, while keeping schools and businesses open, maintaining health system capacity and protecting vulnerable people, including those in long-term care.

Details were provided today by Premier Doug Ford, Christine Elliott, Deputy Premier and Minister of Health, Rod Phillips, Minister of Finance, Peter Bethlenfalvy, President of the Treasury Board, and Dr. David Williams, Chief Medical Officer of Health.

"It's clear COVID-19 will be with us for a while, which is why we are putting in place a framework that will protect the health and safety of individuals and families, while avoiding broader closures across the province," said Premier Ford. "This framework, developed in consultation with our health experts, will serve as an early warning system allowing us to scale up and scale back public health restrictions on a regional or community basis in response to surges and waves of COVID-19. By introducing public health measures sooner, we can keep this deadly virus at bay, bend the curve and reclaim a little more of our normal lives."

The framework takes a gradual approach that includes introducing preventative measures earlier to help avoid broader closures and allow for additional public health and workplace safety measures to be introduced or removed incrementally. It categorizes public health unit regions into five levels: Green-Prevent, Yellow-Protect, Orange-Restrict, Red-Control, and Lockdown being a measure of last and urgent resort. Each level outlines the types of public health and workplace safety measures for businesses and organizations. These include targeted measures for specific sectors, institutions and other settings.

"The health and wellbeing of Ontarians is our number one priority. This framework, informed by public health experts, data and the experiences of other jurisdictions, is focused on introducing less invasive measures earlier to stop the spread of COVID-19," said Minister Elliott. "We are committed to being transparent with Ontarians, businesses and local communities as we work together to keep Ontarians safe, while keeping our economy open."

"This framework is critical to ensuring that public health measures are able to help slow the spread of the virus, while also supporting mental health and other social determinants of health," said Dr. Williams. "The framework operates like a dimmer switch, enabling measures and restrictions to be increased and give individuals and families the information they need to adjust their activities and interactions based on local epidemiological data."

As the province continues to expand access to real-time data, enhancements are also being made to Ontario.ca/coronavirus, Ontario's one-stop shop for information on COVID-19. Information about the spread of the virus, and public health and health system capacity will now be available on the website. This includes local cases by public health unit regions, the total number of cases, resolved cases, deaths, and tests completed and how many are positive. The province will continue to add data sets as they become available, such as sources of outbreaks as a subset of overall cases. This information will better help businesses, organizations and local communities access key information to prepare in advance for any changes in their region.

"You deserve to have access to the same information that we have, and that's why our government is enhancing online data and data visualization," said Minister Bethlenfalvy. "Greater transparency means that the people of Ontario have reliable access to the information they need to protect their health, and for businesses to reopen and operate safely. This is another way we're using technology and pursuing innovation to put the people at the centre of government and move Ontario onwards."

To provide the utmost transparency, each public health unit will be classified according to current framework indicators. Proposed classifications based on data for the week of October 26, 2020 can be found below. These will be confirmed by the province on Friday, November 6, 2020 and become effective on Saturday, November 7, 2020 at 12:01 a.m. Final decisions on moving public health unit regions into the framework will be made by the government based on updated data and in consultation with the Chief Medical Officer of Health, local medical officers of health and other health experts, and will be reviewed weekly.

Going forward, the government will continually assess the impact of public health measures applied to public health unit regions for 28 days, or two COVID-19 incubation periods.

Supporting Businesses Affected by COVID-19 Public Health Measures

The Ontario government is making $300 million available to businesses required to close or significantly restrict services in areas subject to modified Stage 2 public health restrictions (Ottawa, Peel, Toronto, and York Region) or, going forward, in areas categorized as Control or Lockdown.

Rebates will cover the period of time that businesses are required to temporarily close or significantly restrict services as a result of being located in areas subject to the targeted modified Stage 2 public health restrictions or, going forward, in areas categorized as Control or Lockdown.

Beginning November 16, 2020, eligible businesses will be able to apply for temporary property tax and energy cost rebates directly to the province through a single, online application portal. Many businesses should expect to receive their rebate payments within a few weeks of finalizing and submitting their completed application. Eligible businesses include restaurants, bars, gyms and cinemas.

"On Thursday, I'll introduce Ontario's 2020 Budget, the next phase of Ontario's Action Plan," said Minister Phillips. "It is a plan that will have three pillars. As we announced yesterday, the first is protect. The second pillar is support, because we know COVID-19 has brought severe challenges and economic difficulties to families and employers. Supporting businesses affected by necessary public health restrictions in regions experiencing a greater risk from COVID-19 is one way we are helping employers manage during these difficult times."

Through Ontario's Property Tax and Energy Cost Rebates program, the government is building on its efforts to ensure eligible businesses receive the financial help they need as a result of targeted provincial public health restrictions.

Public Health Unit Region Classifications

As of November 7, 2020, the province will transition public health unit regions to the new framework. The following proposed classifications for public health unit regions are based on data for the week of October 26, 2020. Updated data will be used for final review by the Chief Medical Officer of Health and approval by Cabinet on Friday, November 6, 2020.

Lockdown:

- No public health unit regions

Red-Control:

- No public health unit regions

Orange-Restrict:

- Eastern Ontario Health Unit;
- Ottawa Public Health;
- Peel Public Health;
- Toronto Public Health (may be delayed in entering Orange-Restrict level until November 14, 2020); and
- York Region Public Health.

Yellow-Protect:

- Brant County Health Unit;
- City of Hamilton Public Health Services;
- Durham Region Health Department; and
- Halton Region Public Health.

Green-Prevent:

- Algoma Public Health;
- Chatham-Kent Public Health;
- Grey Bruce Health Unit;
- Kingston, Frontenac and Lennox & Addington Public Health;
- Haliburton, Kawartha, Pine Ridge District Health Unit;
- Haldimand-Norfolk Health Unit;
- Hastings Prince Edward Public Health;
- Huron Perth Public Health;
- Lambton Public Health;
- Leeds, Grenville & Lanark District Health Unit;
- Middlesex-London Health Unit;
- Niagara Region Public Health;
- North Bay Parry Sound District;
- Northwestern Health Unit;
- Peterborough Public Health;
- Porcupine Health Unit;
- Public Health Sudbury & Districts;
- Region of Waterloo Public Health and Emergency Services;
- Renfrew County and District Health Unit;
- Simcoe Muskoka District Health Unit;
- Southwestern Public Health;
- Thunder Bay District Health Unit;
- Timiskaming Health Unit;
- Wellington-Dufferin-Guelph Public Health; and
- Windsor-Essex County Health Unit.

Quick Facts

- The Ontario government has developed a $2.8 billion COVID-19 fall preparedness plan, *Keeping Ontarians Safe: Preparing for Future Waves of COVID-19*, to ensure the province's health care, long-term care and education systems are prepared for the immediate challenges of the fall, including a second wave of COVID-19 and the flu season.
- If you are concerned you were exposed to COVID-19 or have symptoms, take the online COVID-19 self assessment.
- Get tested if you have symptoms compatible with COVID-19, or if you have been advised of exposure by your local public health unit or through the COVID Alert app. Visit Ontario.ca/covidtest to find the nearest testing location.
- Types of businesses that are eligible for support include restaurants and bars, bingo halls, gaming establishments, casinos, conference centres and convention centres, gyms, facilities for indoor sports and recreational fitness activities, community centres and multi-purpose facilities, museums, performing arts and cinemas and personal care services (with exception of oxygen bars) that were required to close or are subject to significant restrictions under modified Stage 2.
- Businesses that are not eligible are those that were already required to close prior to the introduction of modified Stage 2 public health restrictions, those that were not required to close or restrict services due to modified Stage 2 public health restrictions, and those who do not pay property taxes or energy costs.

Additional Resources

- Ontario Moving Additional Region to Modified Stage 2
- Ontario Implementing Additional Public Health Measures in Toronto, Ottawa and Peel Region
- Property Tax and Energy Cost Rebates
- Visit Ontario's website to learn more about how the province continues to protect the people of Ontario from COVID-19.

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Learn about the government services available to you and how government works. Learn more

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This is **"Exhibit EE"**
to the Affidavit of David McKeown,
affirmed this 22nd day of November, 2022

A Commissioner, etc.

NEWS RELEASE

Ontario Maintains COVID-19 Restrictions as Stay-at-Home Order is Set to Expire

Measures address ongoing risks as province prepares to safely and cautiously reopen

June 01, 2021
Solicitor General

TORONTO — As was previously announced, Ontario's Stay-at-Home order will expire on June 2, 2021. When it does, all other public health and workplace measures will remain in place provincewide until Ontario enters Step One of the Roadmap to Reopen, at which point some restrictions will ease with an initial focus on outdoor settings.

"We've seen great progress in our fight against COVID-19 in recent weeks, but now is not the time to let our guard down," said Solicitor General Sylvia Jones. "With the Stay-At-Home order set to expire, we need to provide people with certainty so that they can continue to follow public health guidance. Doing so will help us to meet our goal of starting to gradually lift some restrictions when we enter Step One of the Roadmap when it is safe to do so."

On April 7, 2021, in response to the rapid increase in COVID-19 transmission driven by new, more contagious variants, the Ontario government declared a provincial emergency and issued a Stay-at-Home order as well as enhanced public health measures. In a concentrated effort to reduce mobility and opportunities for transmission, the Stay-At-Home order required Ontarians to remain at home except for the purposes set out in the order, such as exercise, going to the grocery store or pharmacy, or accessing health care services. Once the Stay-at-Home order expires on June 2, these restrictions will no longer be in effect.

However, all other existing measures will remain in place provincewide, including restrictions on gatherings, businesses, services and activities. This includes limiting indoor gatherings to households only and outdoor gatherings to up to five people, subject to limited exceptions, maintaining a cap of 25 per cent capacity for essential retail where only certain goods are permitted to be sold, restricting non-essential retail to curbside pickup and delivery only, as well as limiting short-term rentals to individuals in need of housing and allowing Ontario Parks and campgrounds on public lands to be used for day-use only, subject to limited exceptions.

Ontarians will be able to leave home to travel within the province to a secondary residence for any reason, however, they are not be permitted to host members of another household indoors except for a person from another household who lives alone or a caregiver.

A simple, easy-to-understand summary of restrictions can be found on the province's "Reopening Ontario" webpage, which provides details on what public health measures are in place before the province enters Step One of the Roadmap to Reopen. As always, anyone who may have been exposed to COVID-19 or who may be exhibiting symptoms of the virus should use the province's self-assessment tool to determine what they should do next, including getting a test and isolating if necessary.

"As we continue to accelerate second doses of the COVID-19 vaccine for Ontarians, maintaining public health measures will ensure we continue to protect our hospital capacity and help stop the spread of COVID-19 variants," said Christine Elliott, Deputy Premier and Minister of Health. "As we look towards Step One of Ontario's Roadmap and begin to gradually lift public health measures, it remains critical that all Ontarians continue to follow public health advice and roll up their sleeves to receive the vaccine. Every dose administered means we are one step closer to the end of the pandemic."

With the expiry of the Stay-at-Home order, emergency order O. Reg 266/21 (Residential Evictions) will also expire on June 2, 2021. Emergency orders currently in effect under the *Emergency Management and Civil Protection Act* have been extended until June 16, 2021:

- O. Reg. 8/21 Enforcement of COVID-19 Measures
- O. Reg. 55/21 Compliance Orders for Retirement Homes
- O. Reg. 271/21 Work Redeployment for Local Health Integration Networks and Ontario Health
- O. Reg. 272/21 Transfer of Hospital Patients

- O. Reg. 288/21 Closure of Public Lands for Recreational Camping
- O. Reg. 293/21 Persons Entering Ontario From Manitoba or Quebec
- O. Reg. 304/21 Work Redeployment for Independent Health Facilities
- O. Reg. 305/21 Regulated Health Professionals
- O. Reg. 317/21 Agreements Between Health Service Providers and Retirement Homes

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Additional Resources

- Ontario Releases Three-Step Roadmap to Safely Reopen the Province
- For up-to-date information on the province's vaccine rollout and instructions on how to book an appointment, visit Ontario's vaccine webpage.
- For resources in multiple languages to help local communication efforts in responding to COVID-19, visit Ontario's COVID-19 communication resources webpage.
- Visit Ontario's website to learn more about how the province continues to protect the people of Ontario from COVID-19.

Related Topics

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This is **"Exhibit FF"**
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A Commissioner, etc.

NEWS RELEASE

Ontario Moving to Step Three of Roadmap to Reopen on July 16

Continuing Improvements in Key Indicators Allowing Province to Safely Expand Indoor Settings and Capacity Limits

July 09, 2021

Office of the Premier

TORONTO — With key public health and health care indicators continuing to improve and the provincewide vaccination rate surpassing the targets outlined in the province's Roadmap to Reopen, in consultation with the Chief Medical Officer of Health the Ontario government is moving the province into Step Three of the Roadmap to Reopen at 12:01 a.m. on Friday, July 16, 2021.

"Thanks to the tireless efforts of our frontline heroes, and the ongoing commitment of Ontarians to get vaccinated, we have surpassed the targets we set in order to enter Step Three of our Roadmap," said Premier Doug Ford. "While this is welcome news for everyone who wants a return to normal, we will not slow down our efforts to fully vaccinate everyone who wants to be and put this pandemic behind us once and for all."

In order to enter Step Three of the Roadmap, Ontario needed to have vaccinated 70 to 80 per cent of individuals 18 years of age or older with one dose and 25 per cent with two doses for at least two weeks, ensuring a stronger level of protection against COVID-19. Thanks to the dedicated efforts of Ontario's health care partners, as of July 8, 2021, over 77 per cent of the population in Ontario ages 12 and over have received one dose of a COVID-19 vaccine and over 50 per cent have received their second dose. More than 16.6 million doses of the COVID-19 vaccine have been administered provincewide.

The province also needed to see continued improvement in other key public health and health care indicators, including hospitalizations, ICU occupancy and the weekly cases incidence rates. After entering Step Two, during the period of June 29 to July 5, 2021, the provincial case rate decreased by 23.3 per cent. As of July 8, the

number of patients with COVID-19 in ICUs is 202, including three patients from Manitoba, as compared to 286 two weeks ago. The province expects these positive trends to continue over the coming days before entering Step Three.

“Ontario has continued to see improvements in key health indicators, allowing the province to move to Step Three of the Roadmap and safely resume more of the activities we’ve missed,” said Christine Elliott, Deputy Premier and Minister of Health. “While this is exciting news, we most still remain vigilant and continue to follow the public health measure we know work and keep us safe. Vaccines remain our ticket out of the pandemic so if you haven’t booked your appointment yet, please do so today.”

Step Three of the Roadmap focuses on the resumption of additional indoor services with larger numbers of people and restrictions in place. This includes, but is not limited to:

- Outdoor social gatherings and organized public events with up to 100 people with limited exceptions;
- Indoor social gatherings and organized public events with up to 25 people;
- Indoor religious services, rites or ceremonies, including wedding services and funeral services permitted with physical distancing;
- Indoor dining permitted with no limits on the number of patrons per table with physical distancing and other restrictions still in effect;
- Indoor sports and recreational fitness facilities to open subject to a maximum 50 per cent capacity of the indoor space. Capacity for indoor spectators is 50 per cent of the usual seating capacity or 1,000 people, whichever is less. Capacity for outdoor spectators is 75 per cent of the usual seating capacity or 15,000 people, whichever is less;
- Indoor meeting and event spaces permitted to operate with physical distancing and other restrictions still in effect and capacity limited to not exceed 50 per cent capacity or 1,000 people, (whichever is less);
- Essential and non-essential retail with with capacity limited to the number of people that can maintain a physical distance of two metres;
- Personal care services, including services requiring the removal of a face covering, with capacity limited to the number of people that can maintain a physical distance of two metres;
- Museums, galleries, historic sites, aquariums, zoos, landmarks, botanical gardens, science centres, casinos/bingo halls, amusement parks, fairs and rural exhibitions, festivals, with capacity limited to not exceed 50 per cent capacity indoors and 75 per cent capacity outdoors;

- Concert venues, cinemas, and theatres permitted to operate at:
  - up to 50 per cent capacity indoors or a maximum limit of 1,000 people for seated events (whichever is less)
  - up to 75 per cent capacity outdoors or a maximum limit of 5,000 people for unseated events (whichever is less); and up to 75 per cent capacity outdoors or a maximum of 15,000 people for events with fixed seating (whichever is less).
- Real estate open houses with capacity limited to the number of people that can maintain a physical distance of two metres; and
- Indoor food or drink establishments where dance facilities are provided, including nightclubs and restobars, permitted up to 25 per cent capacity or up to a maximum limit of 250 people (whichever is less).

Face coverings in indoor public settings and physical distancing requirements remain in place throughout Step Three. This is in alignment with the advice on personal public health measures issued by the Public Health Agency of Canada, while also accounting for Ontario specific information and requirements. Face coverings will also be required in some outdoor public settings as well.

Please view the regulation for the full list of public health and workplace safety measures that need to be followed.

“Thanks to the continued efforts of Ontarians adhering to public health measures and advice, as well as going out to get vaccinated, we have seen most key health indicators continue to improve,” said Dr. Kieran Moore, Chief Medical Officer of Health. “However, the pandemic is not over and we must all remain vigilant and continue following the measures and advice in place, as the Delta variant continues to pose a threat to public health.”

The province will remain in Step Three of the Roadmap for at least 21 days and until 80 per cent of the eligible population aged 12 and over has received one dose of a COVID-19 vaccine and 75 per cent have received their second, with no public health unit having less than 70 per cent of their eligible population aged 12 and over fully vaccinated. Other key public health and health care indicators must also continue to remain stable. Upon meeting these thresholds, the vast majority of public health and workplace safety measures, including capacity limits for indoor and outdoor settings and limits for social gatherings, will be lifted. Only a small number of measures will remain in place, including the requirement for passive screening, such as posting a sign, and businesses requiring a safety plan.

Ontario's epidemiological situation is distinct from other jurisdictions and the Delta variant is the dominant strain in Ontario, which is not the case with some other provinces. As a result, on the advice of the Chief Medical Officer of Health, face coverings will also continue to be required for indoor public settings. The Chief Medical Officer of Health will continue to evaluate this need on an ongoing basis.

Quick Facts

QUICK FACTS

- On June 30, 2021, the province moved into Step Two of the Roadmap to Reopen, based on the provincewide vaccination rate and continued improvements in key public health and health system indicators.
- The Ontario government has released the Roadmap to Reopen, a three-step plan to reopen the province and ease public health measures based on the provincewide vaccination rate and improvements in key public health and health care indicators.
- With a majority of Ontario adults having received their first dose of the vaccine, providing a strong level of protection from COVID-19, the province is accelerating eligibility to book a second dose appointment, including for children and youth aged 12 to 17.

Additional Resources

- Visit Ontario's COVID-19 communications resources web page for resources in multiple languages to help local communication efforts.
- Visit Ontario's website to find out if you are eligible to receive a COVID-19 vaccine at this time.
- For up-to-date information on the province's vaccine rollout and instructions on how to book an appointment, visit Ontario's vaccine webpage.
- Visit Ontario's COVID-19 information website to learn more about how the province continues to protect the people of Ontario from the virus.
- For public inquiries call ServiceOntario, INFOline at 1-866-532-3161 (Toll-free in Ontario only).

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