

EVIDENCE BRIEF

(ARCHIVED) COVID-19 Delta: Risk Assessment and Implications for Practice (September 20, 2021 Update)

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ARCHIVED DOCUMENT

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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





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 England⁹) 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 Arabia¹⁷ 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**).

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

Table 1. Risk assessment for Delta

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.

References

1. Ontario COVID-19 Science Advisory Table; Modelling Consensus Table. Update on COVID-19 projections [Webinar]. Toronto, ON: Ontario COVID-19 Science Advisory Table; 2021 [presented 2021 Sep 01; cited 2021 Sep 24]. Available from: <u>https://covid19-sciencetable.ca/wp-content/uploads/2021/09/Update-on-COVID-19-Projections 2021.09.01 English-1.pdf</u>

2. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Epidemiologic summary: SARS-CoV-2 whole genome sequencing in Ontario [Internet]. Toronto, ON: Queen's Printer for Ontario; 2021 [cited 2021 Sep 24]. Available from: <u>https://www.publichealthontario.ca/-</u> /media/documents/ncov/epi/covid-19-sars-cov2-whole-genome-sequencing-episummary.pdf?sc_lang=en

3. Ontario Agency for Health Protection and Promotion (Public Health Ontario). COVID-19 Delta: risk analysis and implications for public health measures [Internet]. Toronto, ON: Queen's Printer for Ontario; 2021 [cited 2021 Sep 13]. Available from: <u>https://www.publichealthontario.ca/-/media/documents/ncov/voc/2021/07/covid-19-delta-risk-analysis-public-health-measures.pdf?sc_lang=en</u>

4. Ontario Agency for Health Protection and Promotion (Public Health Ontario). COVID-19 Delta: risk assessment and implications for practice [Internet]. Toronto, ON: Queen's Printer for Ontario; 2021 [cited 2021 Sep 13]. Available from: https://www.publichealthontario.ca/-//media/documents/ncov/voc/2021/08/covid-19-delta-variant-risk-assessment-implications.pdf?sc_lang=en

5. Ontario Agency for Health Protection and Promotion (Public Health Ontario). COVID-19: severity of the Delta (B.1.617.2) variant in children [Internet]. Toronto, ON: Queen's Printer for Ontario; 2021 [cited 2021 Sep 13]. Available from: <u>https://www.publichealthontario.ca/-</u>/media/documents/ncov/voc/2021/09/covid-19-severity-delta-children.pdf?sc lang=en

6. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Estimating the prevalence and growth of SARS-CoV-2 variants in Ontario using mutation profiles [Internet]. Toronto, ON: Queen's Printer for Ontario; 2021 [cited 2021 Sep 24]. Available from: <u>https://www.publichealthontario.ca/-/media/documents/ncov/epi/covid-19-prevalence-growth-voc-mutation-epi-summary.pdf?sc_lang=en</u>

7. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Epidemiologic summary: COVID-19 in children and education settings – July 4, 2021 to September 4, 2021 [Internet]. Toronto, ON: Queen's Printer for Ontario; 2021 [cited 2021 Sep 24]. Available from: <u>https://www.publichealthontario.ca/-/media/documents/ncov/epi/covid-19-children-school-outbreaks-epi-summary.pdf?sc_lang=en</u>

8. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Weekly epidemiologic summary: COVID-19 in Ontario – focus on September 12, 2021 to September 18, 2021 [Internet]. Toronto, ON: Queen's Printer for Ontario; 2021 [cited 2021 Sep 24]. Available from: https://www.publichealthontario.ca/-/media/documents/ncov/epi/covid-19-weekly-epi-summary-report.pdf?sc_lang=en.

9. Allen H, Vusirikala A, Flannagan J, Twohig KA, Zaidi A; COG-UK Consortium, et al. Increased household transmission of COVID-19 cases associated with SARS-CoV-2 variant of concern B.1.617.2 - a national case-control study [Internet]. London: Crown Copyright; 2021 [cited 2021 Sep 13]. Available from: <u>https://khub.net/documents/135939561/405676950/Increased+Household+Transmission+of+COVID - 19+Cases+-+national+case+study.pdf/7f7764fb-ecb0-da31-77b3-b1a8ef7be9aa</u>

10. Brown KA, Joh E, Buchan SA, Daneman N, Mishra S, Patel S, Day T. Inflection in prevalence of SARSCoV-2 infections missing the N501Y mutation as a marker of rapid Delta (B.1.617.2) lineage expansion in Ontario, Canada. medRxiv 21259349 [Preprint]. 2021 Jun 25 [cited 2021 Sep 15]. Available from: <u>https://doi.org/10.1101/2021.06.22.21259349</u>

11. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Confirmed cases of COVID19 following vaccination in Ontario: December 14, 2020 to September 4, 2021 [Internet]. Toronto, ON: Queen's Printer for Ontario; 2021 [cited 2021 Sep 13]. Available from: <u>https://www.publichealthontario.ca/-/media/documents/ncov/epi/covid-19-epi-confirmed-cases-post-vaccination.pdf?sc_lang=en</u>

12. Ontario Agency for Health Protection and Promotion (Public Health Ontario). PHO In action – explained: COVID-19 PCR testing and cycle thresholds [Internet]. Toronto, ON: Queen's Printer for Ontario; 2021 [cited 2021 Sep 24]. Available from:

https://www.publichealthontario.ca/en/about/blog/2021/explained-covid19-pcr-testing-and-cyclethresholds

13. Kang M, Xin H, Yuan J, Ali ST, Liang Z, Zhang J, et al. Transmission dynamics and epidemiological characteristics of Delta variant infections in China. medRxiv 21261991 [Preprint]. 2021 Aug 13 [cited 2021 Sep 05]. Available from: <u>https://doi.org/10.1101/2021.08.12.21261991</u>

14. Bolze A, Cirulli ET, Luo S, White S, Cassens T, Jacobs S, et al. SARS-CoV-2 variant Delta rapidly displaced variant Alpha in the United States and led to higher viral loads. medRxiv 21259195 [Preprint]. 2021 Jul 30 [cited 2021 Sep 06]. Available from: <u>https://doi.org/10.1101/2021.06.20.21259195</u>

15. von Wintersdorff C dJ, van Alphen L, Wolffs P, van der Veer B, Hoebe C, et al. Infections caused by the Delta variant (B.1.617.2) of SARS-CoV-2 are associated with increased viral loads compred to infections with the Alpha variant (B.1.1.7) or non-variants of concern. Res Sq 777577 [Preprint]. 2021 Aug 04 [cited 2021 Sep 06]. Available from: <u>https://doi.org/10.21203/rs.3.rs-777577/v1</u>

16. Williams GH, Llewelyn A, Brandao R, Chowdhary K, Hardisty K-M, Loddo M. SARS-CoV-2 testing and sequencing for international arrivals reveals significant cross border transmission of high risk variants into the United Kingdom. EClinicalMedicine. 2021 Jul 14 [Epub ahead of print]. Available from: https://doi.org/10.1016/j.eclinm.2021.101021

17. Alhamlan F, Al-Qahtani A, Obeid D, Aljumaah S, Alghamdi S, Alnafee K, et al. SARS-CoV-2 Delta variant predominant at a tertiary-care hospital in Saudi Arabia. Res Sq 779549 [Preprint]. 2021 Aug 06 [2021 Sep 06]. Available from: <u>https://doi.org/10.21203/rs.3.rs-779549/v1</u>

18. Li B, Deng A, Li K, Hu Y, Li Z, et al. Viral infection and transmission in a large well-traced outbreak caused by the Delta SARS-CoV-2 variant. Virological. 2021 Jul 7 [Preprint]. Available from: <u>https://virological.org/t/viral-infection-and-transmission-in-a-large-well-traced-outbreak-caused-bythe-delta-sars-cov-2-variant/724/1</u>

19. Ryu S, Kim D, Lim JS, Ali ST, Cowling BJ. Changes in the serial interval and transmission dynamics associated with the SARS-CoV-2 Delta variant in South Korea. medRxiv 21262166 [Preprint]. 2021 Aug 20 [cited 2021 Oct 01]. Available from: https://doi.org/10.1101/2021.08.18.21262166

20. Kim S, Liu Y, Lei Z, Dicker J, Cao Y, Zhang F, et al. Differential interactions between human ACE2 and spike RBD of SARS-CoV-2 variants of concern. bioRxiv 452598 [Preprint]. 2021 Jul 26 [cited 2021 Sep 13]. Available from: <u>https://doi.org/10.1101/2021.07.23.453598</u>

21. Ren W, Ju X, Gong M, Lan J, Yu Y, Long Q, et al. Characterization of SARS-CoV-2 variant B.1.617.1 (Kappa), B.1.617.2 (Delta) and B.1.618 on cell entry, host range, and sensitivity to convalescent plasma and ACE2 decoy receptor. medRxiv 458829 [Preprint]. 2021 Sep 03 [cited 2021 Oct 01]. Available from: https://doi.org/10.1101/2021.09.03.458829

22. Saville JW, Mannar D, Zhu X, Srivastava SS, Berezuk AM, Demers JP, et al. Structural and biochemical rationale for enhanced spike protein fitness in Delta and Kappa SARS-CoV-2 variants. bioRxiv 458774 [Preprint]. 2021 Sep 02 [cited 2021 Oct 01]. Available from: <u>https://doi.org/10.1101/2021.09.02.458774</u>

23. Micochova P, Kemp S, Dhar MS, Papa G, Meng B, Mishra S, et al. SARS-CoV-2 B.1.617.2 Delta variant replication and immune evasion. Nature. 2021 Sep 6 [Epub ahead of print]. Available from: <u>https://doi.org/10.1038/s41586-021-03944-y</u>

24. Xia F, Yang X, Cheke RA, Xiao Y. Quantifying competitive advantages of mutant strains in a population involving importation and mass vaccination rollout. Infect Dis Model. 2021;6:988-96. Available from: <u>https://doi.org/10.1016/j.idm.2021.08.001</u>

25. Liu Y, Liu J, Johnson BA, xia H, Ku Z, Schindewolf C, et al. Delta spike P681R mutation enhances SARS-CoV-2 fitness over Alpha variant. bioRxiv 456173 [Preprint]. 2021 Aug 15. Available from: <u>https://doi.org/10.1101/2021.08.12.456173</u>

26. Khedar RS, Mittal K, Bmbaliya HC, Mathur A, Gupta JB, Sharma KK, et al. Greater Covid-19 severity and mortality in hospitalized patients in second (Delta variant) wave compared to the first: single centre prospective study in India. medRxiv 21263091 [Preprint]. 2021 Sep 7 [cited 2021 Oct 01]. Available from: https://doi.org/10.1101/2021.09.03.21263091

27. Twohig KA, Nyberg T, Zaidi A, Thelwall S, Sinnathamby MA, Aliabadi S, et al. Hospital admission and emergency care attendance risk for SARS-CoV-2 delta (B.1.617.2) compared with alpha (B.1.1.7) variants of concern: a cohort study. Lancet Infect Dis. 2021 Aug 27 [Epub ahead of print]. Available from: https://doi.org/10.1016/S1473-3099(21)00475-8

28. Veneti L, Salamanca BV, Seppala E, Starrfelt J, Storm ML, Bragstad K, et al. No difference in risk of hospitalisation between reported cases of the SARS-CoV-2 Delta variant and Alpha variant in Norway. medRxiv 21263014 [Preprint]. 2021 Sep 5 [cited 2021 Oct 01]. Available from: https://doi.org/10.1101/2021.09.02.21263014

29. Scobie HM, Johnson AG, Suthar AB, Severson R, Alden NB, Balter S, et al. Monitoring incidence of COVID-19 cases, hospitalizations, and deaths, by vaccination status — 13 U.S. jurisdictions, April 4-July 17, 2021. MMWR Morb Mortal Wkly Rep. 2021 Sep 10 [Epub ahead of print]. Available from: http://dx.doi.org/10.15585/mmwr.mm7037e3

30. Grannis SJ, Rowley EA, Ong TC, Stenehjem E, Klein NP, DeSilva MB, et al. Interim estimates of COVID-19 vaccine effectiveness against COVID-19–associated emergency department or urgent care clinic encounters and hospitalizations among adults during SARS-CoV-2 B.1.617.2 (Delta) variant predominance — nine states, June–August 2021. MMWR Morb Mortal Wkly Rep. 2021 Sep 10 [Epub ahead of print]. Available from: <u>http://dx.doi.org/10.15585/mmwr.mm7037e2external</u>

31. Barlow RS, Jian K, Larson L. Infection during a Delta variant epidemic surge in Multnomah County, Oregon, July 2021. medRixv 21262446 [Preprint]. 2021 Sep 03 [cited 2021 Oct 01]. Available from: https://doi.org/10.1101/2021.08.30.21262446

32. Herlihy R, Bamberg W, Burakoff A, Alden N, Severson R, Bush E, et al. SARS-CoV-2 B.1.617.2 (Delta) variant — Mesa County, Colorado, April-June 2021. MMWR Morb Mortal Wkly Rep. 2021;70:1084-7. Available from: <u>http://dx.doi.org/10.15585/mmwr.mm7032e2</u>

33. Nanduri S, Pilishvili T, Derado G, et al. Effectiveness of Pfizer-BioNTech and Moderna vaccines in preventing SARS-CoV-2 infection among nursing home residents before and during widespread circulation of the SARS-CoV-2 B.1.617.2 (Delta) variant — National Healthcare Safety Network, March 1– August 1, 2021. MMWR Morb Mortal Wkly Rep. 2021;70(34):1163-6. Available from: http://dx.doi.org/10.15585/mmwr.mm7034e3

34. de Gier B, Kooijman M, Kemmeren J, de Keizer N, Dongelmans D, van Iersel SCJL, et al. COVID-19 vaccine effectiveness against hospitalizations and ICU admissions in the Netherlands, April- August 2021. medRxiv 21263613 [Preprint]. 2021 Sep 17 [cited 2021 Oct 01]. Available from: https://doi.org/10.1101/2021.09.15.21263613

35. Hu Z, Tao B, Li Z, Song Y, Yi C, Li J, et al. Effectiveness of inactive COVID-19 vaccines against severe illness in B.1.617.2 (Delta) variant-infected patients in Jiangsu, China. medRxiv 21263010 [Preprint]. 2021 Sep 05 [cited 2021 Oct 01]. Available from: <u>https://doi.org/10.1101/2021.09.02.21263010</u>

36. Kislaya I, Rodrigues EF, Borges V, Gomes JP, Sousa C, Almeida JP, et al. Delta variant and mRNA Covid-19 vaccines effectiveness: higher odds of vaccine infection breakthroughs. medRxiv 21262020 [Preprint]. 2021 Aug 22 [cited 2021 Sep 06]. Available from: <u>https://doi.org/10.1101/2021.08.14.21262020</u>

37. Luo CH, Morris CP, Sachithanandham J, Amadi A, Gaston D, Li M, et al. Infection with the SARS-CoV-2 Delta variant is associated with higher infectious virus loads compared to the Alpha variant in both unvaccinated and vaccinated individuals. medRxiv 21262077 [Preprint]. 2021 Aug 20 [cited 2021 Sep 06]. Available from: https://doi.org/10.1101/2021.08.15.21262077

38. Brown CM, Vostok J, Johnson H, Burns M, Gharpure R, Sami S, et al. Outbreak of SARS-CoV-2 infections, including COVID-19 vaccine breakthrough infections, associated with large public gatherings — Barnstable County, Massachusetts, July 2021. MMWR Morb Mortal Wkly Rep. 2021;70(31):1059-62. Available from: https://doi.org/10.15585/mmwr.mm7031e2

39. Griffin JB, Haddix M, Danza P, Fisher R, Koo TH, Traub E, et al. SARS-CoV-2 infections and hospitalizations among persons aged ≥16 years, by vaccination status — Los Angeles County, California, May 1–July 25, 2021. MMWR Morb Mortal Wkly Rep. 2021;70(34):1170-6. Available from: https://doi.org/10.15585/mmwr.mm7034e5

40. Pouwels KB, Pritchard E, Matthews PC, Stoesser N, Eyre DW, Vihta KD, et al. Impact of Delta on viral burden and vaccine effectiveness against new SARS-CoV-2 infections in the UK [Preprint]. Oxford, UK: University of Oxford; 2021 Aug 16 [cited 2021 Aug 19]. Available from: <u>https://www.ndm.ox.ac.uk/files/coronavirus/covid-19-infection-survey/finalfinalcombinedve20210816.pdf</u>

41. Chia PY, Ong S, Chiew CJ, Ang LW, Chavatte J-mG, Mak TM, et al. Virological and serological kinetics of SARS-CoV-2 Delta variant vaccine-breakthrough infections: a multi-center cohort study. medRxiv 21261295 [Preprint]. 2021 Jul 31 [cited 2021 Sep 05]. Available from: https://doi.org/10.1101/2021.07.28.21261295

42. Linsenmeyer K, Gupta K, Madjarov R, Charness ME. Cryptic transmission of the Delta variant AY.3 sublineage of SARS-CoV-2 among fully vaccinated patients on an inpatient ward. medRxiv 21261562 [Preprint]. 2021 Aug 10 [cited 2021 Sep 05]. Available from: https://doi.org/10.1101/2021.08.05.21261562

43. Levine-Tiefenbrun M, Yelin I, Alapi H, Katz R, Herzel E, Kuint J, et al. Viral loads of Delta-variant SARS-CoV2 breakthrough infections following vaccination and booster with the BNT162b2 vaccine. medRxiv 21262798 [Preprint]. 2021 Sep 01 [cited 2021 Sep 06]. Available from: <u>https://doi.org/10.1101/2021.08.29.21262798</u>

44. World Health Organization. COVID-19 weekly epidemiological update: edition 56, Sept 7 2021 [Internet]. Geneva: World Health Organization; 2021 [cited 2021 Sept 13]. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports

45. UK Government. Coronavirus (COVID-19) in the UK: cases in England [Internet]. London: Crown Copyright; 2021 [cited 2021 Sep 16]. Available from: <u>https://coronavirus.data.gov.uk/details/cases?areaType=nation&areaName=England</u>

46. UK Government. Coronavirus (COVID-19) in the UK: healthcare in England [Internet]. London: Crown Copyright; 2021 [cited 2021 Sep 16]. Available from: https://coronavirus.data.gov.uk/details/healthcare?areaType=nation&areaName=England

47. UK Government. Coronavirus (COVID-19) in the UK: deaths in England [Internet]. London: Crown Copyright; 2021 [cited 2021 Sep 16]. Available from: <u>https://coronavirus.data.gov.uk/details/deaths?areaType=nation&areaName=England</u>

48. Public Health England. SARS-CoV-2 variants of concern and variants under investigation in England: technical briefing 22 [Internet]. London: Crown Copyright; 2021 [cited 2021 Sep 16]. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/10 14926/Technical_Briefing_22_21_09_02.pdf

49. Our World in Data. Share of people who received at least one dose of COVID-19 vaccine [Internet]. Oxford: Global Change Data Lab; 2021 [cited 2021 Sept 14]. Available from: <u>https://ourworldindata.org/grapher/share-people-vaccinated-covid?country=~England</u>

50. Our World in Data. Share of the population fully vaccinated against COVID-19 [Internet]. Oxford: Global Change Data Lab; 2021 [cited 2021 Sept 14]. Available from: <u>https://ourworldindata.org/grapher/share-people-fully-vaccinated-covid?country=~England</u>

51. UK Government. COVID-19 response: autumn and winter plan [Internet]. London: Crown Copyright; 2021 [cited 2021 Sep 16]. Available

from: <u>https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/f</u> ile/1017779/COVID-19-response-autumn-and-winter-plan-2021.pdf

52. Our World in Data. Weekly confirmed COVID-19 cases per million people [Internet]. Oxford: Global Change Data Lab; 2021 [cited 2021 Sep 16]. Available from: <u>https://ourworldindata.org/grapher/weekly-covid-cases-per-million-people?tab=chart&country=ITA~ISR~DEU~USA~IRL~FIN~DNK~FRA~NOR~NLD</u>

53. Our World in Data. COVID-19 hospitalizations [Internet]. Oxford: Global Change Data Lab; 2021 [cited 2021 Sep 16]. Available from: <u>https://ourworldindata.org/covid-hospitalizations</u>

54. Our World in Data. COVID-19 deaths [Internet]. Oxford: Global Change Data Lab; 2021 [cited 2021 Sep 16]. Available from: <u>https://ourworldindata.org/covid-deaths</u>

55. European Centre for Disease Prevention and Control. SARS-CoV-2 variants dashboard [Internet]. Stockholm: European Centre for Disease Prevention and Control; 2021 [cited 2021 Sep 14]. Available from:

https://gis.ecdc.europa.eu/portal/apps/opsdashboard/index.html#/25b6e879c076412aaa9ae7adb78d3 241

56. Our World in Data. Share of people vaccinated against COVID-19 [Internet]. Oxford: Global Change Data Lab; 2021 [cited 2021 Sept 14]. Available from: <u>https://ourworldindata.org/explorers/coronavirus-data-</u>

<u>explorer?zoomToSelection=true&facet=none&pickerSort=desc&pickerMetric=population&hideControls</u> <u>=true&Interval=Cumulative&Relative+to+Population=true&Align+outbreaks=false&country=GBR~FRA~I</u> <u>TA~NLD~ISR&Metric=People+vaccinated+%28by+dose%29</u>

57. Gouvernement français. Restrictions and requirements in metropolitan France [Internet]. Paris: Gouvernement français; 2021 [cited 2021 Sep 16]. Available from: <u>https://www.gouvernement.fr/en/coronavirus-covid-19</u>

58. Belligoni S. Italy – once overwhelmed by COVID-19 – turns to a health pass and stricter measures to contain virus. The Conversation [Internet], 2021 Aug 23 [cited 2021 Sep 16]. Available from: <u>https://theconversation.com/italy-once-overwhelmed-by-covid-19-turns-to-a-health-pass-and-stricter-measures-to-contain-virus-165457</u>

59. Governo Italiano Presidenza del Consiglio dei Ministri. COVID-19 – domande frequenti sulle misure adottate dal Governo [Internet]. Roma: Presidenza del Consiglio dei Ministri; 2021 [cited 2021 Sep 16]. Available from: <u>https://www.governo.it/it/articolo/domande-frequenti-sulle-misure-adottate-dal-governo/15638#zone</u>

60. Balmer C, Fonte G. Italy makes COVID-19 health pass mandatory for all workers. CTV News [Internet], 2021 Sep 16 [cited 2021 Sep 16]. Available from: <u>https://www.ctvnews.ca/health/coronavirus/italy-makes-covid-19-health-pass-mandatory-for-all-workers-1.5587865</u>

61. Government of the Netherlands. Netherlands to reopen further with coronavirus entry passes [Internet]. Amsterdam: Government of the Netherlands; 2021 [cited 2021 Sep 16]. Available

from: <u>https://www.government.nl/topics/coronavirus-covid-19/news/2021/09/14/netherlands-to-reopen-further-with-coronavirus-entry-passes</u>

62. Israel. Ministry of Health. The green pass outline for higher education establishments, courses and training programs has taken effect [Internet]. Jerusalem: Government of Israel; 2021 [modified 2021 Aug 22; cited 2021 Sep 16]. Available from: <u>https://www.gov.il/en/departments/news/22082021-01</u>

63. Israel. Ministry of Health. Parents are requested to use today the home coronavirus test kits that were delivered this week [Internet]. Jerusalem: Government of Israel; 2021 [modified 2021 Aug 31; cited 2021 Sep 16]. Available from: <u>https://www.gov.il/en/departments/news/31082021-01</u>

64. Israel. Ministry of Health. Amendment to activity restriction regulations updated ahead of yom kippur [Internet]. Jerusalem: Government of Israel; 2021 [modified 2021 Sep 14; cited 2021 Sep 16]. Available from: https://www.gov.il/en/departments/news/14092021-03

65. Israel. Ministry of Health. Recommendation for the country classification scheme that shall take effect on 14.9.2021 [Internet]. Jerusalem: Government of Israel; 2021 [modified 2021 Sep 8; cited 2021 Sep 16]. Available from: https://www.gov.il/en/departments/news/06092021-04

66. Israel. Ministry of Health. Updated guidance for travelers returning from abroad [Internet]. Jerusalem: Government of Israel; 2021 [modified 2021 Sep 2; cited 2021 Sep 16]. Available from: <u>https://www.gov.il/en/departments/news/02092021-02</u>

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