2021

Public Health Implications of SARS-CoV-2 Variants of Concern

UPDATED: OCTOBER 22, 2021

JANET CURRAN, PHD RN, DALHOUSIE UNIVERSITY, PROFESSOR

LEAH BOULOS, MLIS, MARITIME SPOR SUPPORT UNIT, EVIDENCE SYNTHESIS COORDINATOR

MARI SOMERVILLE, PHD, DALHOUSIE UNIVERSITY, POSTDOCTORAL FELLOW

JUSTINE DOL, PHD, DALHOUSIE UNIVERSITY, RESEARCH COORDINATOR

CATIE JOHNSON, DALHOUSIE UNIVERSITY, RESEARCH ASSISTANT

BEARACH REYNOLDS, MB BCH BAO BA MRCPI, ESI FELLOW, EVIDENCE SYNTHESIS IRELAND

JULIE CARUSO, MLIS, RESEARCH ASSOCIATE, DALHOUSIE UNIVERSITY

TRUDY FLYNN, PATIENT PARTNER

REBECCA MACKAY, PATIENT PARTNER

FUNDED BY **COVARR-NET**

Acknowledgments

The authors would like to acknowledge Ruth Martin-Misener, Marilyn Macdonald, Helen Wong, Danielle Shin, Allyson Gallant, and Daniel Crowther for their assistance with study screening and data extraction.

Public Health Implications of SARS-CoV-2 Variants of Concern

Updated October 22, 2021

Evidence up to October 4, 2021

Introduction

The SARS-CoV-2 virus, responsible for COVID-19, was declared a global pandemic by the World Health Organization (WHO) in March 2020.[1] As of October 22, 2021, over 241 million cases of COVID-19 have been reported worldwide and over 4.9 million people have died as a result of COVID-19 since the start of the pandemic.[2] Increased numbers of COVID-19 cases are causing significant concerns around identifying optimal vaccination strategies and enforcing appropriate public health measures to manage the spread of the SARS-CoV-2 virus.

As of September 10, 2021, four variants of the original SARS-CoV-2 lineage have been declared variants of concern (VOC) by the WHO, with other variants under ongoing assessment (see Table 1).[3] VOC are defined by their increased potential for transmission, presence of genomic mutations, and rapid spread across countries or regions leading to possible decreased effectiveness of public health measures.[4] The increased transmissibility of VOC has led to surges in COVID-19 incidence and consequently, hospitalizations and mortality.[5] Therefore, this living systematic review aims to provide a synthesis of current evidence related to VOC in the context of public health measures. This living synthesis builds on a previous rapid scoping review examining the impacts of VOC on public health and health systems conducted by this team.[6]

Table 1. Current variants of concern (VOC)[3,7]

WHO Name	PANGO LINEAGE	Alternate name	Country first detected in	Earliest samples
Alpha	B.1.1.7	VOC 202012/01	United Kingdom	September 2020
Beta	B.1.351	VOC 202012/02	South Africa	August 2020
Gamma	P.1	VOC 202101/02	Brazil	December 2020
Delta	B.1.617.2	N/A	India	October 2020

Emerging Points of Interest

- **There is evolving evidence regarding changes in vaccine scheduling related to the need for a third dose of vaccine.**
- **Multiple studies show that frequent PCR or rapid antigen testing (ideally, 1-3 times per week) is one of the most effective strategies for preventing and containing outbreaks, especially in schools and post-secondary settings.**

- **Public health measures in the community help mitigate cases in schools, as transmission is more likely to occur in the community than in schools.**
- **Evidence related to public health measures and Delta is emerging rapidly.**
- **An increasing number of modelling studies indicate that by vaccinating children and/or adolescents, the impact of VOC, particularly Delta, could be mitigated, along with the continued vaccination of adults.**
- **Increasing evidence shows that combined NPIs are more effective than single NPIs at containing outbreaks.**
- **Some evidence showing that mixing vaccine types and booster vaccines (i.e., third doses) provides good protection against VOCs.**
- **Increasing evidence suggests that a third dose of vaccine would be beneficial, particularly against Delta, due to waning immunity among early vaccinated populations.**
- **In light of Delta, continued evidence suggests that a combination of vaccine rollout and NPIs is needed to reduce infection.**
- **Universal mask-wearing continues to show importance in reducing the spread of COVID-19, particularly indoors (e.g., workplaces and schools), regardless of vaccination status.**
- **Minimizing social contacts among adults may be required to reduce spread and keep children in school, and hybrid learning may further reduce the spread of COVID-19, hospitalization, and death.**

Patient-Identified Key Messages

- There is a need to continue with masking and other NPIs as indicated by Public Health, even if you are double vaccinated.
- A third (booster) vaccine is likely going to be required to stay ahead of Delta variant. Be prepared when your times comes.
- Frequent PCR and rapid testing, including asymptomatic testing, is needed to monitor and manage transmission of VOCs.

Categories of evidence included in this report are as follows:

Modifying approach to vaccines: Any studies that reported on changing approaches to vaccinations such as modelling the rollout schedules or impact of NPIs in relation to vaccine schedules. Four sub-categories fell under this category:

a) Modelling potential vaccination rollout schedules
b) Evaluating past vaccination rollout schedules
c) Modelling potential vaccination rollout schedules in the presence of NPIs
d) Evaluating past vaccination rollout schedules in the presence of NPIs

Infection prevention measures: Any studies that reported on public health measures aimed at preventing the spread of VOC such as mask wearing, hand washing or physical distancing.

Infection control measures: Any studies that reported on public health measures aimed at controlling the spread of VOC such as quarantines, lockdowns, screening or testing strategies.

Results Tables

The following tables present a summary of evidence in relation to each of the categories described above. **42 studies were added to this update, and the most recent content is in bold, blue font.**

Table 2. Evidence related to modifying approach to vaccination, divided by VOC
*Note: Only observational studies were appraised for quality

Category	Alpha (B.1.1.7)	Beta (B.1.351)	Gamma (P.1)	Delta (B.1.617.2)
Modifying approach to vaccination				
Modelling potential vaccination rollout schedules *for first and second doses*	• **Mixing vaccine types may be effective against SARS-CoV-2**[8] • **Global death toll would increase by 20% if vaccine-rich countries achieve full vaccination status before exporting vaccines to countries in-need**[9] • Accelerated vaccine rollout (60 doses/day/10,000 pop) would reduce severe health outcomes[10] • Estimated current vaccine schedule of 1/1000 doses/person/day would need to be quadrupled to control the spread of VOC[11] • Speed of vaccine rollout is key factor in achieving low IAR, burden of disease[12–18], preventing additional VOC-driven waves[19], and mitigating the effect of decreased vaccine effectiveness[20] • Change in inter-dose vaccine period from 21 to 42 days is preferrable for vaccine mode of action at the end of infection course, severe	• Speed of vaccine rollout is key factor in achieving low IAR and disease burden[13] • Herd immunity could be reached in China by Sept 2021 if vaccines extended to age 3+[24]	• Speed of vaccine rollout is key factor in achieving low IAR and disease burden[16,18] and preventing additional VOC-driven waves[19,26] • Postponing second vaccine dose is not recommended to avoid VOC-driven waves[19] • Herd immunity could be reached in China by Sept 2021 if vaccines extended to age 3+[24]	• **Targeted vaccine roll out focusing on children[27] or adolescents[28–30] needed to mitigate spread and reach herd immunity** • **Mixing vaccine types may be effective against SARS-CoV-2**[8] • **Unvaccinated individuals about 10x more likely to experience symptomatic infections vs vaccinated people**[31] • Speed of vaccine rollout is key factor in achieving low IAR and disease burden[16], preventing additional VOC-driven waves [19], and mitigating the effect of decreased vaccine effectiveness[20] • Prioritizing first dose is recommended, as higher protection

	epidemic and low vaccine supply rate[21] • Postponing second vaccine dose is not recommended to avoid VOC-driven waves[19] • Proactive surveillance and prioritized vaccination can reduce severe illness and mortality in vulnerable groups[22] with vaccinating children enhancing these benefits[23,24] • Minimal impact of vaccinating youth (10-19yr) in reducing transmission, unless 80% of adult population is vaccinated[25]			associated with extended schedules[32] • Postponing second vaccine dose is not recommended to avoid VOC-driven waves[19] • Herd immunity could be reached in China by Sept 2021 if vaccines extended to age 3+; however, 87.5% of entire population would need to be vaccinated with a 95% efficacious vaccine using Delta's transmission properties[24]
Modelling potential vaccination rollout schedules *for third doses*	• Third dose of vaccine is required to eliminate developing mutations and reduce transmission rates[33,34]	• Third dose of vaccine is required to eliminate developing mutations and reduce transmission rates[33]	• Third dose of vaccine is required to eliminate developing mutations and reduce transmission rates[33]	• **Third dose of vaccine provides good protection against VOC[35] and may be necessary to mitigate the expected waning immunity of vaccines and increased infectivity of Delta[28,36]** • Third dose of vaccine is required to eliminate developing mutations, reduce

				transmission rates[33,34]
Evaluating vaccination rollout schedules *for first and second doses*	• Prioritizing first dose is recommended, as higher protection is associated with extended schedules[32,37] **particularly in individuals not previously exposed to SARS-CoV-1**[38] • Mixing doses (AstraZeneca + Pfizer) at 10-12 week intervals was well tolerated & improved immunogenicity compared to 2 doses of the same vaccine at the same or shorter intervals[39] ***Appraised studies were of high quality***	• Mixing doses (AstraZeneca + Pfizer) at 10-12 week intervals was well tolerated & improved immunogenicity compared to 2 doses of the same vaccine at the same or shorter intervals[39] • **2 doses of vaccine with 10 week delay increases antibody response in serum samples of both previously infected and naïve individuals**[40] • **Second dose can be delayed in situations of limited supply and high incidence**[41] ***Appraised studies were of high quality***	• Targeted vaccination of 80+ age group associated with decreased mortality compared with younger group[42] ***Appraised study was of medium quality***	• Prioritizing first dose is recommended, as higher protection associated with extended schedules[32] **particularly in individuals not previously exposed to SARS-CoV-1**[38] • **2 doses of vaccine with 10-week delay increases antibody response in serum samples of both previously infected and naïve individuals**[40] • **Transmission reduction declines 3 months post 2-dose regime of Pfizer and AZ**[43] ***Appraised studies were of medium to high quality***
Evaluating vaccination rollout schedules *for third doses*	• **Third dose of vaccine provides good protection against VOC**[44,45]	N/A	• **Third dose of vaccine provides good protection against VOC**[44,45]	• Third doses can increase antibody levels and neutralizing

	Appraised study was of medium quality		*Appraised study was of medium quality*	capability[46] among immunocompromised individuals[47] • **Third dose can result in short term reduction of testing positive for Delta compared with 2-dose regime**[46] • **Third dose of vaccine provides good protection against VOC**[44,45,48,49] *Appraised studies were of medium quality*
Modelling different vaccine schedules in relation to NPIs *in the general population*	• Advocate for NPIs to remain in place during vaccine roll out until sufficient population immunity[25,50–57] • NPIs alongside accelerated vaccine roll out is needed to control outbreak[18,28,30,31,54,57–61], **with a focus on targeting vulnerable populations**[9] • In OECD, countries fully vaccinating 40% of the population would allow for easing of containment policies[62]	• Advocate for NPIs to remain in place during vaccine roll out until sufficient population immunity[50,51,57]	• **Advocate for NPIs to remain in place during vaccine roll out until sufficient population immunity**[57] • **NPIs alongside accelerated vaccine rollout is needed to control outbreak**[18] • **Herd immunity is achieved through a combination of natural immunity, the use of different vaccines and social distancing**[26]	• **Advocate for NPIs to remain in place during vaccine roll out until sufficient population immunity**[57] • Combination vaccine (accelerated) and NPIs are required to reduce transmission rate[19,56,58,63–69], hospitalizations and deaths[70] • Stringent NPIs and third booster may be needed to stop spread of Delta[36,71,72]

Modelling different vaccine schedules in relation to NPIs *in school settings*	N/A	N/A	N/A	• Even with the combination of vaccine and NPIs, infections will hit school aged children the hardest during the Fall 2021[73] • NPI and intense vaccine strategy targeting students [29,74] **and/or teachers**[75] is needed to substantially reduce the risk of infection • Increasing vaccine coverage in adolescents and regular testing essential to keep schools open[76]
Evaluating different vaccine schedules in relation to NPIs *in the general population*	N/A	N/A	N/A	• **High vaccine rates plus multicomponent prevention strategies are important to reduce transmission in congregate settings**[77] ***Appraised study was of high quality***
Evaluating different vaccine schedules in relation to NPIs *in school settings*	N/A	N/A	N/A	• **Staff vaccination and strict NPI are needed in schools to protect younger children**[78]

				Appraised study was of medium quality

Table 3. Evidence related to infection prevention measures, divided by VOC
*Note: Only observational studies were appraised for quality

Category	Alpha (B.1.1.7)	Beta (B.1.351)	Gamma (P.1)	Delta (B.1.617.2)
Infection prevention measures				
Hand washing	• VOC responds similarly to ethanol and soap as non-VOC[79] • Vaccinated individuals may do less handwashing than non-vaccinated individuals[80] ***Appraised study was of medium quality***	• VOC responds similarly to ethanol and soap as non-VOC[79] • Vaccinated individuals may do less handwashing than non-vaccinated individuals[80] ***Appraised study was of medium quality***	• Vaccinated individuals may do less handwashing than non-vaccinated individuals[80] ***Appraised study was of medium quality***	• Vaccinated individuals may do less handwashing than non-vaccinated individuals[80] ***Appraised study was of medium quality***
Hand washing—*Modelling studies*	N/A	N/A	N/A	N/A
Masking	• No difference was found between surgical and cloth masks, but tighter fitting masks recommended indoors[81] • Double mask combination of surgical/two-layer cloth l + N-95 improved fit and protection[82] • Vaccination status did not change mask wearing in China[80] ***Appraised studies were of medium quality***	• Double mask combination of surgical/two-layer cloth + N-95 improved fit and protection[82] • Vaccination status did not change mask wearing in China[80] ***Appraised study was of medium quality***	• Double mask combination of surgical/two-layer cloth + N-95 improved fit and protection[82] • Vaccination status did not change mask wearing in China[80] ***Appraised study was of medium quality***	• Vaccination status did not change mask wearing in China[80] ***Appraised study was of medium quality***

Masking <u>in the general population</u>—*Modelling studies*	• Moderately effective masks, when worn consistently correctly by a large portion of the population, are effective at preventing transmission[83]	N/A	N/A	• **Regardless of vaccination status, masks can reduce the spread of COVID-19**[69] • **Masks are recommended in the workplace unless 100% vaccination with 95% effectiveness and community infection rate is <150 per 100,000**[84]
Masking <u>in school settings</u>—*Modelling studies*	N/A	N/A	N/A	• Universal masking in schools is recommended to reduce in-school transmission[71,75,85–87]
Physical distancing	• Settings where physical distancing is unlikely (e.g., hair salons, visiting with friends inside the home) present the highest risk of transmission[88] • In daycares, strict contact restrictions like group assignments among children and staff assignments to groups prevent infections[89] • Vaccinated individuals may engage in less physical distancing than non-vaccinated individuals[80]	• Vaccinated individuals may engage in less physical distancing than non-vaccinated individuals[80]	• Vaccinated individuals may engage in less physical distancing than non-vaccinated individuals[80]	• Vaccinated individuals may engage in less physical distancing than non-vaccinated individuals[80]

	Appraised studies were of medium to high quality	***Appraised study was of medium quality***	***Appraised study was of medium quality***	***Appraised study was of medium quality***
Physical distancing <u>in the general population</u>— ***Modelling studies***	• Strong physical distancing measures are critical, even with a mass vaccination campaign[19,91] and physical distancing may need to be strengthened by 33.7%[93]	• Strong physical distancing measures are critical even with a mass vaccination campaign[50,94]	• Strong physical distancing measures are critical even with a mass vaccination campaign[94]	• Strong physical distancing measures and high compliance are critical even with a mass vaccination campaign[19,91,92]
Physical distancing <u>in school settings</u>— ***Modelling studies***	• **Adult physical distancing may need to be reduced by 30%[66] to minimize high case counts and allow children to return to school**	N/A	N/A	• **Adult physical distancing may need to be reduced by 30%[66] to minimize high case counts and allow children to return to school** • **Increasing social distance (e.g., hybrid schooling) can reduce peak hospitalization and death, although it is more disruptive to learning[87]**

Table 4. Evidence related to infection control measures, divided by VOC
*Note: Only observational studies were appraised for quality

Category	Alpha (B.1.1.7)	Beta (B.1.351)	Gamma (P.1)	Delta (B.1.617.2)
Infection control measures				
Testing in the general population	• Offering voluntary testing 1-2 times/week to all employees and daily to close contacts of cases for 10 days allowed employees to continue working rather than quarantine[95] • Employees more likely to get tested using saliva samples than nasal swabs[95] • Testing and routine surveillance of populations at risk are critical[96] • Self-collection and pooling approaches to testing of travellers allows large-scale screening using less human, material and financial resources[97] ***Appraised studies were of high quality***	• Offering voluntary testing 1-2 times/week to all employees and daily to close contacts of cases for 10 days allowed employees to continue working rather than quarantine • Employees more likely to get tested using saliva samples than nasal swabs[95] ***Appraised study was of high quality***	• Mass saliva analysis is a cheap, easy to collect, and feasible asymptomatic testing strategy to potentially slow variant outbreaks[98] ***Appraised study was of low quality***	N/A
Testing in school settings	• **In one university setting, compulsory weekly testing of students living in dormitories successfully detected an outbreak**[99]; in another, asymptomatic mass testing needed to be	N/A	N/A	N/A

	very frequent (~every 3 days) to be effective at containing outbreaks[100] ***Appraised study was of medium quality***			
Testing <u>in the general population</u>—*Modelling studies*	• **Expanding testing capacity and reducing testing delays (e.g., time from testing to results) both have an effect on epidemic growth**[101] • Another strategy to prevent outbreaks in the workplace is to offer targeted rapid testing (rather than mass testing) and begin quarantine procedures sooner for direct and indirect contacts[102] • Testing and routine surveillance of populations at risk are critical[103] • Surveillance of travellers remains important[52] • Daily testing for 5 days could circumvent the need for quarantine of travellers[104] • Pre-flight tests may prevent the majority of transmission from travellers[104]	• **Expanding testing capacity and reducing testing delays (e.g., time from testing to results) both have an effect on epidemic growth**[101] • Testing and routine surveillance of populations at risk are critical even with a mass vaccination campaign[50]	• **Expanding testing capacity and reducing testing delays (e.g., time from testing to results) both have an effect on epidemic growth**[101]	• **More frequent testing (PCR or rapid antigen) is an effective NPI against Delta**[75,84,105,106] • **Rapid antigen tests perform best in low prevalence settings; when prevalence increases, they perform poorly due to high numbers of false negatives**[105] • **Rapid antigen test performance improves with repeat testing (in one model, 2 tests 36 hours apart**[105]**; in another, 3 times/week**[84] • **Expanding testing capacity and reducing testing delays (e.g., time from testing to results) both have an effect on epidemic growth**[101] • The optimal testing strategy is weekly testing of the entire unvaccinated population, plus a 10-day isolation requirement for positive cases and their households[107,108]

Testing <u>in school settings</u>—*Modelling studies*	N/A	N/A	N/A	• **In schools, the only single NPI (vs. combined NPIs) that is effective is antigen testing students twice weekly**[75] • **In schools, regular testing is a more effective strategy than bubble quarantining**[106] • In a model of partially vaccinated K-12 schools, regular testing effectively prevented outbreaks; effect correlated with frequency (i.e., testing 1-2 times/week was better than biweekly)[76] • In another model of K-12 schools with mandatory masking, testing 50% of students reduced infections to 22%[85]
Quarantine (close contacts and travellers) <u>in the general population</u>	• In a workplace with mandatory daily testing and other NPIs for close contacts, quarantine was not required to contain outbreaks[95] • Alpha cases almost twice as likely to give rise to household clusters compared with wild type cases, highlighting importance of quarantining household contacts[109,110]	• Some studies found that mandatory quarantine and contact tracing are required[77] • Conversely, in a workplace with mandatory daily testing and other NPIs for close contacts, quarantine was not required to contain outbreaks[95]	• Mandatory quarantine may be an effective way to contain Gamma[113]	N/A

	• Mandatory quarantine and contact tracing are required[77,96,104,111–113] ***Appraised studies were of low to high quality***	***Appraised studies were of high quality***	***Appraised study was of low quality***	
Quarantine (close contacts and travellers) <u>in the general population</u>—*Modelling studies*	• **At least 40% (ideally 50%) of close contacts must be traced and quarantined to achieve containment of strain-specific outbreaks**[101] • Mandatory quarantine and contact tracing are required[69,75] and may need to be extended to indirect contacts in workplace settings[102] • A 10-day quarantine period may be as effective as a 14-day quarantine period[104]	• **At least 40% (ideally 50%) of close contacts must be traced and quarantined to achieve containment of strain-specific outbreaks**[101] • Some studies found that mandatory quarantine and contact tracing are required[76], and Beta may require more extreme quarantine and testing measures than other variants[111]	• **At least 40% (ideally 50%) of close contacts must be traced and quarantined to achieve containment of strain-specific outbreaks**[101] • Forced prolonged cohabiting may boost viral ability to generate Gamma mutation[114]	• **At least 40% (ideally 50%) of close contacts must be traced and quarantined to achieve containment of strain-specific outbreaks**[101]
Quarantine (close contacts and travellers) <u>in school settings</u>—*Modelling studies*	• In a university setting, quarantine of close contacts is important in preventing transmission during the term [100]	N/A	N/A	• **In schools, bubble quarantine (i.e., sending classroom contacts home) results in large numbers of pupils absent from school, with only modest impact on classroom infection rates**[106] • In K-12 schools, reactive quarantining of classes with

				a confirmed case do not have a high benefit, but do have a high cost in terms of student-days lost[76]
Isolation (confirmed COVID-19/VOC cases)	N/A	N/A	N/A	N/A
Isolation (confirmed COVID-19/VOC cases) <u>in the general population</u>—*Modelling studies*	• Complete isolation of Alpha cases is required to prevent outbreaks; even a small number of infected people dramatically increases the probability of sustained community transmission[12]	N/A	N/A	• To control outbreaks, the optimal testing strategy is weekly testing of the entire unvaccinated population, plus a 10-day isolation requirement for positive cases and their households[107]
Isolation (confirmed COVID-19/VOC cases) <u>in school settings</u>—*Modelling studies*	• In a university setting, isolation of confirmed cases is important in preventing transmission during the term[100]	N/A	N/A	N/A
Lockdowns <u>in the general population</u>	• **Lockdowns can exacerbate outbreaks when transient workers are forced to return home from cities to smaller villages**[115]	• **Lockdowns can exacerbate outbreaks when transient workers are forced to return home from cities to smaller villages**[115]	N/A	• **Lockdown was one of the most effective strategies to address India's Delta wave**[116]
Lockdowns <u>in the general population</u>—	• **Decreased retail and recreational mobility contributed the most to a**	N/A	N/A	• Delta requires stronger lockdown measures than wild type [34,64]

Modelling studies	**reduction in community transmission**[117] • Alpha requires stronger lockdown measures than wild type[34,60,64,118,119] including increased length,[120,121] earlier implementation[118] and stricter regional travel restrictions[34,103] • Shorter, stricter lockdowns may be more effective than longer, moderate lockdowns due to waning adherence[122]			• In an Australian model, the strength of lockdown had a bigger impact on hospitalizations and deaths than vaccination strategies[70] • Early public interventions—lockdowns imposed during an 'optimal time window'—lead to reduced death counts from Delta[123]
Lockdowns <u>in school settings</u>—*Modelling studies*	• Keeping schools partially open while keeping most of society closed brought R below 1 in a UK model[65]	N/A	N/A	N/A
Other/combined NPIs <u>in the general population</u>	• In June 2021, when Alpha was still prevalent, VOC were highest in Canadian provinces with moderate vaccine uptake and strict NPIs, and lowest in provinces with low vaccine uptake and moderate NPIs; this may suggest that the *timing* of NPI implementation (reactive vs. proactive) may have more of an impact than stringency[124]	• NPIs should be implemented until herd immunity is reached[24]	N/A	• **Combined NPIs were required to address India's Delta wave**[116] • NPIs should be implemented until herd immunity is reached[24]

	• In daycares, NPIs like closures in the event of an outbreak can help contain Alpha[125] ***Appraised study is of high quality***			
Other/combined NPIs <u>in school settings</u>	• **Opening schools is associated with increased infection rates in the community, but transmission is more likely to occur outside of school and be related to community prevalence[126]** • **Public health measures in the community decreased school-related growth 2-6 times[126]** • **In a university setting, isolation of students with COVID-19, contact tracing, and institution-wide prevention measures contributed to reductions in transmission[99]** ***Appraised study is of medium quality***	N/A	N/A	• **In schools, combined NPIs such as masking, routine testing, ventilation, social distancing, and isolation when symptomatic are very important[78,106]** ***Appraised study is of medium quality***
Other/combined NPIs <u>in the general population</u>—	• Multiple NPIs are more effective than single NPIs,[17,24] and reactive NPIs (e.g., quarantine of close	N/A	• Strict NPIs are required to contain Gamma[24,63]	• **Combined NPIs in the community have an immediate impact on case levels vs. the delayed impact of vaccines[71]**

Modelling studies	contacts) must be deployed quickly • Strong test-trace-isolate programs can be sufficient to maintain low case numbers[58,127] • Regional mobility networks and spatial connectivity drive patterns of transmission throughout the United States[91] • Strict NPIs may lead to overdispersion of highly transmissible variants, leading to their eventual dominance[128]; evolution of highly transmissible variants may actually be a sign that NPI policies are effective[129]			• **In a model of France, the only way to contain Delta was to keep combined NPIs in place until 100% vaccination coverage was reached**[57] • Regional mobility networks and spatial connectivity drive patterns of transmission throughout the United States[91] • Even modest improvements in a find, test, trace, isolate and support program would control transmission[130]
Other/combined NPIs <u>in school settings</u>—*Modelling studies*	• In a university setting, staggering the return of students to residences is not significantly effective in preventing transmission[100]	N/A	N/A	• **The most effective NPI combination to prevent outbreaks in schools is improved ventilation and weekly antigen testing of teachers and students if a student is the source of infection; if a teacher is the source, mask usage is also required**[75] • In schools, continued use of multiple NPIs (e.g., universal masking and distancing or cohorting) is

				recommended[29,74,131], combined with high vaccination coverage[86]

Overview of the Evidence

As of October 22, 2021, 126 studies have reported on VOC and public health measures. We include 84 studies from earlier reports (including 21 studies from an earlier rapid review[6], 31 from the first iteration of this report[132], and 32 from the updated search on August 25, 2021). The key findings of included studies can be found in tables 2-4 above, while a more detailed summary of each study can be found in the supplementary material tables. The majority of reported evidence was related to Alpha (n=88), with fewer studies reporting on Beta (n=28 studies), Gamma (n=25 studies) and a rapidly growing volume of evidence related to Delta (n=60 studies).

Modifying Approach to Vaccine Delivery

- 76[8–34,36–39,39–60,62–69,71–78,86,88,99,108,133] studies reported on vaccine delivery. The majority of modelling studies explored potential vaccine rollout schedules and made recommendations for accelerated vaccination campaigns. This included studies that modelled vaccine rollout in both the presence and absence of NPIs, such as lockdown measures.
- **There is evidence to support delay of the second dose under certain conditions, such as limited supply and high incidence.**[22,23,38,40,41]
- Evidence is emerging about the value of third dose or booster vaccines[33], particularly in the context of Delta[43–46,48,72,88] and immunocompromised patients.[47]
- Several modelling studies[73,74,76]suggest infections will likely hit school-aged children the hardest and recommend different targeted vaccine schedules with continued NPIs including testing.
- NPIs are recommended to continue in tandem with a vaccine rollout schedule.
- **Modelling studies suggest that extending vaccine rollout to children and/or adolescents would help mitigate the spread of VOC, particularly Delta.**[27–30]

Infection Prevention Measures

- The one study that reported on handwashing and VOC found that Alpha and Beta respond similarly to ethanol and soap as wildtype SARS-CoV-2.[79]
- One study found that vaccinated individuals may engage in less handwashing and physical distancing than non-vaccinated individuals but not mask wearing.[80]
- **Modelling studies suggest that when worn correctly, masks are effective against Alpha**[83] **and Delta, regardless of vaccination status**[69]**, unless 100% vaccination with 95% effectiveness and community infection rate are <150 per 100,000.**[84]
- One study found no difference between cloth and surgical masks against Alpha,[81] but another study found double masking better for protection against all VOCs.[82]
- **Universal masking in schools is recommended to reduce in-school transmission.**[71,75,85–87]
- **Nine** studies reported on VOC and physical distancing measures.[19,50,66,87–90,93,94] All studies recommended imposing strong physical distancing measures in the presence of all VOCs. **Two studies suggest that reducing social contacts by adults may be required**

to minimize spread and keep children in school, yet hybrid learning may further reduce the spread of COVID-19, hospitalization, and death.[66,87]

Infection Control Measures

- Twenty[50,52,75,76,84,85,95–108] studies reported on testing strategies related to VOC. Testing and routine surveillance of populations are critical to containing Alpha, Beta and Delta, even in the presence of mass vaccination campaigns. Cheaper approaches to testing are possible for detecting Alpha and Gamma.
- Fourteen[94–96,100–102,104,106,109–114] studies reported on quarantine and VOC. Mandatory quarantine were reported as necessary to contain Alpha and Beta. Alpha and Gamma were identified as giving rise to more household clusters than wildtype, suggesting a need for adequate household quarantine measures.
- Three[12,100,107] studies reported on isolation and VOC to contain transmission of the virus. One study was related to Alpha and Gamma respectively. Isolation duration varied across studies.
- Thirteen[60,64,65,70,103,115–121,123] studies reported on lockdowns and VOC. All studies reported needing strict lockdown measures to contain Alpha or Delta. Some studies recommended longer lockdowns and more restrictive travel restrictions, while one study recommended short, strict lockdowns to mitigate the waning adherence to longer lockdowns. Two studies suggested earlier implementation of lockdown measures to limit virus spread[105,123].
- Twenty-four[17,24,37,57,58,63,71,74,75,78,86,91,99,100,102,106,116,125–131] studies reported on other NPI infection control measures and VOC. Two studies recommended modest to strong test, trace and isolate strategies as necessary to control the spread of Alpha and Delta. Two studies found that deploying a combination of NPIs is more effective than single NPIs[17,24], and multiple studies recommended employing NPIs in conjunction with vaccine rollout to mitigate the spread of Alpha or Delta.

Methods

This living synthesis is building on previous evidence gathered up to May 11, 2021. Searches for this update were run on October 4, 2021, in MEDLINE (Ovid MEDLINE All), Embase (Elsevier Embase.com), the Cochrane Database of Systematic Reviews (CDSR) and Central Register of Controlled Trials (CENTRAL) (Cochrane Library, Wiley), Epistemonikos' L·OVE on COVID-19, and medRxiv and bioRxiv. Titles/abstracts and full text were screened independently by two reviewers. Data were double extracted using a standardized form. Studies were included if they reported on at least one of the VOC and public health measures. Critical appraisal was conducted for case-control, cohort, and cross-sectional studies using the Newcastle-Ottawa Scale for studies included in our previous rapid review[6] while the appropriate Joanna Briggs critical appraisal tools were used for studies included in the living syntheses. Critical appraisal was not conducted for modelling or laboratory studies.

List of Abbreviations

COVID-19: coronavirus disease 2019
IAR: infection attack rate
NPI: non-pharmaceutical intervention/s
R: effective reproduction number
VOC: variant/s of concern
WHO: World Health Organization

References

1. Cucinotta D, Vanelli M. WHO Declares COVID-19 a Pandemic. Acta Bio-Medica Atenei Parm. 2020 19;91(1):157–60.

2. World Health Organization. Global Situation: WHO Coronavirus (COVID-19) Dashboard [Internet]. 2021. Available from: https://covid19.who.int/

3. WHO. Tracking SARS-CoV-2 variants [Internet]. 2021 [cited 2021 Jun 7]. Available from: https://www.who.int/en/activities/tracking-SARS-CoV-2-variants/

4. WHO. COVID-19 Weekly epidemiological update - February 25, 2021 [Internet]. 2021 Feb [cited 2021 Mar 12]. Available from: https://www.who.int/publications/m/item/covid-19-weekly-epidemiological-update

5. Davies NG, Abbott S, Barnard RC, Jarvis CI, Kucharski AJ, Munday JD, et al. Estimated transmissibility and impact of SARS-CoV-2 lineage B.1.1.7 in England. Science [Internet]. 2021 Apr 9 [cited 2021 Apr 24];372(6538). Available from: https://science.sciencemag.org/content/372/6538/eabg3055

6. Curran J, Dol J, Boulos L, Somerville M, McCulloch H. Public Health and Health Systems Impacts of SARS-CoV-2 Variants of Concern: A Rapid Scoping Review. medRxiv. 2021 May 22;2021.05.20.21257517.

7. Public Health Agency of Canada (PHAC). Emerging Evidence on COVID-19: Living summary of SARS-CoV-2 Variants of Concern, April 28th 2021 version. 2021;

8. Rose R, Neumann F, Grobe O, Lorentz T, Fickenscher H, Krumbholz A. The anti-SARS-CoV-2 immunoglobulin G levels and neutralising capacities against alpha and delta virus variants of concern achieved after initial immunisation with vector vaccine followed by mRNA vaccine boost are comparable to those after double immunisation with mRNA vaccines [Internet]. Infectious Diseases (except HIV/AIDS); 2021 Jul [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.07.09.21260251

9. Gollier C. The Welfare Cost of Vaccine Misallocation, Delays and Nationalism. J Benefit-Cost Anal. 2021;12(2):199–226.

10. Sah P, Vilches TN, Moghadas SM, Fitzpatrick MC, Singer BH, Hotez PJ, et al. Accelerated vaccine rollout is imperative to mitigate highly transmissible COVID-19 variants. EClinicalMedicine [Internet]. 2021 May 1 [cited 2021 May 26];35. Available from: https://www.thelancet.com/journals/eclinm/article/PIIS2589-5370(21)00145-0/abstract

11. Tokuda Y, Kuniya T. Japan's Covid mitigation strategy and its epidemic prediction. medRxiv. 2021 May 7;2021.05.06.21256476.

12. Sanz-Leon P, Stevenson NJ, Stuart RM, Abeysuriya RG, Pang JC, Lambert SB, et al. Susceptibility of zero community transmission regimes to new variants of SARS-CoV-2: a modelling study of Queensland. medRxiv. 2021 Jul 8;2021.06.08.21258599.

13. Kim D, Keskinocak P, Pekgün P, Yildirim I. The Balancing Role of Distribution Speed against Varying Efficacy Levels of COVID-19 Vaccines under Variants. medRxiv. 2021 Apr 13;2021.04.09.21255217.

14. Braun P, Braun J, Woodcock BG. COVID-19: Effect-modelling of vaccination in Germany with regard to the mutant strain B.1.1.7 and occupancy of ICU facilities. Int J Clin Pharmacol Ther. 2021 Jul 1;59(07):487–95.

15. Mancuso M, Eikenberry SE, Gumel AB. Will Vaccine-derived Protective Immunity Curtail COVID-19 Variants in the US? medRxiv. 2021 Jul 13;2021.06.30.21259782.

16. Moghadas SM, Sah P, Fitzpatrick MC, Shoukat A, Pandey A, Vilches TN, et al. COVID-19 deaths and hospitalizations averted by rapid vaccination rollout in the United States. medRxiv. 2021 Jul 8;2021.07.07.21260156.

17. Cazelles B, Nguyen-Van-Yen B, Champagne C, Comiskey C. Dynamics of the COVID-19 epidemic in Ireland under mitigation. BMC Infect Dis. 2021 Dec;21(1):735.

18. Antonini C, Calandrini S, Bianconi F. A Modeling Study on Vaccination and Spread of SARS-CoV-2 Variants in Italy. Vaccines. 2021 Aug 17;9(8):915.

19. España G, Cucunubá ZM, Cuervo-Rojas J, Díaz H, González-Mayorga M, Ramírez JD. The potential impact of delta variant of SARS-CoV-2 in the context of limited vaccination coverage and increasing social mixing in Bogotá, Colombia [Internet]. Epidemiology; 2021 Aug [cited 2021 Sep 3]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.06.21261734

20. Krueger T, Gogolewski K, Bodych M, Gambin A, Giordano G, Cuschieri S, et al. Assessing the risk of COVID-19 epidemic resurgence in relation to the Delta variant and to vaccination passes [Internet]. Epidemiology; 2021 May [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.05.07.21256847

21. Berec L, Levínský R, Weiner J, Šmíd M, Neruda R, Vidnerová P, et al. Importance of epidemic severity and vaccine mode of action and availability for delaying the second vaccine dose. medRxiv. 2021 Jul 5;2021.06.30.21259752.

22. Munitz A, Yechezkel M, Dickstein Y, Yamin D, Gerlic M. BNT162b2 vaccination effectively prevents the rapid rise of SARS-CoV-2 variant B.1.1.7 in high-risk populations in Israel. Cell Rep Med. 2021 May 18;2(5):100264.

23. Tran Kiem C, Massonnaud CR, Levy-Bruhl D, Poletto C, Colizza V, Bosetti P, et al. A modelling study investigating short and medium-term challenges for COVID-19 vaccination: From prioritisation to the relaxation of measures. EClinicalMedicine. 2021 Aug;38:101001.

24. Liu H, Zhang J, Cai J, Deng X, Peng C, Chen X, et al. Herd immunity induced by COVID-19 vaccination programs to suppress epidemics caused by SARS-CoV-2 wild type and variants in China [Internet]. Epidemiology; 2021 Jul [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.07.23.21261013

25. Aruffo E, Yuan P, Tan Y, Gatov E, Moyles I, Bélair J, et al. Mathematical modeling of vaccination rollout and NPIs lifting on COVID-19 transmission with VOC: a case study in Toronto, Canada [Internet]. Epidemiology; 2021 Aug [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.11.21261932

26. Fiori M, Bello G, Wschebor N, Lecumberry F, Ferragut A, Mordecki E. SARS-CoV-2 epidemic in the South American Southern cone: can combined immunity from vaccination and infection prevent the spread of Gamma and Lambda variants while easing restrictions? [Internet]. Epidemiology; 2021 Sep [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.09.16.21263701

27. McBryde ES, Meehan MT, Caldwell JM, Adekunle AI, Ogunlade ST, Kuddus MA, et al. Modelling direct and herd protection effects of vaccination against the SARS-CoV-2 Delta variant in Australia. Med J Aust. 2021 Oct 11;mja2.51263.

28. Milne G, Carrivick J, Whyatt D. Reliance on Vaccine-Only Pandemic Mitigation Strategies is Compromised by Highly Transmissible COVID-19 Variants: A Mathematical Modelling Study. SSRN Electron J [Internet]. 2021 [cited 2021 Oct 21]; Available from: https://www.ssrn.com/abstract=3911100

29. Cuesta-Lazaro C, Quera-Bofarull A, Aylett-Bullock J, Lawrence BN, Fong K, Icaza-Lizaola M, et al. Vaccinations or Non-Pharmaceutical Interventions: Safe Reopening of Schools in England [Internet]. Epidemiology; 2021 Sep [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.09.07.21263223

30. Reingruber J, Papale A, Ruckly S, Timsit J-F, Holcman D. Monitoring and forecasting the SARS-CoV-2 pandemic in France [Internet]. Epidemiology; 2021 Jul [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.07.28.21260870

31. de León UA-P, Avila-Vales E, Huang K. Modeling the transmission of the SARS-CoV-2 delta variant in a partially vaccinated population [Internet]. Epidemiology; 2021 Sep [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.09.23.21264032

32. Amirthalingam G, Bernal JL, Andrews NJ, Whitaker H, Gower C, Stowe J, et al. Higher serological responses and increased vaccine effectiveness demonstrate the value of extended vaccine schedules in combatting COVID-19 in England [Internet]. Infectious Diseases (except HIV/AIDS); 2021 Jul [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.07.26.21261140

33. Quinonez E, Vahed M, Hashemi Shahraki A, Mirsaeidi M. Structural Analysis of the Novel Variants of SARS-CoV-2 and Forecasting in North America. Viruses. 2021 May;13(5):930.

34. Mathiot J-F, Gerbaud L, Breton V. PERCOVID: A Model to Describe COVID Percolation on a Network of Social Relationships [Internet]. Epidemiology; 2021 Sep [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.31.21262909

35. Chen X, Wang W, Chen X, Wu Q, Sun R, Ge S, et al. Prediction of long-term kinetics of vaccine-elicited neutralizing antibody and time-varying vaccine-specific efficacy against the SARS-CoV-2 Delta variant by clinical endpoint [Internet]. Public and Global Health; 2021 Sep [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.09.23.21263715

36. De-Leon H, Aran D. What pushed Israel out of herd immunity? Modeling COVID-19 spread of Delta and Waning immunity [Internet]. Epidemiology; 2021 Sep [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.09.12.21263451

37. Payne RP, Longet S, Austin JA, Skelly D, Dejnirattisai W, Adele S, et al. Sustained T Cell Immunity, Protection and Boosting Using Extended Dosing Intervals of BNT162b2 mRNA Vaccine. SSRN Electron J [Internet]. 2021 [cited 2021 Sep 10]; Available from: https://www.ssrn.com/abstract=3891065

38. Tauzin A, Gong SY, Beaudoin-Bussières G, Vézina D, Gasser R, Nault L, et al. Strong humoral immune responses against SARS-CoV-2 Spike after BNT162b2 mRNA vaccination with a sixteen-week interval between doses [Internet]. Infectious Diseases (except HIV/AIDS); 2021 Sep [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.09.17.21263532

39. Hillus D, Schwarz T, Tober-Lau P, Vanshylla K, Hastor H, Thibeault C, et al. Safety, reactogenicity, and immunogenicity of homologous and heterologous prime-boost immunisation with ChAdOx1 nCoV-19 and BNT162b2: a prospective cohort study. Lancet Respir Med. 2021 Aug;S221326002100357X.

40. Urbanowicz RA, Tsoleridis T, Jackson HJ, Cusin L, Duncan JD, Chappell JG, et al. Two doses of the SARS-CoV-2 BNT162b2 vaccine enhance antibody responses to variants in individuals with prior SARS-CoV-2 infection. Sci Transl Med. 2021 Sep;13(609):eabj0847.

41. Abu-Raddad LJ, Chemaitelly H, Yassine HM, Benslimane FM, Al Khatib HA, Tang P, et al. Pfizer-BioNTech mRNA BNT162b2 Covid-19 vaccine protection against variants of concern after one versus two doses. J Travel Med. 2021 Oct 11;28(7):taab083.

42. Victora C, Castro MC, Gurzenda S, Barros AJD. Estimating the early impact of immunization against COVID-19 on deaths among elderly people in Brazil: analyses of secondary data on vaccine coverage and mortality. medRxiv. 2021 Apr 30;2021.04.27.21256187.

43. Eyre DW, Taylor D, Purver M, Chapman D, Fowler T, Pouwels K, et al. The impact of SARS-CoV-2 vaccination on Alpha and Delta variant transmission [Internet]. Infectious Diseases (except HIV/AIDS); 2021 Sep [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.09.28.21264260

44. Wang K, Cao Y, Zhou Y, Wu J, Jia Z, Hu Y, et al. A third dose of inactivated vaccine augments the potency, breadth, and duration of anamnestic responses against SARS-CoV-2 [Internet]. Infectious Diseases (except HIV/AIDS); 2021 Sep [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.09.02.21261735

45. Yorsaeng R, Suntronwong N, Phowatthanasathian H, Assawakosri S, Kanokudom S, Thongmee T, et al. Immunogenicity of a third dose viral-vectored COVID-19 vaccine after receiving two-dose inactivated vaccines in healthy adults [Internet]. Allergy and Immunology; 2021 Sep [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.09.16.21263692

46. Patalon T, Gazit S, Pitzer VE, Prunas O, Warren JL, Weinberger DM. Short Term Reduction in the Odds of Testing Positive for SARS-CoV-2; a Comparison Between Two Doses and Three doses of the BNT162b2 Vaccine [Internet]. Infectious Diseases (except HIV/AIDS); 2021 Aug [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.29.21262792

47. Karaba AH, Zhu X, Liang T, Wang KH, Rittenhouse AG, Akinde O, et al. A Third Dose of SARS-CoV-2 Vaccine Increases Neutralizing Antibodies Against Variants of Concern in Solid Organ Transplant Recipients [Internet]. Infectious Diseases (except HIV/AIDS); 2021 Aug [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.11.21261914

48. Bar-On YM, Goldberg Y, Mandel M, Bodenheimer O, Freedman L, Kalkstein N, et al. BNT162b2 vaccine booster dose protection: A nationwide study from Israel [Internet]. Epidemiology; 2021 Aug [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.27.21262679

49. 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 [Internet]. Infectious Diseases (except HIV/AIDS); 2021 Sep [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.29.21262798

50. Giordano G, Colaneri M, Di Filippo A, Blanchini F, Bolzern P, De Nicolao G, et al. Modeling vaccination rollouts, SARS-CoV-2 variants and the requirement for non-pharmaceutical interventions in Italy. Nat Med. 2021 Apr 16;1–6.

51. Pageaud S, Ponthus N, Gauchon R, Pothier C, Rigotti C, Eyraud-Loisel A, et al. Adapting French COVID-19 vaccination campaign duration to variant dissemination. medRxiv. 2021 Mar 20;2021.03.17.21253739.

52. Sachak-Patwa R, Byrne H, Dyson L, Thompson R. The risk of SARS-CoV-2 outbreaks in low prevalence settings following the removal of travel restrictions [Internet]. Research Square. 2021 [cited 2021 Jul 27]. Available from: https://www.researchsquare.com/article/rs-547702/v1

53. Betti M, Bragazzi N, Heffernan J, Kong J, Raad A. Could a New COVID-19 Mutant Strain Undermine Vaccination Efforts? A Mathematical Modelling Approach for Estimating the Spread of B.1.1.7 Using Ontario, Canada, as a Case Study. Vaccines. 2021 Jun;9(6):592.

54. Borchering RK. Modeling of Future COVID-19 Cases, Hospitalizations, and Deaths, by Vaccination Rates and Nonpharmaceutical Intervention Scenarios — United States, April–September 2021. MMWR Morb Mortal Wkly Rep [Internet]. 2021 [cited 2021 Jul 27];70. Available from: https://www.cdc.gov/mmwr/volumes/70/wr/mm7019e3.htm

55. Conn H, Taylor R, Willis MJ, Wright A, Bramfitt V. Mechanistic model calibration and the dynamics of the COVID-19 epidemic in the UK (the past, the present and the future). medRxiv. 2021 May 22;2021.05.18.21257384.

56. Jayasundara P, Peariasamy KM, Law KB, Rahim KNKA, Lee SW, Ghazali IMM, et al. Sustaining effective COVID-19 control in Malaysia through large-scale vaccination. medRxiv. 2021 Jul 7;2021.07.05.21259999.

57. Vignals C, Dick DW, Thiébaut R, Wittkop L, Prague M, Heffernan J. Barrier gesture relaxation during vaccination campaign in France: modelling impact of waning immunity [Internet]. Epidemiology; 2021 Aug [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.29.21262788

58. Dimeglio C, Milhes M, Loubes J-M, Ranger N, Mansuy J-M, Trémeaux P, et al. Influence of SARS-CoV-2 Variant B.1.1.7, Vaccination, and Public Health Measures on the Spread of SARS-CoV-2. Viruses. 2021 May;13(5):898.

59. Zou Z, Fairley CK, Shen M, Scott N, Xu X, Li Z, et al. Critical timing for triggering public health interventions to prevent COVID-19 resurgence: a mathematical modelling study. medRxiv. 2021 Jul 7;2021.07.06.21260055.

60. Domenico LD, Sabbatini CE, Pullano G, Lévy-Bruhl D, Colizza V. Impact of January 2021 curfew measures on SARS-CoV-2 B.1.1.7 circulation in France. medRxiv. 2021 Mar 10;2021.02.14.21251708.

61. Bauer S, Contreras S, Dehning J, Linden M, Iftekhar E, Mohr SB, et al. Relaxing restrictions at the pace of vaccination increases freedom and guards against further COVID-19 waves. Struchiner CJ, editor. PLOS Comput Biol. 2021 Sep 2;17(9):e1009288.

62. Turner D, Égert B, Guillemette Y, Botev J. The tortoise and the hare: The race between vaccine rollout and new COVID variants. 2021 Jun 11 [cited 2021 Jul 27]; Available from: https://www.oecd-ilibrary.org/economics/the-tortoise-and-the-hare-the-race-between-vaccine-rollout-and-new-covid-variants_4098409d-en

63. Yang HM, Junior LPL, Castro FFM, Yang AC. Quarantine, relaxation and mutation explaining the CoViD-19 epidemic in São Paulo State (Brazil). medRxiv. 2021 Apr 15;2021.04.12.21255325.

64. Sonabend R, Whittles LK, Imai N, Perez-Guzman PN, Knock ES, Rawson T, et al. Non-pharmaceutical interventions, vaccination and the Delta variant: epidemiological insights from modelling England's COVID-19 roadmap out of lockdown [Internet]. Epidemiology; 2021 Aug [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.17.21262164

65. Panovska-Griffiths J, Stuart RM, Kerr CC, Rosenfield K, Mistry D, Waites W, et al. Modelling the impact of reopening schools in the UK in early 2021 in the presence of the alpha variant and with roll-out of vaccination against SARS-CoV-2 [Internet]. Epidemiology; 2021 Feb [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.02.07.21251287

66. Cipriano LE, Haddara WMR, Sander B. MITIGATING THE 4 th WAVE OF THE COVID-19 PANDEMIC IN ONTARIO [Internet]. Infectious Diseases (except HIV/AIDS); 2021 Sep [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.09.02.21263000

67. Wu J, Bragazzi NL, Scarabel F, McCarthy Z, David J, the LIAM/ADERSIM COVID-19 Reopening and Recovery Modeling Group. COVID-19 attack ratio among children critically depends on the time to removal and activity levels [Internet]. Infectious Diseases (except HIV/AIDS); 2021 Sep [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.09.25.21263542

68. Truelove S, Smith CP, Qin M, Mullany LC, Borchering RK, Lessler J, et al. Projected resurgence of COVID-19 in the United States in July—December 2021 resulting from the increased transmissibility of the Delta variant and faltering vaccination [Internet]. Epidemiology; 2021 Aug [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.28.21262748

69. McPeck R, Magori K. Masking significantly reduces, but does not eliminate COVID-19 infection in a spatial agent-based simulation of a University dormitory floor [Internet]. Epidemiology; 2021 Sep [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.09.13.21263458

70. Bablani L, Wilson T, Andrabi H, Sundararajan V, Ait Oukarim D, Abraham P, et al. Can a vaccine-led approach end the NSW outbreak in 100 days, or at least substantially reduce morbidity and mortality? [Internet]. Epidemiology; 2021 Aug [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.18.21262252

71. Raina MacIntyre C, Costantino V, Chanmugam A. The use of face masks during vaccine roll-out in New YorkCity and impact on epidemic control. Vaccine. 2021 Oct;39(42):6296–301.

72. Layton A, Sadria M. Understanding the Dynamics of SARS-CoV-2 Variants of Concern in Ontario, Canada: A Case Study [Internet]. In Review; 2021 Aug [cited 2021 Sep 2]. Available from: https://www.researchsquare.com/article/rs-788073/v1

73. Koslow W, Kühn MJ, Binder S, Klitz M, Abele D, Basermann A, et al. Appropriate relaxation of non-pharmaceutical interventions minimizes the risk of a resurgence in SARS-CoV-2 infections in spite of the Delta variant [Internet]. Infectious Diseases (except HIV/AIDS); 2021 Jul [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.07.09.21260257

74. Giardina J, Bilinski A, Fitzpatrick MC, Kendall EA, Linas BP, Salomon J, et al. When do elementary students need masks in school? Model-estimated risk of in-school SARS-CoV-2 transmission and related infections among household members before and after student vaccination [Internet]. Infectious Diseases (except HIV/AIDS); 2021 Aug [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.04.21261576

75. Lasser J, Sorger J, Richter L, Thurner S, Schmid D, Klimek P. Assessing the impact of SARS-CoV-2 prevention measures in Austrian schools by means of agent-based simulations calibrated to cluster tracing data [Internet]. Epidemiology; 2021 Apr [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.04.13.21255320

76. Colosi E, Bassignana G, Contreras DA, Poirier C, Cauchemez S, Yazdanpanah Y, et al. Self-testing and vaccination against COVID-19 to minimize school closure [Internet]. Infectious Diseases (except HIV/AIDS); 2021 Aug [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.15.21261243

77. Hagan LM, McCormick DW, Lee C, Sleweon S, Nicolae L, Dixon T, et al. Outbreak of SARS-CoV-2 B.1.617.2 (Delta) Variant Infections Among Incarcerated Persons in a Federal Prison — Texas, July–August 2021. MMWR Morb Mortal Wkly Rep. 2021 Sep 24;70(38):1349–54.

78. Lam-Hine T, McCurdy SA, Santora L, Duncan L, Corbett-Detig R, Kapusinszky B, et al. Outbreak Associated with SARS-CoV-2 B.1.617.2 (Delta) Variant in an Elementary School — Marin County, California, May–June 2021. MMWR Morb Mortal Wkly Rep. 2021 Sep 3;70(35):1214–9.

79. Meister T, Fortmann J, Todt D, Heinen N, Ludwig A, Brüggemann Y, et al. Comparable environmental stability and disinfection profiles of the currently circulating SARS-CoV-2 variants of concern B.1.1.7 and B.1.351. 2021.

80. Si R, Yao Y, Zhang X, Lu Q, Aziz N. Investigating the Links Between Vaccination Against COVID-19 and Public Attitudes Toward Protective Countermeasures: Implications for Public Health. Front Public Health. 2021 Jul 21;9:702699.

81. Adenaiye OO, Lai J, de Mesquita PJB, Hong F, Youssefi S, German J, et al. Infectious SARS-CoV-2 in Exhaled Aerosols and Efficacy of Masks During Early Mild Infection [Internet]. Infectious Diseases (except HIV/AIDS); 2021 Aug [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.13.21261989

82. Arumuru V, Samantaray SS, Pasa J. Double masking protection vs. comfort—A quantitative assessment. Phys Fluids. 2021 Jul;33(7):077120.

83. Gurbaxani BM, Hill AN, Paul P, Prasad PV, Slayton RB. Evaluation of Different Types of Face Masks to Limit the Spread of SARS-CoV-2 – A Modeling Study. medRxiv. 2021 Apr 27;2021.04.21.21255889.

84. Pettit R, Peng B, Yu P, Matos PG, Greninger AL, McCashin J, et al. Optimized Post-Vaccination Strategies and Preventative Measures for SARS-CoV-2 [Internet]. Health Informatics; 2021 Sep [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.09.17.21263723

85. Zhang Y, Johnson K, Lich KH, Ivy J, Keskinocak P, Mayorga M, et al. COVID-19 Projections for K12 Schools in Fall 2021: Significant Transmission without Interventions [Internet]. Infectious Diseases (except HIV/AIDS); 2021 Aug [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.10.21261726

86. Head JR, Andrejko KL, Remais JV. Model-based assessment of SARS-CoV-2 Delta variant transmission dynamics within partially vaccinated K-12 school populations [Internet]. Epidemiology; 2021 Aug [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.20.21262389

87. Mele J, Rosenstrom E, Ivy J, Mayorga M, Patel MD, Swann J. Mask Interventions in K12 Schools Can Also Reduce Community Transmission in Fall 2021 [Internet]. Health Policy; 2021 Sep [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.09.11.21263433

88. Chen C, Packer S, Turner C, Anderson C, Hughes G, Edeghere O, et al. Using Genomic Concordance to Estimate COVID-19 Transmission Risk Across Different Community Settings in England 2020/21. Prepr Lancet [Internet]. 2021 Jun 15 [cited 2021 Jul 27]; Available from: https://papers.ssrn.com/abstract=3867682

89. Neuberger F, Grgic M, Diefenbacher S, Spensberger F, Lehfeld A-S, Buchholz U, et al. COVID-19 infections in day care centres in Germany: Social and organisational determinants of infections in children and staff in the second and third wave of the pandemic. medRxiv. 2021 Jul 3;2021.06.07.21257958.

90. Borges V, Sousa C, Menezes L, Gonçalves AM, Picão M, Almeida JP, et al. Tracking SARS-CoV-2 lineage B.1.1.7 dissemination: insights from nationwide spike gene target failure (SGTF) and spike gene late detection (SGTL) data, Portugal, week 49 2020 to week 3 2021. Euro Surveill Bull Eur Sur Mal Transm Eur Commun Dis Bull. 2021 Mar;26(10).

91. Susswein Z, Valdano E, Brett T, Rohani P, Colizza V, Bansal S. Ignoring spatial heterogeneity in drivers of SARS-CoV-2 transmission in the US will impede sustained elimination [Internet]. Epidemiology; 2021 Aug [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.09.21261807

92. Chang S, Cliff O, Zachreson C, Prokopenko M. Nowcasting transmission and suppression of the Delta variant of SARS-CoV-2 in Australia [Internet]. In Review; 2021 Aug [cited 2021 Sep 2]. Available from: https://www.researchsquare.com/article/rs-757351/v1

93. Piantham C, Ito K. Estimating the increased transmissibility of the B.1.1.7 strain over previously circulating strains in England using frequencies of GISAID sequences and the distribution of serial intervals. medRxiv. 2021 Mar 30;2021.03.17.21253775.

94. Van Egeren D, Stoddard M, Novodhodko A, Rogers M, Joseph-McCarthy D, Zetter B, et al. The specter of Manaus: the risks of a rapid return to pre-pandemic conditions after COVID-19 vaccine rollout. 2021 May.

95. Gorji H, Lunati I, Rudolf F, Vidondo B, Hardt W-D, Jenny P, et al. Results from Canton Grisons of Switzerland Suggest Repetitive Testing Reduces SARS-CoV-2 Incidence (February-March 2021) [Internet]. Epidemiology; 2021 Jul [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.07.13.21259739

96. Lane CR, Sherry NL, Porter AF, Duchene S, Horan K, Andersson P, et al. Genomics-informed responses in the elimination of COVID-19 in Victoria, Australia: an observational, genomic epidemiological study. Lancet Public Health [Internet]. 2021 Jul 9 [cited 2021 Jul 27];0(0). Available from: https://www.thelancet.com/journals/lanpub/article/PIIS2468-2667(21)00133-X/abstract

97. Aubry M, Teiti I, Teissier A, Richard V, Mariteragi-Helle T, Chung K, et al. Self-collection and pooling of samples as resources-saving strategies for RT-PCR-based SARS-CoV-2 surveillance, the example of travelers in French Polynesia. medRxiv. 2021 Jun 21;2021.06.17.21254195.

98. Adamoski D, Carvalho de Oliveira J, Bonatto AC, Wassem R, Bordignon Nogueira M, Raboni SM, et al. Large-Scale Screening of Asymptomatic Persons for SARS-CoV-2 Variants of Concern and Gamma Takeover, Brazil. Emerg Infect Dis [Internet]. 2021 Dec;27(12). Available from: https://wwwnc.cdc.gov/eid/article/27/12/21-1326_article

99. Doyle K, Teran RA, Reefhuis J, Kerins JL, Qiu X, Green SJ, et al. Multiple Variants of SARS-CoV-2 in a University Outbreak After Spring Break — Chicago, Illinois, March–May 2021. MMWR Morb Mortal Wkly Rep. 2021 Sep 3;70(35):1195–200.

100. Enright J, Hill EM, Stage HB, Bolton KJ, Nixon EJ, Fairbanks EL, et al. SARS-CoV-2 infection in UK university students: lessons from September–December 2020 and modelling insights for future student return. R Soc Open Sci. 2021 Aug;8(8):210310.

101. Majeed B, Tosato M, Wu J. Variant-specific interventions to slow down replacement and prevent outbreaks. Math Biosci. 2021 Sep;108703.

102. Paaßen A, Anderle L, John K, Wilbrand S. Workplace risk management for SARS-CoV-2: a three-step early in-tervention strategy for effective containment of infection chains with special regards to virus variants with increased infectivity [Internet]. Occupational and Environmental Health; 2021 Jul [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.07.21.21260756

103. Kühn MJ, Abele D, Binder S, Rack K, Klitz M, Kleinert J, et al. Regional opening strategies with commuter testing and containment of new SARS-CoV-2 variants. medRxiv. 2021 Apr 26;2021.04.23.21255995.

104. Quilty BJ, Russell TW, Clifford S, Flasche S, Pickering S, Neil SJ, et al. Quarantine and testing strategies to reduce transmission risk from imported SARS-CoV-2 infections: a global modelling study [Internet]. Epidemiology; 2021 Jun [cited 2021 Jul 29]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.06.11.21258735

105. Kost GJ. DIAGNOSTIC STRATEGIES FOR ENDEMIC CORONAVIRUS DISEASE 2019 (COVID-19): RAPID ANTIGEN TESTS, REPEAT TESTING, AND PREVALENCE BOUNDARIES. Arch Pathol Lab Med [Internet]. 2021 Sep 22 [cited 2021 Oct 21]; Available from: https://meridian.allenpress.com/aplm/article/doi/10.5858/arpa.2021-0386-SA/470650/DIAGNOSTIC-STRATEGIES-FOR-ENDEMIC-CORONAVIRUS

106. Woodhouse MJ, Aspinall WP, Sparks RSJ, CoMMinS Project "COVID-19 Mapping and Mitigation in Schools." Analysis of alternative Covid-19 mitigation measures in school classrooms: an agent-based model of SARS-CoV-2 transmission [Internet]. Health Policy; 2021 Aug [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.30.21262826

107. Du Z, Wang L, Bai Y, Wang X, Pandey A, Chinazzi M, et al. Cost Effective Proactive Testing Strategies During COVID-19 Mass Vaccination: A Modelling Study. Prepr Lancet [Internet]. 2021 Jul 1 [cited 2021 Jul 27]; Available from: https://papers.ssrn.com/abstract=3878074

108. Bilinski A, Ciaranello A, Fitzpatrick MC, Giardina J, Shah M, Salomon JA, et al. SARS-CoV-2 testing strategies to contain school-associated transmission: model-based analysis of impact and cost of diagnostic testing, screening, and surveillance. 2021 Aug.

109. Chudasama DY, Flannagan J, Collin SM, Charlett A, Twohig KA, Lamagni T, et al. Household clustering of SARS-CoV-2 variant of concern B.1.1.7 (VOC-202012–01) in England. J Infect [Internet]. 2021 Apr 29 [cited 2021 May 26];0(0). Available from: https://www.journalofinfection.com/article/S0163-4453(21)00216-4/abstract

110. Buchan SA, Tibebu S, Daneman N, Whelan M, Vanniyasingam T, Murti M, et al. Increased household secondary attacks rates with Variant of Concern SARS-CoV-2 index cases. medRxiv. 2021 Apr 5;2021.03.31.21254502.

111. Wells CR, Townsend JP, Pandey A, Fitzpatrick MC, Crystal WS, Moghadas SM, et al. Quarantine and testing strategies for safe pandemic travel [Internet]. Epidemiology; 2021

Apr [cited 2021 May 26]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.04.25.21256082

112. Linka K, Peirlinck M, Schäfer A, Tikenogullari OZ, Goriely A, Kuhl E. Effects of B.1.1.7 and B.1.351 on COVID-19 dynamics. A campus reopening study. medRxiv. 2021 Apr 27;2021.04.22.21255954.

113. Maison DP, Cleveland SB, Nerurkar VR. Genomic Analysis of SARS-CoV-2 Variants of Concern Circulating in Hawai'i to Facilitate Public-Health Policies [Internet]. Research Square. 2021 [cited 2021 Jul 27]. Available from: https://www.researchsquare.com/article/rs-378702/v2

114. Zimerman RA, Cadegiani FA, Pereira E Costa RA, Goren A, Campello de Souza B. Stay-At-Home Orders Are Associated With Emergence of Novel SARS-CoV-2 Variants. Cureus. 2021 Mar 11;13(3):e13819.

115. Cowley LA, Afrad MH, Rahman SIA, Mamun MMA, Chin T, Mahmud A, et al. Genomics, social media and mobile phone data enable mapping of SARS-CoV-2 lineages to inform health policy in Bangladesh. Nat Microbiol. 2021 Oct;6(10):1271–8.

116. Sarkar A, Chakrabarti AK, Dutta S. Covid-19 Infection in India: A Comparative Analysis of the Second Wave with the First Wave. Pathogens. 2021 Sep 21;10(9):1222.

117. Li Y, Wang X, Campbell H, Nair H. The association of community mobility with the time-varying reproduction number (R) of SARS-CoV-2: a modelling study across 330 local UK authorities. Lancet Digit Health. 2021 Oct;3(10):e676–83.

118. Bosetti P, Kiem CT, Andronico A, Paireau J, Bruhl DL, Lina B, et al. A race between SARS-CoV-2 variants and vaccination: The case of the B.1.1.7 variant in France [Internet]. 2021 [cited 2021 May 26]. Available from: https://hal-pasteur.archives-ouvertes.fr/pasteur-03149525

119. Ahn H-S, Silberholz J, Song X, Wu X. Optimal COVID-19 Containment Strategies: Evidence Across Multiple Mathematical Models [Internet]. Rochester, NY: Social Science Research Network; 2021 Apr [cited 2021 May 26]. Report No.: ID 3834668. Available from: https://papers.ssrn.com/abstract=3834668

120. Scherbina A. Would the United States Benefit from a COVID Lockdown? Reassessing the Situation. SSRN [Internet]. 2021 Feb 20 [cited 2021 Apr 26]; Available from: https://papers.ssrn.com/abstract=3789690

121. Plan ELCVM, Thi HL, Le DM, Phan H. Temporal considerations in the 2021 COVID-19 lockdown of Ho Chi Minh City [Internet]. Epidemiology; 2021 Aug [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.04.21261332

122. Domenico LD, Sabbatini CE, Boëlle P-Y, Poletto C, Crépey P, Paireau J, et al. Adherence and sustainability of interventions informing optimal control against COVID-19 pandemic. medRxiv. 2021 May 16;2021.05.13.21257088.

123. Salvatore M, Bhattacharyya R, Purkayastha S, Zimmermann L, Ray D, Hazra A, et al. Resurgence of SARS-CoV-2 in India: Potential role of the B.1.617.2 (Delta) variant and delayed interventions. 2021 Jun. Report No.: 10.1101/2021.06.23.21259405.

124. Adeyinka DA, Camillo CA, Marks W, Muhajarine N. Implications of COVID-19 vaccination and public health countermeasures on SARS-CoV-2 variants of concern in Canada: evidence from a spatial hierarchical cluster analysis. medRxiv. 2021 Jul 5;2021.06.28.21259629.

125. Loenenbach A, Markus I, Lehfeld A-S, Heiden M an der, Haas W, Kiegele M, et al. SARS-CoV-2 variant B.1.1.7 susceptibility and infectiousness of children and adults deduced from investigations of childcare centre outbreaks, Germany, 2021. Eurosurveillance. 2021 May 27;26(21):2100433.

126. Brom C, Drbohlav J, Šmíd M, Zajíček M. Contribution of Schools to Covid-19 Pandemic: Evidence from Czechia [Internet]. Epidemiology; 2021 Sep [cited 2021 Oct 21]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.09.28.21264244

127. Contreras S, Dehning J, Mohr SB, Bauer S, Spitzner FP, Priesemann V. Low case numbers enable long-term stable pandemic control without lockdowns [Internet]. Public and Global Health; 2020 Dec [cited 2021 Sep 3]. Available from: http://medrxiv.org/lookup/doi/10.1101/2020.12.10.20247023

128. Nielsen BF, Eilersen A, Simonsen L, Sneppen K. Lockdowns exert selection pressure on overdispersion of SARS-CoV-2 variants. medRxiv. 2021 Jul 6;2021.06.30.21259771.

129. Vie A. Emergence of more contagious COVID-19 variants from the coevolution of viruses and policy interventions. ArXiv210314366 Phys Q-Bio [Internet]. 2021 Mar 26 [cited 2021 Sep 2]; Available from: http://arxiv.org/abs/2103.14366

130. Bowie C. Modelling the effect of an improved trace and isolate system in the wake of a highly transmissible Covid-19 variant with potential vaccine escape. medRxiv. 2021 Jun 10;2021.06.07.21258451.

131. Dick DW, Childs L, Feng Z, Li J, Röst G, Buckeridge DL, et al. Fall 2021 Resurgence and COVID-19 Seroprevalence in Canada Modelling waning and boosting COVID-19 immunity in Canada A Canadian Immunization Research Network Study [Internet]. Public and Global Health; 2021 Aug [cited 2021 Sep 2]. Available from: http://medrxiv.org/lookup/doi/10.1101/2021.08.17.21262188

132. Curran J, Boulos L, Somerville M, Dol J, Johnson C, Crowther D, et al. Public Health Implications of SARS-CoV-2 VOC. SPOR Evidence Alliance; COVID-END; CoVaRR-NET; 2021 Jul. Report No.: Deliverable 1.

133. Bauer S, Contreras S, Dehning J, Linden M, Iftekhar E, Mohr SB, et al. Relaxing restrictions at the pace of vaccination increases freedom and guards against further COVID-19 waves. 2021 Jul. Report No.: arXiv:2103.06228v4.