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

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Updated September 10, 2021

Evidence up to August 25, 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 September 9, 2021, over 222 million cases of COVID-19 have been reported worldwide and over 4.5 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

- **The majority of available evidence is related to the Alpha variant; however, evidence related to public health measures and Delta is emerging rapidly**
- **While some of the recent modelling studies recommend extending/targeting vaccine campaigns to adolescents and younger children to reach herd immunity faster, other studies suggest vaccinating youth is only helpful if adults are vaccinated at sufficient levels**

- In schools, universal masking plus other non-pharmaceutical interventions (NPIs) such as physical distancing or cohorting are more effective than masking alone
- There is evolving evidence regarding changes in vaccine scheduling related to inter-dose timing and need for third dose of vaccine. Several modelling studies point to prioritizing first dose while others suggest administering second dose as soon as possible for best results. Several studies also suggest that a third dose would be beneficial, with some specifying conditions
- Universal mask wearing is recommended, particularly indoors, and double masking has the potential to improve protection against VOCs
- Some concerns exist around whether vaccinated individuals have lower engagement with NPIs, such as hand washing and physical distancing
- Some studies found that rapid and frequent testing may be an adequate substitute for quarantine of close contacts, while others recommended quicker and stricter quarantine measures

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. **The most recent additions to this living synthesis are 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	<ul style="list-style-type: none"> Accelerated vaccine rollout (60 doses/day/10,000 pop) would reduce severe health outcomes⁸ Estimated current vaccine schedule of 1/1000 doses/person/day would need to be quadrupled to control the spread of VOC⁹ Speed of vaccine rollout is key factor in achieving low IAR, burden of disease¹⁰⁻¹⁵, preventing additional VOC-driven waves¹⁶, and mitigating the effect of decreased vaccine effectiveness¹⁷ Change in inter-dose vaccine period from 21 to 42 days is preferable for vaccine mode of action at the end of infection course, severe epidemic and low vaccine supply rate¹⁸ Postponing 2nd vaccine dose is not recommended to avoid VOC-driven waves¹⁶ Third dose of vaccine is required to eliminate 	<ul style="list-style-type: none"> Speed of vaccine rollout is key factor in achieving low IAR and disease burden¹¹ Third dose of vaccine is required to eliminate developing mutations and reduce transmission rates¹⁹ Herd immunity could be reached in China by Sept 2021 if vaccines extended to age 3+²² 	<ul style="list-style-type: none"> Speed of vaccine rollout is key factor in achieving low IAR and disease burden¹⁴ and preventing additional VOC-driven waves¹⁶ Third dose of vaccine is required to eliminate developing mutations and reduce transmission rates¹⁹ Postponing 2nd vaccine dose is not recommended to avoid VOC-driven waves¹⁶ Herd immunity could be reached in China by Sept 2021 if vaccines extended to age 3+²² 	<ul style="list-style-type: none"> Speed of vaccine rollout is key factor in achieving low IAR and disease burden¹⁴, preventing additional VOC-driven waves¹⁶, and mitigating the effect of decreased vaccine effectiveness¹⁷ Third dose of vaccine is required to eliminate developing mutations and reduce transmission rates¹⁹ Prioritizing 1st dose is recommended, as higher protection associated with extended schedules²⁴ Postponing 2nd vaccine dose is not recommended to avoid VOC-driven waves¹⁶ Herd immunity could be reached in China by Sept 2021 if vaccines extended to age 3+, however,

	<p>developing mutations and reduce transmission rates¹⁹</p> <ul style="list-style-type: none"> • Proactive surveillance and prioritized vaccination can reduce severe illness and mortality in vulnerable groups²⁰ with vaccinating children enhancing these benefits^{21,22} • Minimal impact of vaccinating youth (10-19yr) in reducing transmission, unless 80% of adult population is vaccinated²³ 			<p>87.5% of entire population would need to be vaccinated with a 95% efficacious vaccine using Delta's transmission properties²²</p>
<p>Evaluating vaccination rollout schedules</p>	<ul style="list-style-type: none"> • Prioritizing 1st dose is recommended, as higher protection associated with extended schedules^{24,25} • 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 intervals²⁶ <p><i>Appraised studies were of high quality</i></p>	<ul style="list-style-type: none"> • 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 intervals²⁶ <p><i>Appraised study was of high quality</i></p>	<ul style="list-style-type: none"> • Targeted vaccination of 80+ age group associated with decreased mortality compared with younger group²⁷ <p><i>Medium quality evidence</i></p>	<ul style="list-style-type: none"> • Prioritizing 1st dose is recommended, as higher protection associated with extended schedules²⁴ • 3rd doses can increase antibody levels and neutralizing capability among immunocompromised individuals²⁸ <p><i>Appraised studies were of medium to high quality</i></p>
<p>Modelling different vaccine schedules in relation to NPIs</p>	<ul style="list-style-type: none"> • Advocate for NPIs to remain in place during vaccine roll out until sufficient population immunity^{23,29-35} 	<ul style="list-style-type: none"> • Advocate for NPIs to remain in place during vaccine roll out until sufficient 		<p>Combination vaccine (accelerated) and NPIs are required to reduce transmission rate^{16,35,36,41-43},</p>

	<ul style="list-style-type: none"> • NPIs alongside accelerated vaccine roll out is needed to control outbreak^{33,36-39} • In OECD, countries fully vaccinating 40% of the population would allow for easing of containment policies⁴⁰ 	population immunity ^{29,30}		<p>hospitalizations and deaths.⁴⁴ Further, even with the combination of Vaccine and NPIs, infections will hit school aged children the hardest during the Fall 2021.⁴⁵</p> <p>NPI and intense vaccine strategy targeting students is needed to substantially reduce the risk of infection⁴⁶</p> <p>Increasing vaccine coverage in adolescents and regular testing essential to keep schools open⁴⁷</p> <p>Stringent NPIs and third booster may be needed to stop spread of Delta⁴⁸</p>
Evaluating different vaccine schedules in relation to NPIs	N/A	N/A	N/A	N/A

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	<ul style="list-style-type: none"> • VOC responds similarly to ethanol and soap as non-VOC⁴⁹ 	<ul style="list-style-type: none"> • VOC responds similarly to ethanol 	<ul style="list-style-type: none"> • Vaccinated individuals may do 	<ul style="list-style-type: none"> • Vaccinated individuals may do

	<ul style="list-style-type: none"> Vaccinated individuals may do less handwashing than non-vaccinated individuals⁵⁰ <p><i>Appraised study was of medium quality</i></p>	<p>and soap as non-VOC⁴⁹</p> <ul style="list-style-type: none"> Vaccinated individuals may do less handwashing than non-vaccinated individuals⁵⁰ <p><i>Appraised study was of medium quality</i></p>	<p>less handwashing than non-vaccinated individuals⁵⁰</p> <p><i>Appraised study was of medium quality</i></p>	<p>less handwashing than non-vaccinated individuals⁵⁰</p> <p><i>Appraised study was of medium quality</i></p>
Hand washing—Modelling studies	N/A	N/A	N/A	N/A
Masking	<ul style="list-style-type: none"> No difference was found between surgical and cloth masks, but tighter fitting masks recommended indoors⁵¹ Double mask combination of surgical/two-layer cloth I + N-95 improved fit and protection⁵² Vaccination status did not change mask wearing in China⁵⁰ <p><i>Appraised studies were of medium quality</i></p>	<ul style="list-style-type: none"> Double mask combination of surgical/two-layer cloth + N-95 improved fit and protection⁵² Vaccination status did not change mask wearing in China⁵⁰ <p><i>Appraised study was of medium quality</i></p>	<ul style="list-style-type: none"> Double mask combination of surgical/two-layer cloth + N-95 improved fit and protection⁵² Vaccination status did not change mask wearing in China⁵⁰ <p><i>Appraised study was of medium quality</i></p>	<ul style="list-style-type: none"> Vaccination status did not change mask wearing in China⁵⁰ <p><i>Appraised study was of medium quality</i></p>
Masking—Modelling studies	<ul style="list-style-type: none"> Moderately effective masks, when worn consistently correctly by a large portion of the population, are effective at preventing transmission⁵³ 	N/A	N/A	<ul style="list-style-type: none"> Universal masking in schools is recommended to reduce in-school transmission^{54,55}

Physical distancing	<ul style="list-style-type: none"> Settings where physical distancing is unlikely (e.g., hair salons; visiting with friends inside the home) present the highest risk of transmission⁵⁶ In daycares, strict contact restrictions like group assignments among children and staff assignments to groups prevent infections⁵⁷ Vaccinated individuals may engage in less physical distancing than non-vaccinated individuals⁵⁰ <p><i>Appraised studies were of medium to high quality</i></p>	<ul style="list-style-type: none"> Vaccinated individuals may engage in less physical distancing than non-vaccinated individuals⁵⁰ <p><i>Appraised study was of medium quality</i></p>	<ul style="list-style-type: none"> Vaccinated individuals may engage in less physical distancing than non-vaccinated individuals⁵⁰ <p><i>Appraised study was of medium quality</i></p>	<ul style="list-style-type: none"> Vaccinated individuals may engage in less physical distancing than non-vaccinated individuals⁵⁰ <p><i>Appraised study was of medium quality</i></p>
Physical distancing— Modelling studies	<ul style="list-style-type: none"> Strong physical distancing measures are critical, even with a mass vaccination campaign^{16,59,60} and may need to be strengthened by 33.7%⁶¹ 	<ul style="list-style-type: none"> Strong physical distancing measures are critical even with a mass vaccination campaign^{29,62} 	<ul style="list-style-type: none"> Strong physical distancing measures are critical even with a mass vaccination campaign⁶² 	<ul style="list-style-type: none"> Strong physical distancing measures and high compliance are critical even with a mass vaccination campaign^{16,59,60}

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	<ul style="list-style-type: none"> In a university setting, asymptomatic mass testing needs to be very frequent 	<ul style="list-style-type: none"> Offering voluntary testing 1-2 times/week to all 	<ul style="list-style-type: none"> Mass saliva analysis is a cheap, easy to collect, and feasible 	N/A

	<p>(~every 3 days) to be effective at containing outbreaks⁶³</p> <ul style="list-style-type: none"> • 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 quarantine⁶⁴ • Employees more likely to get tested using saliva samples than nasal swabs⁶⁴ • Testing and routine surveillance of populations at risk are critical⁶⁵ • Self-collection and pooling approaches to testing of travellers allows large-scale screening using less human, material and financial resources⁶⁶ <p><i>Appraised studies were of high quality</i></p>	<p>employees and daily to close contacts of cases for 10 days allowed employees to continue working rather than quarantine⁶⁴</p> <ul style="list-style-type: none"> • Employees more likely to get tested using saliva samples than nasal swabs⁶⁴ <p><i>Appraised study was of high quality</i></p>	<p>asymptomatic testing strategy to potentially slow variant outbreaks⁶⁷</p> <p><i>Appraised study was of low quality</i></p>	
<p>Testing—Modelling studies</p>	<ul style="list-style-type: none"> • 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 contacts⁶⁸ • Testing and routine surveillance of populations at risk are critical⁶⁹ 	<ul style="list-style-type: none"> • Testing and routine surveillance of populations at risk are critical even with a mass vaccination campaign²⁹ 	<p>N/A</p>	<ul style="list-style-type: none"> • In a model of partially vaccinated K-12 schools, regular testing effectively prevented outbreaks; effect correlated with frequency (i.e., testing 1-2

	<ul style="list-style-type: none"> • Surveillance of travellers remains important³¹ • Daily testing for 5 days could circumvent the need for quarantine of travellers⁷⁰ • Pre-flight tests may prevent the majority of transmission from travellers⁷⁰ 			<p>times/week was better than biweekly)⁴⁷</p> <ul style="list-style-type: none"> • In another model of K-12 schools with mandatory masking, testing 50% of students reduced infections to 22%⁵⁴ • The optimal testing strategy is weekly testing of the entire unvaccinated population, plus a 10-day isolation requirement for positive cases and their households^{71,72}
<p>Quarantine (close contacts and travellers)</p>	<ul style="list-style-type: none"> • In a workplace with mandatory daily testing and other NPIs for close contacts, quarantine was not required to contain outbreaks⁶⁴ • Alpha cases almost twice as likely to give rise to household clusters compared with wild type cases, highlighting importance of quarantining household contacts^{73,74} • Mandatory quarantine and contact tracing are required^{66,77} 	<ul style="list-style-type: none"> • Some studies found that mandatory quarantine and contact tracing are required⁷⁷ • Conversely, in a workplace with mandatory daily testing and other NPIs for close contacts, quarantine was not required to contain outbreaks⁶⁴ 	<ul style="list-style-type: none"> • Mandatory quarantine may be an effective way to contain Gamma⁷⁷ 	<p>N/A</p>

	<i>Appraised studies of low to high quality</i>	<i>Appraised studies of low to high quality</i>	<i>Appraised study was of low quality</i>	
Quarantine (close contacts and travellers)—<i>Modelling studies</i>	<ul style="list-style-type: none"> • In a university setting, quarantine of close contacts is important in preventing transmission during the term⁶³ • Mandatory quarantine and contact tracing are required^{69,75,76} and may need to be extended to indirect contacts in workplace settings⁶⁸ • A 10-day quarantine period may be as effective as a 14-day quarantine period⁷⁰ 	<ul style="list-style-type: none"> • Some studies found that mandatory quarantine and contact tracing are required⁷⁶, and Beta may require more extreme quarantine and testing measures than other variants⁷⁵ 	<ul style="list-style-type: none"> • Forced prolonged cohabiting may boost viral ability to generate Gamma mutation⁷⁸ 	<ul style="list-style-type: none"> • 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 lost⁶²
Isolation (confirmed COVID-19/VOC cases)	N/A	N/A	N/A	N/A
Isolation (confirmed COVID-19/VOC cases)—<i>Modelling studies</i>	<ul style="list-style-type: none"> • In a university setting, isolation of confirmed cases is important in preventing transmission during the term⁶³ • Complete isolation of Alpha cases is required to prevent outbreaks; even a small number of infected people dramatically increases the probability of sustained community transmission¹⁰ 	N/A	N/A	<ul style="list-style-type: none"> • 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 households⁷¹
Lockdowns	N/A	N/A	N/A	N/A

<p>Lockdowns— Modelling studies</p>	<ul style="list-style-type: none"> • Alpha requires stronger lockdown measures than wild type^{38,42,79,80} including increased length,^{81,82} earlier implementation⁷⁹ and stricter regional travel restrictions⁶⁹ • Shorter, stricter lockdowns may be more effective than longer, moderate lockdowns due to waning adherence⁸³ • Keeping schools partially open while keeping most of society closed brought R below 1 in a UK model⁴³ 	<p>N/A</p>	<p>N/A</p>	<ul style="list-style-type: none"> • Delta requires stronger lockdown measures than wild type⁴² • In an Australian model, the strength of lockdown had a bigger impact on hospitalizations and deaths than vaccination strategies⁴⁴ • Early public interventions—lockdowns imposed during an ‘optimal time window’—lead to reduced death counts from Delta⁸⁴
<p>Other/combined NPIs</p>	<ul style="list-style-type: none"> • 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 stringency⁸⁵ 	<ul style="list-style-type: none"> • NPIs should be implemented until herd immunity is reached²⁵ 	<p>N/A</p>	<ul style="list-style-type: none"> • NPIs should be implemented until herd immunity is reached²⁵

	<ul style="list-style-type: none"> In daycares, NPIs like closures in the event of an outbreak can help contain Alpha⁸⁶ 			
Other/combined NPIs—Modelling studies	<ul style="list-style-type: none"> In a university setting, staggering the return of students to residences is not significantly effective in preventing transmission⁶³ Multiple NPIs are more effective than single NPIs,^{15,22} and reactive NPIs (e.g., quarantine of close contacts) must be deployed quickly⁶⁸ Strong test-trace-isolate programs can be sufficient to maintain low case numbers^{36,87} Regional mobility networks and spatial connectivity drive patterns of transmission throughout the United States⁵⁹ Strict NPIs may lead to overdispersion of highly transmissible variants, leading to their eventual dominance⁸⁸; evolution of highly transmissible variants may actually be a sign that NPI policies are effective⁸⁹ 	N/A	<ul style="list-style-type: none"> Strict NPIs are required to contain Gamma^{22,41} 	<ul style="list-style-type: none"> In schools, continued use of multiple NPIs (e.g., universal masking and distancing or cohorting) is recommended^{46,90}, combined with high vaccination coverage⁵⁵ Regional mobility networks and spatial connectivity drive patterns of transmission throughout the United States⁵⁹ Even modest improvements in a find, test, trace, isolate and support program would control transmission⁹¹

Overview of the Evidence

As of August 25, 2021, 86 studies have reported on VOC and public health measures. We include 54 studies from earlier reports (including 21 studies from an earlier rapid review⁶ and 33 from the first iteration of this report⁹²) and 32 from our updated search on August 25th, 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=71) with fewer studies reporting on Beta (n=20 studies), Gamma (n=17 studies) and a growing volume of evidence related to Delta (n=29 studies).

Modifying Approach to Vaccine Delivery

- 44^{8–26,26–38,40–43,45–48,55,72,93} 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.
- **Evidence is emerging about the value of 3rd dose or booster vaccines¹⁹, particularly in the context of Delta⁴⁸ and immunocompromised patients²⁸**
- **Several modelling studies^{45–47} 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

Infection Prevention Measures

- The one⁴⁹ study that reported on handwashing and VOC found that Alpha and Beta respond similarly to ethanol and soap as wildtype SARS-CoV-2
- One⁵³ study that reported on mask wearing and VOC found that when worn correctly, masks are effective against Alpha
- **One study⁵¹ found no difference between cloth and surgical masks against Alpha, but another study⁵² found double masking better for protection against all VOCs**
- **Seven^{16,29,56–58,61,62} studies reported on VOC and physical distancing measures. All studies recommended imposing strong physical distancing measures in the presence of all VOCs**
- **One study⁵⁰ found that vaccinated individuals may engage in less handwashing and physical distancing than non-vaccinated individuals but not mask wearing**

Infection Control Measures

- Fourteen^{29,31,47,54,63–72} 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.
- Twelve^{62–65,68,70,73–78} 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^{10,63,71} 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.
- Ten^{38,42–44,69,79–82,84} 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**^{79,84}.
- Sixteen^{15,22,25,36,41,46,55,59,63,68,86–91} 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**^{15,22}, 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 August 25, 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 review⁶ 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

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