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Public health implications of SARS-CoV-2 variants of concern: a rapid scoping review

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ABSTRACT

Objectives The four SARS-CoV-2 variants of concern (VOC; Alpha, Beta, Gamma and Delta) identified by May 2021 are highly transmissible, yet little is known about their impact on public health measures. We aimed to synthesise evidence related to public health measures and VOC.

Design A rapid scoping review.

Data sources On 11 May 2021, seven databases (MEDLINE, Embase, the Cochrane Database of Systematic Reviews, Central Register of Controlled Trials, Epistemonikos' L-OVE on COVID-19, medRxiv, bioRxiv) were searched for terms related to VOC, public health measures, transmission and health systems. No limit was placed on date of publication.

Eligibility criteria Studies were included if they reported on any of the four VOCs and public health measures, and were available in English. Only studies reporting on data collected after October 2020, when the first VOC was reported, were included.

Data extraction and synthesis Titles, abstracts and full-text articles were screened by two independent reviewers. Data extraction was completed by two independent reviewers using a standardised form. Data synthesis and reporting followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews guidelines.

Results Of the 37 included studies, the majority assessed the impact of Alpha (n=32) and were conducted in Europe (n=12) or the UK (n=9). Most were modelling studies (n=28) and preprints (n=28). The majority of studies reported on infection control measures (n=17), followed by modifying approaches to vaccines (n=13), physical distancing (n=6) and either mask wearing, testing or hand washing (n=2). Findings suggest an accelerated vaccine rollout is needed to mitigate the spread of VOC.

Conclusions The increased severity of VOC requires proactive public health measures to control their spread. Further research is needed to strengthen the evidence for continued implementation of public health measures in conjunction with vaccine rollout. With no studies reporting on Delta, there is a need for further research on this and other emerging VOC on public health measures.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ To the authors' knowledge, this rapid scoping review is the first to comprehensively synthesise the evidence related to variant of concern (VOC) and public health measures.
⇒ This review involved stakeholder engagement throughout the entire review process to ensure findings were accurately reported and relevant for end users.
⇒ The majority of studies were preprints and not yet peer reviewed, thus findings should be interpreted with caution
⇒ This rapid scoping review highlights the heterogeneity of the existing literature and provides recommendations for future research.
⇒ As of May 2021, most studies reported on Alpha and none reported on Delta, suggesting that ongoing research is needed on the impact of public health measures on newly emerging VOC.

INTRODUCTION

The SARS-CoV-2, responsible for COVID-19, was initially detected in December 2019, and in March 2020, the WHO declared COVID-19 a global pandemic.[1] As of May 24 2021, over 166 million cases of COVID-19 had been detected worldwide, and 3.5 million deaths have been reported as a result of the virus.[2] The growing number of COVID-19 cases presents significant challenges for health systems as they try to adapt and enforce public health measures to control the spread of the virus to prevent further death and disability.

An additional public health challenge of COVID-19 is related to the emergence of SARS-CoV-2 variants of concern (VOC).[3] The WHO defines VOC as novel SARS-CoV-2 strains with increased potential for transmission, presence of genomic mutations and rapid spread across nations or regions with potential for decreased effectiveness of public

health measures.[4] As of 31 May 2021,[5] the four circulating VOCs include Alpha (B.1.1.7) and Beta (B.1.351) which were both identified in December 2020, Gamma (P.1) which first originated in January 2021 and, most recently, Delta (B.1.617.2) which emerged in May 2021.[6] While evidence continues to emerge about these four VOCs, there are clear indications that they are more transmissible than non-VOC strains.[7–9] The increased transmissibility of VOC highlights the urgent need for countries to enforce measures to prevent further spread of COVID-19.

Initially, national governing bodies were directed to manage the spread of COVID-19 through a combination of public health measures and health system restructuring.[10] While the WHO provided initial instruction for managing the spread of COVID-19,[11] contextual differences between regions meant public health officials had to make decisions in the absence of evidence. The majority of public health measures initially introduced across jurisdictions focused on reducing virus transmission through general public health protocols such as hand washing, coughing etiquette, avoiding person-to-person contact and staying home if unwell.[11] However, as more information about COVID-19 began to emerge, public health officials introduced additional measures such as mask wearing, testing, lockdowns and border restrictions.[12–14] After the introduction of these public health measures in early 2020, many countries witnessed a downward trend in case numbers by mid-2020, signalling the stabilisation of wave 1.[15] These epidemiological trends indicated the potential, positive impact of public health measures on mitigating COVID-19.

While public health measures were effective in slowing the initial spread of COVID-19, the emergence of VOC presents a new challenge for public health officials and policy makers. With continuously changing and limited available evidence on the highly transmissible VOC, there is a need to explore how public health measures impact the spread of VOC, and whether changes to public health protocols are needed in relation to VOC characteristics. Therefore, the aim of this study was to synthesise the literature on the four circulating VOCs and their impact on public health measures. This study attempted to answer the following research questions, which were determined through consensus meetings with knowledge users and stakeholder groups:

1. What is known about the global implications of the four circulating VOCs for public health measures on:
   A. Modifying approach to vaccination?
   B. Modifying infection prevention measures in the community?
   C. Modifying infection control procedures?

METHODS

Study design

A rapid scoping review was conducted, following standard methodological guidelines for rapid[16] and scoping reviews.[17] This type of review can be beneficial to inform urgently needed practice or policy change, which is the case for the rapidly evolving COVID-19 pandemic.[18] Ethics approval was not required for this study. The research team collaborated with knowledge users (public health and infectious disease experts, researchers and policy makers) through regular meetings to identify the research question, design the search strategy and synthesise the evidence. The research question was guided by the Population, Context and Concept framework proposed by scoping review guidelines.[17] For the purpose of this review, population includes individuals/communities affected by VOC, concept includes public health measures and context includes any country or region.

Patient and public involvement

Patient partners, experienced in patient engagement but not the lived experience of being diagnosed with COVID-19, were invited to review the summary of findings table. Patient partners will assist in disseminating the key findings of the published paper for a public and lay audience.

Protocol

The study protocol was registered with Open Science Framework (https://osf.io/tkrbm/).[19]

Search strategy

A literature search was designed by an information specialist (LB), trained in scoping review methodology, to identify all sources related to VOC. Seven electronic databases were searched, including MEDLINE (Ovid MEDLINE All), Embase (Elsevier), the Cochrane Database of Systematic Reviews (CDSR), Central Register of Controlled Trials (CENTRAL) (Cochrane Library, Wiley), Epistemonikos' L-OVE on COVID-19, medRxiv and bioRxiv. No limitation was placed on date of publication, but the search was restricted to English-only sources. Any non-English results returned by the search were translated where possible and considered for inclusion. The search was conducted on 11 May 2021. The full search strategy for all databases can be found in the online supplemental material 1.

Eligibility criteria

Studies were eligible for inclusion in the review if they reported on any of the four VOCs which were identified by the WHO at the time of the search: Alpha, Beta, Gamma and Delta (also known as B.1.1.7, B.1.351, P.1 and B.1.617.2, respectively). Studies also had to report on public health measures, relating to three overarching subtopics: modifying approach to vaccines, infection prevention or infection control measures. This could include studies that reported on lockdown measures, quarantine, physical distancing, mask wearing, hand washing, outbreak management and/or vaccination scheduling. Any study setting, country and population were eligible for inclusion. Due to the first VOC, Alpha, being identified in October 2020, any studies that reported on data collected before October 2020 were excluded. Grey literature preprint articles were also eligible for inclusion in

this review. Studies that reported on immune escape, vaccine efficacy, non-VOC-related impacts, novel testing approaches, transmission, health system measures, animal studies or case studies without data related to public health measures were excluded. While this review did not consider studies that reported on health system impacts, these data were extracted and synthesised in a separate review (Dol J *et al* Health systems impacts of SARS-CoV-2 variants of concern: A rapid review).

Screening

Screening occurred in two stages and was conducted by 11 authors (MS, JAC, JD, LB, AJG, HW, HDS, MM, RM-M, BR, DC). First, titles and abstracts of identified studies were uploaded to the online systematic review synthesis software, Covidence,[20] and independently screened in duplicate. Then, full texts of articles were reviewed and independently screened in duplicate. Conflicts were resolved by an independent reviewer from the research team (MS, JD, JAC or LB). All screening tools were pilot tested prior to use.

Data extraction

A data extraction form was developed based on the research questions and in collaboration with the knowledge user partners. Study characteristics, including study design, population, sample size, country, date of publication and objective, were reported in the data extraction form. Details about the type and number of VOCs reported in the study were also extracted. Outcome data related to the specific public health measures employed in the study were extracted and reported in the standardised data extraction form.

Quality appraisal

Although quality appraisal is an optional step in scoping review methodology, based on discussions with knowledge users, it was decided to include this step in our review.The Newcastle-Ottawa Scale (NOS) was used to appraise observational studies in this review.[21] As the NOS tool was originally developed for case–control and cohort studies, the adapted NOS tool[22] was used to appraise studies of cross-sectional design. Modelling and laboratory-based studies were excluded from quality appraisal. Following a pilot test, two members of the research team (MS, BR) independently completed quality appraisal of the included studies. Researchers then met to discuss their final scores. When researchers disagreed on their scores, a third independent team member (JAC) joined the discussion until a consensus was reached about the final quality score of each study. Preprint studies are sometimes excluded from reviews; however, due to the rapidly emerging nature of COVID-19 research, preprint studies were included for synthesis. An additional layer of quality appraisal was applied to preprint studies by subtracting two points from preprint study scores. This deduction was based on advice from knowledge users and methodological experts (ACT, LS, SH, AD).

Data synthesis

Following data extraction, reported outcomes from each study were described and categorised based on public health topic. The findings were reported in a table alongside the quality appraisal score. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews[23] checklist guided the reporting of this study (figure 1).

RESULTS

The electronic database search identified 3323 records. After removal of duplicates, 2518 studies were screened for eligibility. A total of 37 studies reporting on public health measures in relation to VOC were included after screening. The majority of included studies reported on the Alpha VOC (n=32).[24–54] The majority of studies were conducted in Europe (n=12),[24 29 30 34 35 39 40 44 47 51 53 55] followed by the UK (n=9),[26 28 32 33 36 42 45 50 56] USA (n=9),[25 37 38 41 43 48 49 54 57] Brazil (n=3),[58–60] Canada (n=1),[31] South Africa (n=1),[27] Israel (n=1)[46] and Japan (n=1)[52] (figure 2). Additional details of each study can be found in the online supplemental material 2.

The majority of studies were modelling studies (n=28) and 28 were preprints. Nineteen studies reported on infection prevention measures, of which 11 were specifically related to outbreak management. Twelve studies reported on modifying approach to vaccinations and seven studies reported on infection prevention measures (figure 3).

Quality appraisal

Of the 37 studies included in this review, three were cohort studies and four were cross-sectional studies, and therefore underwent quality appraisal. Cohort study scores ranged from 44% to 89% while cross-sectional studies ranged from 10% to 80%. Of these seven cohort/cross-sectional studies, two were categorised as low quality,[28 42] three were of medium quality[26 31 58] and two were considered high quality[32 36] (table 1).

Question 1A: modifying approach to vaccination considering VOC

Of the 12 studies that reported on modifying approaches to vaccination in consideration of VOC, seven were modelling studies,[35 38 43 46–48 52] three were observational studies[28 42 58] and two were laboratory-based studies.[33 57] Of the three observational studies, one was appraised as medium quality[58] and two were appraised as low quality.[28 42] Therefore, the findings should be interpreted with caution. The modelling and laboratory-based studies were not appraised. Ten studies reported on different vaccine schedules and VOC.[33–35 38 43 46 47 52 57 58] One study reported on attitudes towards vaccines related to VOC prevalence[28] and one study compared natural protection versus vaccine protection against VOC.[42] A summary of studies can be found in table 2.

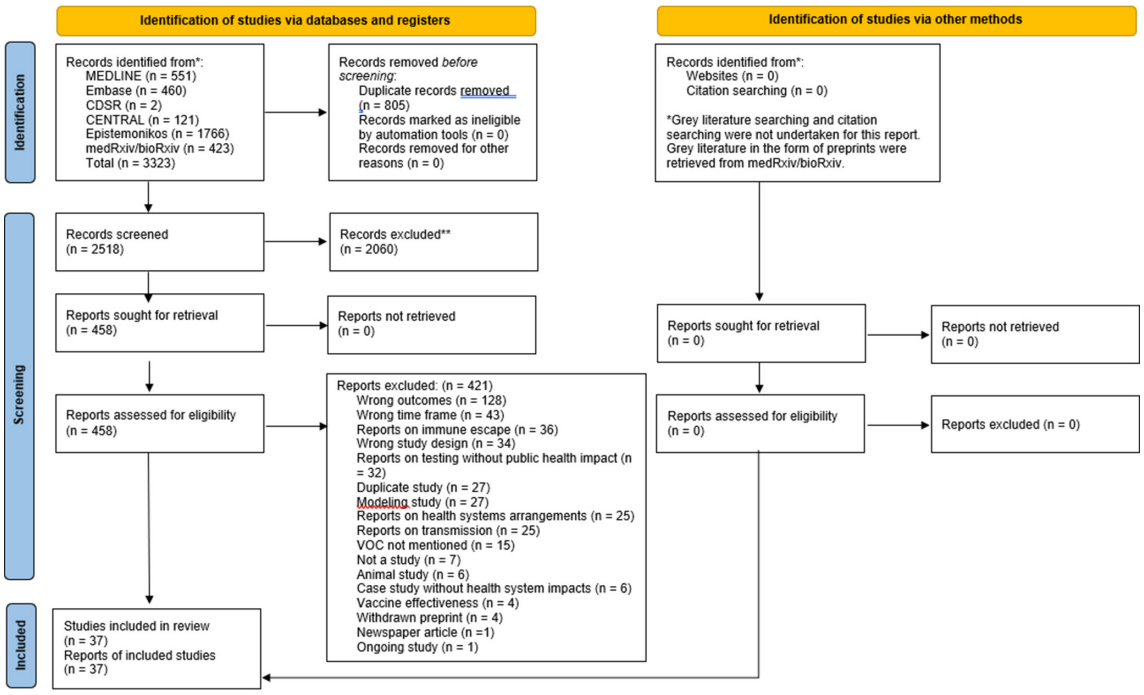

Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources. VOC, variant of concern. From: Page MJ *et al*[66]

Vaccine schedules that offer greater protection

The 11 studies that reported on modifying approaches to vaccine schedules and VOC were further categorised into two subsections: (1) exploring vaccine protection using a correlate of laboratory neutralisation in consideration of variants; and (2) exploring different vaccination schedules. Further details on each of these studies can be found in table 2.

Exploring vaccine protection using a correlate of laboratory neutralisation in consideration of variants

Three studies contributed data on mRNA vaccines,[33 43 57] which together showed vaccine protection after a second dose (also referred to as booster dose) against the Alpha,[33 43] Beta[43 57] and Gamma[43 57] VOCs. Additional protective effects were noted for older adults in one study.[33]

Exploring different vaccination schedules

Seven modelling studies and one observational study examined the impact of changes in vaccine scheduling on VOC. Findings from these eight studies highlight the importance of an accelerated vaccine rollout either in isolation[38 48 58] or in conjunction with non-pharmaceutical interventions (NPIs)[35 46 47 51 52] to prevent VOC-related transmission, hospitalisations and deaths. Vaccine rollout scenarios varied across studies in terms of length and intensity, and included campaigns ranging from 6 to 24 months[47] and vaccination rates of 9/1000 doses per person per day[48] to 1/250 doses per person per day.[52] The

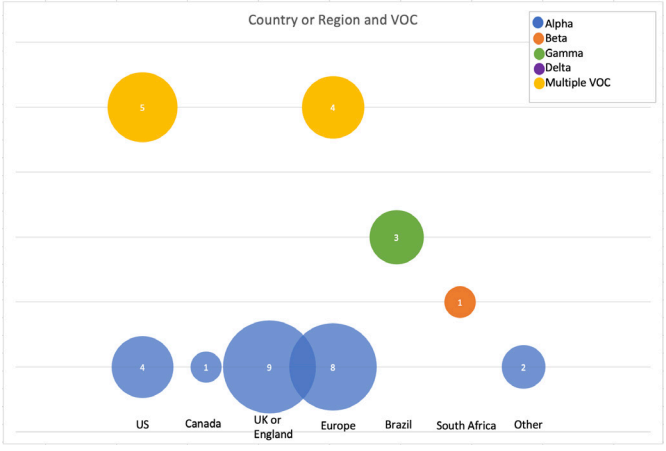

Figure 2 Overview of country or region of data collection and variant of concern up until 11 May 2021.

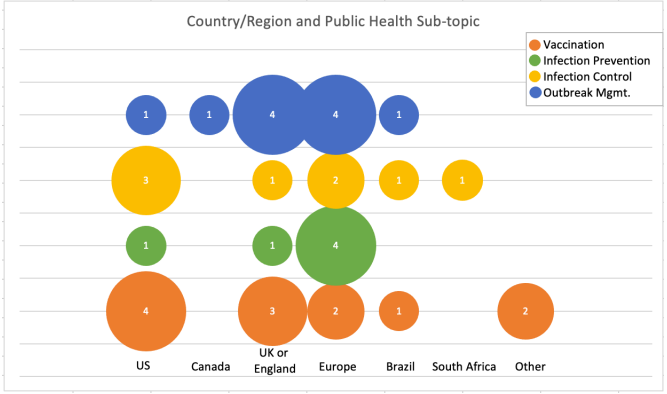

Figure 3 Overview of country or region of data collection and public health subtopic up until 11 May 2021. VOC, variant of concern.

Table 1 Quality appraisal scores based on NOS tool for observational study designs

Author, year	Preprint (PP) or peer review (PR)	Source	Average score per category			Adjusted score for PP	Total score (%) out of 9* or 10†	Overall quality
			Selection	Comparability	Outcome			
Cohort study design								
Buchan *et al* 2021[31]	PP	medRxiv	3.5	2	2.5	–2	6 (67)	Medium
Chudasama *et al* 2021[32]	PR	Journal of Infection	3.5	2	2.5	N/A	8 (89)	High
Lumley *et al* 2021[42]	PP	medRxiv	3	2	1	–2	4 (44)	Low
Cross-sectional study design								
Aiano *et al*[26] 2021	PP	SSRN	4	1	2	–2	5 (50)	Medium
Bachtiger *et al* [28] 2021	PP	medRxiv	2	1	0	–2	1 (10)	Low
Graham *et al*[36] 2021	PR	Lancet	3	2	3	N/A	8 (80)	High
Victora *et al*[58] 2021	PP	medRxiv	4	1.5	2.5	–2	6 (60)	Medium

*Cohort studies scored out of 9.
†Cross-sectional studies scored out of 10; low score <50%; medium score 50%–80%; high score >80%.
N/A, not available; NOS, Newcastle-Ottawa Scale.

NPIs studied included physical distancing, testing strategies and lockdowns of varying intensity, with one modelling study of 20 unique scenarios reporting NPIs to be more important than vaccine rollout.[35]

Attitudes towards vaccination related to VOC

One cross-sectional study assessed changes in COVID-19 vaccine hesitancy related to VOC in the UK in late 2020 when Alpha began circulating.[28] Following the emergence of Alpha, intention to receive the vaccine increased among participants, with changes in attitudes associated with certain demographic characteristics.

Comparing immune protection after COVID-19 infection and vaccination

One prospective cohort study of healthcare workers (HCW) in the UK assessed the protection following infection from Alpha and one or two doses of Pfizer or AstraZeneca vaccines.[42] Alpha did not significantly alter the extent of protection following natural immunity or first dose of vaccine, which means natural infection and/or vaccination may effectively protect against Alpha.

Question 1B: modifying infection prevention measures in the community

The second subquestion addressed by this review related to the impact of infection prevention measures, such as hand washing, mask wearing and physical distancing, in the presence of VOC. Of the seven studies which reported on this subtopic, five were modelling studies,[34 37 40 41 53] one was a laboratory-based study[44] and one was observational.[26] The observational study was appraised as medium quality. A summary of studies can be found in table 3.

Hand washing

One study compared the stability of the wild type, Alpha and Beta, on different surfaces and their sensitivity to heat, soap and ethanol.[44] Both wild type and VOC were efficiently inactivated on treatment with at least 30% ethanol for 30 s and hand soap for 1–5 min, confirming that current measures of hand hygiene would be effective against Alpha and Beta.

Mask wearing

Gurbaxani *et al* modelled face mask efficacy parameters for a variety of mask types and fit.[37] They found masks have potential for significant reduction in both VOC and non-VOC transmissions, even with moderately effective masks, when they are consistently worn correctly by a large portion of the population.

Physical distancing

Five studies assessed the impact of physical distancing on transmission of Alpha[26 34 40 41 53] and/or Beta.[41] Together, these studies found that due to the increased transmissibility between contacts, additional NPIs should be in place alongside physical distancing measures to contain VOC spread.[26 34 40 41 53] These studies considered various settings, including community,[34] workplaces,[53] schools[26 40] and universities.[41]

Question 1C: modifying infection control procedures

The third subquestion addressed by this review related to adjusting infection control procedures in the presence of VOC, such as duration of quarantine, testing strategies, contact tracing and outbreak management. Of the 17 studies reporting on infection control procedures and VOC, 12 were modelling studies,[25 29 30 39 45 49 50 54–56 59 60] 3 were observational[31 32 36] and 2 were laboratory-based studies.[24 27] Two of the observational studies were appraised as high quality[32 36] while one was considered medium quality.[31] A summary of studies can be found in tables 4 and 5.

Duration of quarantine and/or isolation

Two modelling studies explored the impact of quarantine on cases and deaths related to Beta[54 59] and/or Alpha.[54] Both studies highlighted the increased transmissibility of VOC would require lengthier quarantines to control their spread both within and between countries.

Table 2 Study summary on findings related to modifying approach to vaccination, categorised by study topic

Author, year (country)	Study design	Study objective	Data collection	Sample	Outcome measures	Key findings	QA
Vaccine schedules that offer greater protection							
Exploring vaccine protection using a correlate of laboratory neutralisation in consideration of variants							
Collier *et al*[33] 2021 (UK)	Laboratory	Assess immune response after 1st and 2nd BNT162b2 doses.	9 December 2020 to 3 February 2021	51 adults (n=24,<80 years; n=26, >80 years)	Serum antibody neutralisation 3 weeks after 1st dose	Age correlated with serum neutralisation for wild type and Alpha after 1st dose, but not following 2nd dose.	N/A
Jangra *et al*[57] 2021(USA)	Laboratory	Assess impact of E484K mutation in neutralising activity of specific antisera.	N/A	34 sera from SARS-CoV-2-positive and 5 vaccinated people	Serum neutralisation efficiency	Neutralising activity was lower against E484K for both human convalescent and postvaccinated individuals.	N/A
Luo *et al*[43] 2021 (USA)	Modelling	Estimate the durability of mRNA-1273 vaccine against SARS-CoV-2 VOC.	N/A	33 individuals who received 100 µg of mRNA-1273 vaccine on days 1 and 29	Level of binding antibodies and virus neutralisation after 1st dose	After 1 dose of mRNA-1273, Beta took 100 days, Gamma took 202 days and Alpha took 309 days to fall below 20 GMT.	N/A
Exploring different vaccination schedules							
Pageaud *et al*[47] 2021 (France)	Modelling	Model expected dynamics of COVID-19 with different vaccine strategies.	N/A	Santé publique France data from 8 January, 27 January and 18 February 2021	Individuals recovered, in- hospital deaths, ICU resource use	Best outcome with rapid vaccination of whole population in 6 months, and 1-year campaign with NPIs would limit deaths and ICU saturation.	N/A
Giordano *et al*[35] 2021 (Italy)	Modelling	Compare vaccine campaign scenarios, varying SARS-CoV-2 profiles and NPIs.	24 February to 26 March 2021	Data on new positive case provided by SIDARTHE	Healthcare costs, death	NPIs should remain during vaccine rollout until population immunity is reached; pre-emptive NPIs would reduce hospitalisations and deaths.	N/A
Munitz *et al*[46] 2021 (Israel)	Modelling	Explore transmission of Alpha to estimate impact of public health measures.	6 December 2020 to 10 February 2021	>300 000 RT-PCR samples	SGTF data, reproduction number (R_t) and cycle threshold	Israel's age-based vaccine programme reduced Alpha transmission in 60+ age group compared with 0–19 or 20–59 age group.	N/A
Kim *et al*[38] 2021 (USA)	Modelling	Model impact of different vaccines with varying efficacies.	N/A	US population (~330 million)	Infection attack rate (IAR)	Speed of vaccine rollout is key factor in achieving low IAR even after variants emerge and with low-efficacy vaccine.	N/A

Continued

Table 2 Continued

Author, year (country)	Study design	Study objective	Data collection	Sample	Outcome measures	Key findings	QA
Sah *et al*[48] 2021 (USA)	Modelling	Model accelerated vaccine rollout to curb spread of variants.	N/A	US population (~330 million)	Hospitalisation and death rate	Current vaccine rollout (1 million doses/day) will not slow the pandemic; accelerated rollout (2 million doses/day) would reduce health outcomes from variants.	N/A
Teslya *et al*[51] 2021 (Netherlands)	Modelling	Investigate effect of waning physical distancing compliance on vaccine rollout.	N/A	Vaccine rollout data from 7 January to 7 February 2021 from Netherlands and UK	Number of people infected and vaccinated; vaccine compliance to 1–2 years	When vaccine rollout is slow, focus on improving physical distancing compliance in unvaccinated individuals. When vaccine rollout is high, target compliance levels among vaccinated individuals	N/A
Tokuda and Kuniya[52] 2021 (Japan)	Modelling	Model impact of vaccination schedules on infection rate and public health measures.	14 January 2020 to 20 April 2021	N/A	Number of daily infections	Current vaccination pace of 1/1000 vaccinations per person per day needs to be quadrupled to control the spread of Alpha.	N/A
Victora *et al*[58] 2021 (Brazil)	Cross-sectional	Assess effectiveness of vaccination campaign on mortality.	3 January to 22 April 2021	>370 000 registered deaths	Mortality rate among adults aged 0–79, 80+ and 90+ years	Increased vaccination among Brazilians aged 80+ years associated with decline in relative mortality versus those aged 0–79 years when Gamma was prevalent.	60%
Attitudes towards vaccines related to VOC							
Bachtiger *et al*[28] 2021 (UK)	Cross-sectional	Assess impact of variants on vaccine hesitancy and attitude.	13 November and 31 December 2020	9617 people from Imperial College Healthcare NHS Foundation Trust	Attitude towards vaccine prioritisation	Intention to vaccinate increased from 71.5% to 85% after Alpha emergence. Age and gender influenced vaccine behaviours.	10%
Comparing natural or vaccine protection against COVID-19							
Lumley *et al*[42] 2021 (UK)	Cohort	Compare protection by vaccine and Alpha.	April 2020 to 28 February 2021	13 109 HCWs in Oxford University Hospitals	PCR positive test, antibody status	Natural immunity with detectable antispike antibodies and two doses of vaccine gives similar protection against Alpha.	44%

GMT, geometric mean endpoint titre; HCW, healthcare worker; ICU, intensive care unit; N/A, not available; NPI, non-pharmaceutical intervention; QA, quality appraisal (low score <50%; medium score 50%–80%; high score >80%); SGTF, spike gene target failure; SIDARTHE, susceptible, infected, diagnosed, ailing, recognised, threatened, healed and extinct; VOC, variant of concern.

Table 3 Summary of studies reporting on public health infection prevention measures in the community up to 11 May 2021

Author, year (country)	Study design	Objective	Data collection	Sample	Outcome measures	Relevant key findings	QA
Mask wearing							
Gurbaxani *et al*[37] 2021 (USA)	Modelling	Model face mask efficacy parameters for variety of types of masks and efficacy estimates.	N/A	N/A	Effectiveness of mask wearing	Masks can reduce SARS-CoV-2 transmission, even with moderately effective masks, when worn consistently and correctly by a large portion of population.	N/A
Hand washing							
Meister *et al*[44] 2021 (Germany)	Laboratory	Compare surface stability of wild type, Alpha and Beta on different surfaces and their sensitivity to heat, soap and ethanol.	N/A	N/A	Viral stability and viral infectivity	No differences between wild type and VOC in disinfection profiles, indicating current hygiene measures sufficient and appropriate.	N/A
Physical distancing							
Domenico *et al*[34] 2021 (France)	Modelling	Assess impact of social distancing on historical and variant strain through modelling.	N/A	Survey data from Santé publique France on 28 January 2021	Alpha prevalence	Strong social distancing measures including mild lockdown were needed to reduce spread of Alpha in third wave.	N/A
Vazquez *et al*[53] 2021 (Germany)	Modelling	Estimate SARS-CoV-2 transmission per proximity contact and generate a model to simulate outbreaks in workplaces.	N/A	605 individuals from one workplace	Proximity data (via Bluetooth devices) between coworkers over 44 days	Transmission rate per contact was three times higher for Alpha versus SARS-CoV-2. Workplaces can use proximity data to simulate outbreaks and management strategies.	N/A
Aiano *et al*[26] 2021 (England)	Cross-sectional	Investigate COVID-19 outbreaks in nurseries reported to Public Health England.	9–23 February 2021	173 nurseries reporting a COVID-19 outbreak	Outbreak and facility characteristics	1% of nurseries reported COVID-19 outbreaks during study period. Some evidence larger outbreaks and higher attack rates among staff/students in January 2021 when Alpha predominated.	50%
Lasser *et al*[40] 2021 (Austria)	Modelling	Develop model to evaluate effectiveness of NPIs in preventing transmission in different school types.	616 clusters involving 2822 student cases and 676 teacher cases	Austrian school cluster data	Transmission probability	Model suggests combination of two and three preventative strategies for primary and secondary schools, respectively, to limit transmission. Under Alpha scenario with two preventative strategies, secondary schools saw a threefold increase in clusters with student sources.	N/A

Continued

Table 3 Continued

Author, year (country)	Study design	Objective	Data collection	Sample	Outcome measures	Relevant key findings	QA
Linka *et al*[41] 2021 (USA)	Modelling	Model effects of VOC on disease dynamics with reopening Stanford University in 2020–2021.	N/A	Undergraduate students at Stanford University	Number of students infected	Outbreak dynamics with introduction of Alpha and Beta are significantly different from wild-type dynamics. The most affected quarter (Fall 2020) would have seen 203 cases for wild type but 4727 Alpha and 4256 Beta.	N/A

N/A, not available; NPI, non-pharmaceutical intervention; QA, quality appraisal (low score <50%; medium score 50%–80%; high score >80%); VOC, variant of concern.

Frequency or change of testing for VOC

Two studies reported on implications for potentially modifying existing public health testing measures. One study evaluated the use of a primer that could be used in a rapid, low-cost screening protocol to detect VOC.[24] A second study evaluated the PanBio SARS-CoV-2 Rapid Antigen Test in a sample of patients in South Africa, which was found to be effective at detecting both wild type and Beta.[27] Together, these studies highlight potential, novel testing strategies for detecting VOC when access to laboratories for genome sequencing is limited.

Contact tracing

No studies were identified related to the impact of VOC on contact tracing.

Changing approach to outbreak management

Thirteen studies reported on different approaches to outbreak management across a range of settings and outcomes. Four studies discussed managing outbreaks through stricter lockdowns,[25 36 39 49] four studies reported on the impact of physical distancing on outbreak management[29 31 32 60] and five studies reported on outbreak management through various public health measures across community settings.[30 45 50 55 56]

Managing outbreaks through lockdown measures

The four studies reporting on managing outbreaks through lockdown measures evaluated the impact of Alpha on transmission[36 39] and/or the economy[25 49] through lockdowns of varying length and intensity. Together, these studies found that strict lockdowns effectively reduced transmission of Alpha while less strict lockdowns would see the reproductive number exceed one[36 39 49] and contribute additional financial costs to society.[25 49] One study suggested the most effective approach to mitigate the impact of Alpha would be a combination of frequent, systematic testing along with quick, strict lockdowns.[39]

Managing outbreaks through physical distancing

Four studies explored managing outbreaks through physical distancing measures on the spread of Alpha[29 31 32] and Gamma.[60] Of the four studies, one assessed community spread[29] and three assessed household spread.[31 32 60] All four studies found that physical distancing measures were associated with a decrease in transmission.[29 31 32 60] However, in one of these studies, Gamma transmission was higher when individuals remained close to home, and where space was potentially limited.[60] This study highlights the need to tailor public health measures to specific populations and that vigilance regarding household transmission is warranted.

Managing outbreaks through other public health measures

Five studies explored managing outbreaks through other public health measures, not previously discussed. Three studies modelled vaccination schedules and NPIs against outbreaks of Alpha.[30 45 55] Together, these studies found that due to increased hospitalisation, intensive care unit

Table 4 Summary of studies presenting findings on testing and duration of quarantine related to VOC up to 11 May 2021

Author, year (country)	Study design	Objective	Data collection	Sample	Outcome measure	Relevant key finding	QA
Testing							
Abdel Sater *et al*[24] 2021 (Lebanon)	Laboratory	Evaluate a primer to confirm deletion mutations Δ69/Δ70 and Δ106/Δ107.	9 December 2020 to 10 January 2021	20 samples from patients positive for SARS-CoV-2 confirmed through TaqPath kit	SYBR Green-based RT-PCR	This primer could be used as a second step test in RT-PCR to confirm Alpha in COVID-19-positive S-gene-negative patients.	N/A
Akingba *et al*[27] 2021 (South Africa)	Laboratory	Evaluate field performance of PanBio assay to detect Beta.	17–20 November 2020	677 patients from 6 mobile clinics	N/A	The assay reliably detected Beta infection in ambulatory ill patients. Sensitivity was >90% in patients with high viral loads.	N/A
Quarantine							
Yang *et al*[59] 2021 (Brazil)	Modelling	Develop model to evaluate partial quarantine and further relaxation in São Paulo state, Brazil.	26 February 2020 to 5 April 2021	N/A	COVID cases and fatality curves	In the presence of VOC, model predicts increased fatality, and cases of COVID to rise on relaxation of public health measures, as a result of VOC rather than lifting of measures.	N/A
Wells *et al*[54] 2021 (USA)	Modelling	Model travel between European countries to identify travel quarantine and testing strategies that limit infections compared with complete border closure.	N/A	N/A	Length of quarantine for origin-destination pairs of European countries	Quarantines for European destinations informed by country-specific prevalence, daily incidence, vaccine coverage, age demographics and travel flow. For Alpha, in countries with similar prevalence, quarantine and testing strategies are similar for wild-type transmission. In contrast, much greater variance between countries in the presence of Beta, meaning more extreme quarantine and testing measures needed to mitigate its impact.	N/A

N/A, not available; QA, quality appraisal (low score <50%; medium score 50%–80%; high score >80%); VOC, variant of concern.

Table 5 Summary of studies presenting findings on outbreak management related to VOC up to 11 May 2021

Author, year (country)	Study design	Objective	Data collection	Sample	Outcome measure	Relevant key finding	QA
Outbreak management							
Managing outbreaks through lockdowns							
Graham *et al*[36] 2021 (Scotland, Wales and England)	Cross-sectional	Examine the association between Alpha, reported symptoms, disease course and transmissibility.	8 September to 31 December 2020	36 920 participants in COVID Symptom Study	Self-reported symptom data	Regional and then national lockdown led to reduced transmission among regions with high proportion of Alpha cases.	80%
Scherbina[49] 2021 (USA)	Modelling	Estimate the benefits of lockdown in the USA.	N/A	N/A	Estimated future monetary cost of pandemic	Strict lockdown could reduce R. Optimal lockdown time (6–7 weeks) needed to achieve high-dQALY outcomes, or 4–5 weeks for low-dQALY outcomes.	N/A
Ahn *et al*[25] 2021 (USA)	Modelling	Examine the framework to optimise COVID-19 containment policies.	N/A	N/A	Economic and health costs of policy	Findings indicate importance of tracking and containing VOCs before they become widespread.	N/A
Kühn *et al*[39] 2021 (Germany)	Modelling	Model different lockdown/restriction strategies to avoid spread of VOC between neighbouring regions.	N/A	Population in Germany	SARS-CoV-2 incidence levels	Combination of lockdowns and testing can contain outbreaks in low-incidence areas. Travel between high/low incidence regions is problematic. Strict measures plus testing of commuters are effective in preventing spread in hot spots.	N/A
Managing outbreaks through physical distancing							
Borges *et al*[29] 2021 (Portugal)	Modelling	Investigate the proportion of SGTF cases to understand Alpha frequency and spread.	December 2020 to 5 February 2021	3367 positive SGTF tests from National Institutes of Health	SGTF and SGTL tests	After implementing public health measures, decelerating trend was observed in proportion of SGTF/SGTL remaining below 50% in week 7 of 2021.	N/A
Buchan *et al*[31] 2021 (Canada)	Cohort	Compare household secondary attack rates in VOC versus non-VOC index cases in Ontario.	7–27 February 2021	5617 index cases and 3397 secondary cases	Household secondary attack rate 1–14 days after index case	Secondary attack rate higher in VOC versus non-VOC in same household, further accentuated in asymptomatic and presymptomatic cases, suggests need for aggressive NPIs.	67%

Continued

Table 5 Continued

Author, year (country)	Study design	Objective	Data collection	Sample	Outcome measure	Relevant key finding	QA
Chudasama *et al*[32] 2021 (England)	Cross-sectional	Comparative analysis of household clustering of COVID-19 infections.	1 October to 15 December 2020	57 382 positive sequenced cases	Number and proportion of VOCs and wild-type cases	Alpha almost twice as likely to give rise to household clusters than wild type.	89%
Zimerman *et al*[60] 2021 (Brazil)	Modelling	Assess social isolation into small families or groups associated with emergence of new variants.	1 June 2020 to 10 January 2021	773 genomic sequence samples	Social Isolation Index (SII) (% of individuals staying within 450 m of home)	Observed positive correlation between SII and prevalence of Gamma when SII was above 40%. Suggests forced prolonged cohabitation boosts viral mutation and infectivity in Amazonas region.	N/A
Managing outbreaks through other public health measures							
Moore *et al*[45] 2021 (UK)	Modelling	Model impact of relaxing NPI and vaccination on individual risk.	Data for 7 NHS regions of England and 3 nations	N/A	Daily hospital admissions, deaths up to 1 January 2024	Vaccine reduces COVID-19 deaths, but assuming 60%–85% vaccine efficacy, 75%–95% age-dependent vaccine coverage and R=3.15, continued NPIs necessary to limit deaths once vaccine programme ends.	N/A
Shattock *et al*[55] 2021 (Switzerland)	Modelling	Model impact of vaccine scenarios and NPIs on COVID-19 pandemic.	Epidemiological data up to 5 March 2021	Population in Switzerland	Cases, hospitalisations, ICU admissions, deaths up to September 2021	Rigorous monitoring of vaccine uptake and emergence of variants required to prevent third wave. Combination of vaccine uptake and ongoing NPIs will dictate size of third wave.	N/A
Bosetti *et al*[30] 2021 (France)	Modelling	Understand the interplay of variants, vaccines and control measures.	N/A	Metropolitan France	Hospitalisations and deaths	Quick rollout of vaccines to at-risk individuals and NPIs needed to mitigate impact of emerging variants.	N/A
Piantham and Ito[56] 2021 (UK)	Modelling	Propose method to estimate selective advantage of variants.	1 September 2020 to 19 February 2021	71 692 Alpha and 65 850 non-Alpha strains	Time from illness onset in primary case and secondary case	Alpha has reproduction advantage of 33.7% over non-VOC, suggesting control measures need to be strengthened by 33.7%.	N/A
Smith *et al*[50] 2021 (UK)	Modelling	Assess impact of environment (eg, temperature) on VOC transmission.	19 October to 7 December 2020	N/A	Population density, temperature and R	Warmer temperatures associated with decreased VOC transmission. However, impact of temperature only secondary to public health measures.	N/A

dQALY, Quality Adjusted Life Years; ICU, intensive care unit; N/A, not available; NPI, non-pharmaceutical intervention; QA, quality appraisal (low score <50%; medium score 50%–80%; high score >80%); R, reproductive number; SGTF, spike gene target failure; SGTL, spike gene target amplification level; VOC, variant of concern.

(ICU) admission and death related to Alpha, subsequent waves will only be prevented if two doses of vaccine are administered quickly along with strict NPI measures.[30 45 55] One study calculated that due to the increased transmissibility of Alpha, public health measures should be strengthened by 33.7% to mitigate the spread.[56] The fifth study which explored the impact of temperature on VOC found that although warmer temperatures were associated with lower VOC transmission, this was only secondary to the impact of public health measures.[50]

DISCUSSION

This rapid scoping review synthesised the evidence from 37 studies which reported on VOC and public health measures. While the types of public health measures varied in nature, the majority of studies were related to infection control measures, and in particular, outbreak management. Evidence overwhelmingly supports the implementation of NPI measures (eg, lockdowns, physical distancing, mask wearing and hand washing) alongside accelerated vaccine campaigns to mitigate the impact of the highly transmissible VOC.

Most studies contributing data on vaccinations reported on mRNA vaccines. This is not surprising as the first vaccines to be approved for use were two mRNA vaccines, commonly known as Pfizer-BioNTech and Moderna.[61 62] While our review did not report on vaccine efficacy, more research is needed to understand the impact of modifying vaccine rollout for non-mRNA vaccines, such as AstraZeneca, on VOC transmission. In addition, the three studies reporting on vaccine protection using a correlate of laboratory neutralisation included small samples of 34–51 individuals. There are limitations in generalising these findings to a wider population. The findings of our review clearly suggest vaccination campaigns be accelerated in response to the more transmissible VOC. Some models suggest a vaccination rate of 60–90 doses per day per 10 000 population is required to mitigate VOC risk.[48 52] Additionally, certain age groups, such as older adults, should be targeted to optimise immune response and prevention efforts. This is in line with many countries' vaccine rollout plan where vaccine eligibility was largely based on age and HCW status.[63 64] Clearly, there is an urgent need for public health officials to adjust their pandemic response measures to include accelerated vaccine campaigns to mitigate the spread of VOC.

Studies in our review suggest strong NPI measures be implemented in parallel with enhanced vaccine scheduling. The increased transmissibility of VOC signals the need for more pre-emptive restrictions (close phase first and then open with low case numbers) versus reactive (open first, then close to prevent ICU saturation) strategies. Studies relevant to this question focused broadly on social distancing as a strategy, with no specific recommendation regarding objective metrics such as proximity time, distance or type of social distancing strategy. Included studies identified the need for attention to managing contacts in specific environments such as households, educational and early care centres, and workplace settings, yet few recommendations were provided to address these needs. Without clear recommendations, public health officials are left to make decisions based on rapidly changing epidemiology and limited empirical evidence. It is important to highlight that all included studies reporting on NPIs were effective against VOC to some degree. Clearly, further research is needed to guide public health recommendations in response to VOC.

We identified limited evidence focused on modification to hand washing or masking related to the emergence of variant strains. This is surprising as public health messages from national governing bodies encourage mask wearing and hand washing as key infection prevention measures.[12] Although this may be considered a gap in evidence, it is possible that these recommendations were based on non-VOC data and have remained unchanged with the emergence of VOC. With significant COVID-19 research efforts focused on developing and distributing vaccines, it is possible that some public health measures were implemented ahead of evidence. Certain measures, such as hand washing, are common recommendations for other viruses like influenza, and although there is mixed evidence on the effectiveness of hand washing in the community,[65] hand washing recommendations for COVID-19 are likely based on implicit evidence. Despite the possible reasons for limited evidence associated with public health measures and VOC, this highlights a need for further research in this area.

Limitations

The rapid review study design allowed for a robust and timely synthesis of current evidence related to VOC and public health measures, highlighting a strength of this study. However, due to the rapid production of the literature, the majority of papers in this review were preprints and have thus not yet undergone peer review. This must be considered when interpreting study findings. Additionally, our search strategy was limited to articles that specified reporting on one of the recognised VOCs (Alpha, Beta, Gamma or Delta). Given the growing trend that VOCs are replacing the wild type as the dominant strain and the continued emergence of other variants of interest, future consideration of expanding the search strategy may be warranted. Additionally, as the search was conducted during a time when the Delta VOC was just beginning to emerge (May 2021), no studies in this review reported on Delta. New evidence related to this VOC may have emerged since running the search. Another limitation of restricting to studies that reported specifically on VOC, it is difficult to interpret some of the findings without taking into consideration the wider literature on SARS-CoV-2. For example, we report on attitudes towards vaccines only in context of VOC, without wider acknowledgement of the extensive body of literature on vaccine hesitancy for non-VOC. Despite some of these limitations, our study provides a novel overview of

VOC research, which has direct and immediate impact on population health. To our knowledge, no other reviews have provided a synthesis of research on this topic to date.

CONCLUSION

The findings from this review highlight the urgent need for further research employing rigorous study designs on the implications of public health measures and VOC. Apart from outbreak management and vaccine rollout models, we found limited evidence on other public health measures such as mask wearing and quarantine procedures. Further studies are also needed on the range of existing VOCs. Our findings highlight the need for further research to strengthen the evidence related to vaccine campaigns and public health measures to limit the spread of VOC.

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REFERENCES

1 Cucinotta D, Vanelli M. Who Declares COVID-19 a pandemic. *Acta Biomed* 2020;91:157–60.
2 WHO. Weekly operational update on COVID-19 - 24 May 2021, 2021. Available: https://www.who.int/publications/m/item/weekly-operational-update-on-covid-19-24-may-2021 [Accessed 28 May 2021].
3 WHO. *SARS-CoV-2 variants*. World Health Organization, 2020. http://www.who.int/csr/don/31-december-2020-sars-cov2-variants/en/
4 WHO. COVID-19 Weekly epidemiological update - February 25, 2021, 2021. Available: https://www.who.int/publications/m/item/covid-19-weekly-epidemiological-update [Accessed 12 Mar 2021].
5 WHO. Weekly epidemiological update on COVID-19 - 25 May 2021. Available: https://www.who.int/publications/m/item/weekly-epidemiological-update-on-covid-19-25-may-2021 [Accessed 15 Jun 2021].
6 Public Health England. Investigation of novel SARS-COV-2 variant: variant of concern 202012/01, 2020. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/959438/Technical_Briefing_VOC_SH_NJL2_SH2.pdf [Accessed 09 Mar 2021].
7 Curran JA, Dol J, Boulos L. Transmission characteristics of SARS-CoV-2 variants of concern: rapid scoping review. *medRxiv* 2021;21255515. [Epub ahead of print: 2021.04.23].
8 Wibmer CK, Ayres F, Hermanus T. SARS-CoV-2 501Y.V2 escapes neutralization by South African COVID-19 donor plasma. *bioRxiv* 2021.
9 Agency for Clinical Innovation. Living Evidence - SARS-CoV-2 variants, 2021. Available: https://aci.health.nsw.gov.au/covid-19/critical-intelligence-unit/sars-cov-2-variants [Accessed 24 Apr 2021].
10 WHO. Strategic planning and operational guidance for maintaining essential health services during an outbreak. Available: https://www.who.int/publications-detail-redirect/strategic-planning-and-operational-guidance-for-maintaining-essential-health-services-during-an-outbreak [Accessed 15 Jun 2021].
11 WHO. Listings of WHO's response to COVID-19. Available: https://www.who.int/news/item/29-06-2020-covidtimeline [Accessed 15 Jun 2021].
12 WHO. Advice on the use of masks in the context of COVID-19: interim guidance, 5 June 2020, 2020. Available: https://apps.who.int/iris/handle/10665/332293 [Accessed 15 Jun 2021].
13 WHO. Laboratory testing strategy recommendations for COVID-19: interim guidance. Available: https://www.who.int/publications-detail-redirect/laboratory-testing-strategy-recommendations-for-covid-19-interim-guidance [Accessed 15 Jun 2021].
14 WHO. Considerations for implementing and adjusting public health and social measures in the context of COVID-19. Available: https://www.who.int/publications-detail-redirect/considerations-in-adjusting-public-health-and-social-measures-in-the-context-of-covid-19-interim-guidance [Accessed 15 Jun 2021].
15 Leung K, Wu JT, Liu D, *et al*. First-wave COVID-19 transmissibility and severity in China outside Hubei after control measures, and

second-wave scenario planning: a modelling impact assessment. *Lancet* 2020;395:1382–93.
16 Tricco AC, Langlois EV, Straus SE. Rapid reviews to strengthen health policy and systems: a practical guide, 2017. Available: http://apps.who.int/iris/bitstream/10665/258698/1/9789241512763-eng.pdf [Accessed 09 Mar 2021].
17 Peters MDJ, Godfrey CM, Khalil H, *et al*. Guidance for conducting systematic scoping reviews. *Int J Evid Based Healthc* 2015;13:141–6.
18 Khangura S, Konnyu K, Cushman R, *et al*. Evidence summaries: the evolution of a rapid review approach. *Syst Rev* 2012;1:10.
19 Shamseer L, Moher D, Clarke M, *et al*. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. *BMJ* 2015;350:g7647.
20 Covidence. Covidence - Better systematic review management. Available: https://www.covidence.org/ [Accessed 15 Jun 2021].
21 Wells G, Shea B, O'Connell D. The newcastle-ottawa scale (NOS) for assessing the quality of nonrandomised studies in meta-analysesOttawa Hospital Research Institute. Available: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp [Accessed 23 Apr 2021].
22 Modesti PA, Reboldi G, Cappuccio FP, *et al*. Panethnic differences in blood pressure in Europe: a systematic review and meta-analysis. *PLoS One* 2016;11:e0147601.
23 Tricco AC, Lillie E, Zarin W, *et al*. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med* 2018;169:467–73.
24 Abdel Sater F, Younes M, Nassar H. A rapid and low-cost protocol for the detection of B.1.1.7 lineage of SARS-CoV-2 by using SYBR green-based RT-qPCR. *medRxiv* 2021;21250048.
25 Ahn H-S, Silberholz J, Song X. *Optimal COVID-19 containment strategies: evidence across multiple mathematical models*. Rochester, NY: Social Science Research Network, 2021. https://papers.ssrn.com/abstract=3834668
26 Aiano F, McOwat K, Obi C. *COVID-19 outbreaks in nurseries during rapid spread of the B.1.1.7 variant of SARS-CoV-2 in England: cross-sectional national surveillance, November 2020 – January 2021*. Rochester, NY: Social Science Research Network, 2021.
27 Akingba OL, Sprong K, Hardie DR. Field performance evaluation of the PanBio rapid SARS-CoV-2 antigen assay in an epidemic driven by 501Y.v2 (lineage B.1.351) in the eastern cape, South Africa. *medRxiv* 2021;21251057.
28 Bachtiger P, Adamson A, Maclean WA. Increasing but inadequate intention to receive Covid-19 vaccination over the first 50 days of impact of the more infectious variant and roll-out of vaccination in UK: indicators for public health messaging. *medRxiv* 2021;21250083.
29 Borges V, Sousa C, Menezes L, *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* 2021;26 https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2021.26.10.2100130
30 Bosetti P, Kiem CT, Andronico A. A race between SARS-CoV-2 variants and vaccination: the case of the B.1.1.7 variant in France, 2021. Available: https://hal-pasteur.archives-ouvertes.fr/pasteur-03149525 [Accessed 26 May 2021].
31 Buchan SA, Tibebu S, Daneman N, *et al*. Increased household secondary attacks rates with variant of concern SARS-CoV-2 index cases. *Clin Infect Dis* 2021;21254502. doi:10.1093/cid/ciab496. [Epub ahead of print: 09 Jun 2021].
32 Chudasama DY, Flannagan J, Collin SM, *et al*. Household clustering of SARS-CoV-2 variant of concern B.1.1.7 (VOC-202012-01) in England. *J Infect* 2021;83:e26–8.
33 Collier DA, IATM F, Datir R. Age-related heterogeneity in immune responses to SARS-CoV-2 vaccine BNT162b2. *medRxiv* 2021;21251054. [Epub ahead of print: 2021.02.03].
34 Domenico LD, Sabbatini CE, Pullano G. Impact of January 2021 curfew measures on SARS-CoV-2 B.1.1.7 circulation in France. *medRxiv* 2021;21251708. [Epub ahead of print: 2021.02.14].
35 Giordano G, Colaneri M, Di Filippo A. Modeling vaccination rollouts, SARS-CoV-2 variants and the requirement for non-pharmaceutical interventions in Italy. *Nature Medicine* 2021:1–6.
36 Graham MS, Sudre CH, May A, *et al*. Changes in symptomatology, reinfection, and transmissibility associated with the SARS-CoV-2 variant B.1.1.7: an ecological study. *Lancet Public Health* 2021;6:e335–45.
37 Gurbaxani BM, Hill AN, Paul P. Evaluation of different types of face masks to limit the spread of SARS-CoV-2 – a modeling study. *medRxiv* 2021;21255889. [Epub ahead of print: 2021.04.21].
38 Kim D, Keskinocak P, Pekgün P. The balancing role of distribution speed against varying efficacy levels of COVID-19 vaccines under variants. *medRxiv* 2021;21255217. [Epub ahead of print: 2021.04.09].
39 Kühn MJ, Abele D, Binder S. Regional opening strategies with commuter testing and containment of new SARS-CoV-2 variants. *medRxiv* 2021;21255995. doi:10.1101/2021.04.23.21255995. [Epub ahead of print: 2021.04.23] https://www.medrxiv.org/content/10.1101/2021.04.23.21255995v1.full
40 Lasser J, Sorger J, Richter L. Assessing the impact of SARS-CoV-2 prevention measures in schools by means of agent-based simulations calibrated to cluster tracing data. *medRxiv* 2021;21255320. [Epub ahead of print: 2021.04.13].
41 Linka K, Peirlinck M, Schäfer A. Effects of B.1.1.7 and B.1.351 on COVID-19 dynamics. A campus reopening study. *medRxiv* 2021;21255954. [Epub ahead of print: 2021.04.22].
42 Lumley SF, Rodger G, Constantinides B. An observational cohort study on the incidence of SARS-CoV-2 infection and B.1.1.7 variant infection in healthcare workers by antibody and vaccination status. *medRxiv* 2021;21253218.
43 Luo G, Hu Z, Letterio JJ. Modeling and predicting antibody durability for mRNA-1273 vaccine for SARS-CoV-2 variants. *medRxiv* 2021;21256537. [Epub ahead of print: 2021.05.04].
44 Meister T, Fortmann J, Todt D. Comparable environmental stability and disinfection profiles of the currently circulating SARS-CoV-2 variants of concern B.1.1.7 and B.1. *J Infect Dis* 2021;351 https://academic.oup.com/jid/article/224/3/420/6276396
45 Moore S, Hill EM, Tildesley MJ, *et al*. Vaccination and non-pharmaceutical interventions for COVID-19: a mathematical modelling study. *Lancet Infect Dis* 2021;21:793–802.
46 Munitz A, Yechezkel M, Dickstein Y, *et al*. 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;2:100264.
47 Pageaud S, Ponthus N, Gauchon R. Adapting French COVID-19 vaccination campaign duration to variant dissemination. *medRxiv* 2021;21253739.
48 Sah P, Vilches TN, Moghadas SM, *et al*. Accelerated vaccine rollout is imperative to mitigate highly transmissible COVID-19 variants. *EClinicalMedicine* 2021;35:100865.
49 Scherbina A. Assessing the optimality of a COVID Lockdown in the United States. *Econ Disaster Clim Chang* 2021;5:177–201 https://link.springer.com/article/10.1007/s41885-021-00083-6
50 Smith TP, Dorigatti I, Mishra S. Environmental drivers of SARS-CoV-2 lineage B.1.1.7 transmission intensity. *medRxiv* 2021;21253242. doi:10.1101/2021.03.09.21253242. [Epub ahead of print: 2021.03.09] https://www.medrxiv.org/content/10.1101/2021.03.09.21253242v2
51 Teslya A, Rozhnova G, Pham T. The importance of sustained compliance with physical distancing during COVID-19 vaccination rollout. *Research Square*.
52 Tokuda Y, Kuniya T. Japan's Covid mitigation strategy and its epidemic prediction. *medRxiv* 2021;21256476.
53 Vazquez A, Staebler M, Khanin A. Estimating the super-spreading rate at workplaces using bluetooth technology. *medRxiv* 2021;21252550.
54 Wells CR, Townsend JP, Pandey A. Quarantine and testing strategies for safe pandemic travel. *Epidemiology* 2021.
55 Shattock AJ, Rutte EAL, Dünner RP. Impact of vaccination and non-pharmaceutical interventions on SARS-CoV-2 dynamics in Switzerland. *medRxiv* 2021;21255503. doi:10.1101/2021.04.14.21255503. [Epub ahead of print: 2021.04.14] https://www.medrxiv.org/content/10.1101/2021.04.14.21255503v1
56 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;21253775 https://www.medrxiv.org/content/10.1101/2021.03.17.21253775v4
57 Jangra S, Ye C, Rathnasinghe R. The E484K mutation in the SARS-CoV-2 spike protein reduces but does not abolish neutralizing activity of human convalescent and post-vaccination sera. *medRxiv* 2021;21250543. [Epub ahead of print: 2021.01.26].
58 Victora C, Castro MC, Gurzenda S. 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;21256187. [Epub ahead of print: 2021.04.27].
59 Yang HM, Junior LPL, Castro FFM. Quarantine, relaxation and mutation explaining the CoViD-19 epidemic in São Paulo state (Brazil). *medRxiv* 2021;21255325. [Epub ahead of print: 2021.04.12].
60 Zimerman RA, Cadegiani FA, Pereira E Costa RA. Stay-at-home orders are associated with emergence of novel SARS-CoV-2 variants. *Cureus* 2021;13:e13819 https://www.cureus.com/articles/54084-stay-at-home-orders-are-associated-with-emergence-of-novel-sars-cov-2-variants
61 Oliver SE. The Advisory Committee on Immunization Practices' Interim Recommendation for Use of Pfizer-BioNTech COVID-19

Vaccine — United States, December 2020. *MMWR Morb Mortal Wkly Rep* 2020:69.
62 Mahase E. Covid-19: UK approves pfizer and BioNTech vaccine with rollout due to start next week. *BMJ* 2020;371:m4714.
63 Cylus J, Panteli D, van Ginneken E. Who should be vaccinated first? comparing vaccine prioritization strategies in Israel and European countries using the Covid-19 health system response monitor. *Isr J Health Policy Res* 2021;10:16.
64 WHO. Who SAGE roadmap for prioritizing uses of COVID-19 vaccines in the context of limited supply. Available: https://www.who.int/publications-detail-redirect/who-sage-roadmap-for-prioritizing-uses-of-covid-19-vaccines-in-the-context-of-limited-supply [Accessed 15 Jun 2021].
65 Moncion K, Young K, Tunis M, *et al*. Effectiveness of hand hygiene practices in preventing influenza virus infection in the community setting: a systematic review. *Can Commun Dis Rep* 2019;45:12–23.
66 Page MJ, McKenzie JE, Bossuyt PM, Boutron I, *et al*. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71.