UK Health Security Agency

The effectiveness of face coverings to reduce transmission of COVID-19 in community settings

A rapid review (update 2)

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Main messages

1. The purpose of this review was to identify and examine evidence on the effectiveness of face coverings to reduce transmission of coronavirus (COVID-19) in the community. The review includes 25 studies (including 9 preprints and 2 non-peer-reviewed reports): 2 randomised controlled trials (RCTs) and 23 observational studies (search date: up to 14 September 2021).
2. This is an update of an earlier rapid review, which included ecological and descriptive studies (not included in this review) and assessed evidence for the efficacy of face coverings (not addressed in this review). In total, 3 studies (all contact tracing studies) in the previous review were also used in this review.
3. The evidence predominantly suggests that face coverings reduce the spread of COVID-19 in the community, through source control, wearer protection, and universal masking. The studies identified did not support an assessment of whether face coverings were more effective as source control or wearer protection.
4. One RCT provides direct evidence that face coverings (surgical and cloth face coverings) are effective when used as universal masking, particularly for surgical masks and for older people, and that the interventions to increase face covering use also increased social distancing. Another RCT was inconclusive, reporting a non-significant reduction in COVID-19 infections from wearer protection using surgical masks. The study lacked precision as relatively few participants developed COVID-19.
5. Eight contact tracing studies suggested that contacts of primary cases were less likely to develop COVID-19 if either the primary case or the close contact, or both, wore a face covering. However, all studies were observational so factors not considered by the authors in the analysis could have impacted upon the results, for example other mitigation measures such as hand washing and social distancing.
6. Four studies set in schools and a summer camp and 11 other observational association studies had mixed results for the effectiveness of face coverings, with some studies suggesting face coverings were associated with reduced COVID-19 transmission and others suggesting no statistically significant effect. Most studies were of low quality. As all studies were observational factors not considered by the authors in the analysis could have impacted the results.
7. The results from observational studies examine the association between COVID-19 and people who do and do not wear face coverings. It is possible that other differences between these people may contribute to the observed effectiveness of face coverings, for example other mitigation measures such as hand washing and social distancing. As such, the results from observational studies are likely less reliable than those from RCTs.
8. These results are broadly in line with the results of our previous review; however, the addition of RCTs and substantially more individual-level observational studies increase the certainty of the results and strengthens the evidence for the effectiveness of face coverings in reducing transmission in community settings.

Background

Face coverings are one means of mitigating against COVID-19 transmission. They are thought to reduce respiratory virus transmission largely through intercepting and limiting the spread of virus-laden respiratory particles produced by the mask wearer ('source control', and this is how face masks have traditionally been used in healthcare settings) and, to a lesser extent, filtering the air the mask-wearer inhales ('wearer protection') (1).

Medical masks (also known as surgical masks) and respirators play a role in controlling infection in clinical settings when used as part of a comprehensive package of infection control measures. They are intended to be worn by healthcare staff in order to protect patients, and must meet the design and safety requirements of the Medicines and Healthcare products Regulatory Agency (MHRA) (2).

Cloth face coverings, also called non-medical masks, are typically made of fabric or cloth, can be homemade or commercially produced, and may be reusable or disposable. The World Health Organization (WHO) guidance recommends that they should be made of 3 layers, including hydrophobic and hydrophilic materials (3). In England, a face covering is defined as "something which securely covers the nose and mouth" and it is recommended that they should be made of at least 2 layers and form a good fit around the face (4). Both cloth face coverings and medical masks are worn in the community as face coverings. Since 19 July 2021, there is no longer a legal requirement to wear face coverings in indoor settings or on public transport in England but it is expected that members of the public should continue to wear face coverings in crowded and enclosed spaces (4).

During the early stages of the COVID-19 pandemic, evidence examining the effectiveness of face coverings in community settings was largely drawn from the use of medical masks in reducing transmission of influenza and other coronaviruses (specifically Severe Acute Respiratory Syndrome, SARS-CoV-1 and Middle East Respiratory Syndrome, MERS) (5 to 9). None of these early reviews identified studies directly related to COVID-19, and the evidence for the effectiveness of face coverings in community settings was inconclusive, although this could have been because it was derived from different settings (pandemic versus non-pandemic contexts) and based on different types of studies.

We have conducted 2 rapid reviews on this topic, in June 2020 (10) and updated in September 2020 (11). Our most recent review, which included evidence published up to 22 September 2020, identified 17 observational studies that consistently reported that the use of face coverings in the community reduced COVID-19 transmission, although this was mainly based on ecological studies examining the effects of face covering policy or guidance (11). The review also included 14 laboratory studies on the efficacy of different types of face coverings, suggesting that various types of face coverings can filter droplets and aerosols to some extent, and that medical masks may offer better protection than fabric alternatives provided they fit well (11). More recently, an update of our review was conducted by the Wales Covid-19 Evidence Centre (WC19EC), in partnership with Health Technology Wales (search up to 14 July 2021), focusing on higher level evidence (ecological studies and descriptive studies were excluded) and on the effectiveness of face coverings (studies reporting on efficacy were excluded) (12). The WC19EC review summarised our previous review (11) and a rapid review by Chou and others (13), which also looked at the effectiveness of face coverings. In line with the results of our previous reviews, the WC19EC review concluded that face coverings may provide benefits in reducing COVID-19 transmission but that the evidence remained limited (12).

Due to the rapid availability of new studies, and the ongoing role of face coverings in mitigating COVID-19 transmission, there is a need to update our previous review.

Objective

The purpose of this rapid review was to identify and assess the best available evidence from the COVID-19 pandemic on the effectiveness of face coverings when used in the community.

As the new evidence generated includes higher-level studies such as interventional studies and individual-level studies, it was agreed that ecological studies (also called population-level studies) and descriptive studies would be excluded from this update. It was also agreed that the focus of this update would be on the effectiveness of face coverings and that efficacy of different types of face coverings will not be addressed.

Definitions

'Community' refers to non-healthcare settings, including (but not limited to) public spaces, households, shops and public transport.

'Contact tracing' refers to identifying people who have come into contact with someone known to have COVID-19 (the 'primary case' or 'index case', who first brings COVID-19 into a group of people). In contact tracing studies, contacts were either 'close contacts' (was close to a primary case for a period of time) or household contacts (lived in the same household as the primary case).

'Face coverings' are broadly defined as any type of face covering that covers the mouth and nose (including 'medical masks' and other types of face covering). 'Non-medical masks' (sometimes called 'cloth face coverings') are all masks other than respirators and surgical masks. 'Surgical masks' (also called 'medical masks') are designed to be worn in medical settings and are manufactured to a recognised standard.

'Seropositivity' refers to having antibodies against SARS-CoV-2 from a previous COVID-19 infection or vaccination, tested for with a blood sample. 'Seroprevalence' is the proportion of participants who were seropositive for SARS-CoV-2 antibodies.

'Source control' refers to the reduction in virus emitted from an infectious individual which may confer protection to others.

'Universal masking' is when everyone, with some exceptions, is required to wear a face covering.

'Wearer protection' refers to protection conferred to the wearer through reducing their exposure to the virus.

Methods

A rapid review was conducted, following streamlined systematic methodologies to accelerate the review process (14). Primary studies were identified through 2 different sources:

- three rapid reviews were used as a source for primary studies published up to 22 September 2020 (for preprints), and 13 July 2021 (for peer-reviewed publications):
  - our previous rapid review (11), which searched for preprints and published publications up to 22 September 2020
  - a living rapid review by Chou and others (13), which searched for published publications up to 2 June 2021
  - a rapid review by WC19EC (12), which searched for preprints and published publications between 2 June and 13 July 2021
- a literature search was undertaken to look for primary studies related to the COVID-19 pandemic to supplement the studies identified in previous reviews, published (or available as preprint) up to 14 September 2021

Title and abstract screening of records identified through the literature searches was completed in duplicate for 10% of the studies. Full text screening, screening of the bibliographies of relevant systematic reviews, data extraction and risk of bias assessment were conducted by one reviewer and checked by a second. Characteristics of included studies were tabulated, and data combined in narrative review.

Risk of bias was assessed using the quality criteria checklist (QCC) tool which assesses the methodological quality of a study (15). Studies were given a quality rating of high, medium or low.

Full details on the methodology are provided in Annexe A. A protocol was produced a priori and is available in Annexe D.

Evidence

Search results

A total of 154 primary studies included in the 3 rapid reviews (11 to 13) were screened for eligibility, of which 25 were screened on full text. Of these, 7 met the inclusion criteria. The literature search returned 3,138 records. After removal of duplicates, 2,585 records were screened by title and abstract. Of these, 102 full-text articles were assessed for eligibility and 16 were included in this review. A further 2 studies were identified by consultation with topic experts (16, 17).

A total of 25 studies were included in our review. A PRISMA diagram is provided in Annexe A (Figure A.1).

Two studies were randomised controlled trials (RCTs) (16, 18) and 23 were observational studies. Nine studies were conducted in North America, 7 in Asia, 6 in Europe (including 2 from the UK) and 3 in South America. Eleven studies were conducted before August 2020, 9 studies before the end of 2020, 4 studies were conducted up to May 2021, and one study was conducted in September 2021. Eleven studies were not peer-reviewed (9 preprints and 2 reports).

Of the observational studies, 8 were contact tracing studies that investigated the effect of face coverings on limiting transmission from primary cases with known COVID-19 to their contacts (19 to 26), 4 were studies that reported on face covering use in school and summer camps (by adults, children, or both) and COVID-19 transmission within these settings (27 to 30), and the remaining studies were observational studies that assessed the association between a range of factors (including face covering use) and COVID-19 outcomes (17, 31 to 40).

Full details of the included studies can be found in Annexe C.

Evidence from randomised controlled trials (RCT) (Table C.1)

Two RCTs (one non-peer-reviewed report, both rated as medium quality) provided evidence on the effectiveness of face coverings to reduce transmission of COVID-19, one for universal masking (16) and one for wearer protection (18).

The first RCT, by Abaluck and others (non-peer-reviewed report, rated as medium quality), assessed the effectiveness of face coverings as universal masking through interventions to increase face covering use in Bangladesh (16). Using a cluster RCT design, in November 2020 to January 2021, 300 villages received interventions designed to increase face covering use and 300 villages received no intervention (control group) (342,126 adults total). All intervention villages received either cloth face covering (3 layers) or surgical mask distribution at households, markets and mosques, face covering promotion in public spaces, and role-modelling and advocacy by local leaders. Intervention villages were further randomised to additional village-level and household-level interventions with the aim of increasing face covering use, for example monetary incentives given to the village leader for a project benefitting the public, or twice-weekly text reminders about the importance of wearing a face covering. The interventions lasted 8 weeks, and face covering use was directly assessed in the villages by researchers through observation at mosques, markets, the main entrance roads to villages and tea stalls, at baseline and then once per week in weeks 1, 2, 4, 6, 8 and 10. Symptomatic seroprevalence at baseline was assessed using a random sample of 20% of baseline blood draws, the difference between the control and intervention groups was not statistically significant (p=0.85 for differences in joint baseline symptomatic seroprevalence, COVID-19 symptoms, and use of face coverings). Face covering effectiveness was assessed by comparing COVID-19 seroprevalence in participants who reported COVID-19 symptoms (by telephone interviews at week 5 and at week 9) between the groups.

There was a 9.3% relative reduction in symptomatic COVID-19 seroprevalence in the intervention compared to control villages (95% CI: 0.3% to 18.3%, p=0.043). At 8 weeks face covering use (42.3% in intervention villages vs 13.3% in control villages: an increase of 28.8%, 95% CI: 27% to 31%) and social distancing (29.2% practiced social distancing in intervention villages vs 24.1% in control villages: an increase of 5.1%, 95% CI: 4% to 6%) were higher in the intervention villages compared to the controls. Villages that had surgical masks distributed to them were associated with a greater reduction in symptomatic COVID-19 seroprevalence than those that received cloth face coverings, compared with the control villages (surgical masks: relative reduction = 11.2%, p=0.043; cloth face coverings: relative reduction = 5.0%, p=0.54). In villages that received the intervention, older adults had a larger reduction in symptomatic COVID-19 seroprevalence than younger adults, compared with the control villages (at least 60 years: relative reduction = 34.7%, p=0.001; ≤40 years: relative reduction = 3.4%, p=0.62). Based on these findings, the authors estimated that an increase from 0% to 100% of people wearing face coverings over the nose and mouth would be associated with 32% decrease in symptomatic COVID-19 seroprevalence.

One of the main limitations of this report is that seroprevalence of COVID-19 was only measured at 2 time-points and solely in people with symptoms of COVID-19. Approximately 1 in 3 COVID-19 infections are asymptomatic, with asymptomatic infection more common in younger age groups (41); therefore, the study may not fully reflect transmission among the younger age groups. Participants were asked at 5 and 9 weeks whether they had experienced symptoms of COVID-19, those who reported experiencing symptoms were later invited to provide a capillary blood sample (40.3% consented). This means that it is unclear whether face coverings reduce the symptoms of COVID-19, and therefore fewer participants tested positive for COVID-19 as fewer participants were offered an RT-PCR test in the intervention group due to fewer participants having symptoms, or whether face coverings directly reduce transmission of COVID-19, or both. Additionally, face coverings may reduce the risk of developing other respiratory infections, which may reduce the number of people with COVID-19-like symptoms and so further reduce the number of participants offered an RT-PCR test in the intervention group. As such, COVID-19 infections in the intervention group may have been underestimated.

Additionally, more people in the intervention villages socially distanced, which could have contributed to the reduction in community transmission and thus, seroprevalence. However, the increase in social distancing could have been an indirect effect of increased face covering use as the interventions only targeted face covering use. Finally, as only 40.3% of symptomatic participants consented to have their blood taken for serological testing, this may have impacted upon the results if people who consented were different than people who did not consent, particularly if their risk of developing COVID-19 and chance of wearing a face covering were different.

The second RCT, by Bundgaard and others (rated as medium quality), assessed the effectiveness of face coverings as wearer protection in Denmark (18). In April and May 2020, 4,862 adults who spent 3 hours or more a day outside the home and did not wear a face covering while at work were randomised either to wearing study-provided surgical masks outside the home or no intervention. Included participants also needed to be seronegative (have no antibodies) for COVID-19 at baseline. The intervention lasted one month, mask use was assessed using weekly self-reported surveys, and COVID-19 was assessed by RT-PCR tests (at one month and if symptomatic), antibody tests (at baseline and one month) or hospital-based diagnosis.

There was a small, non-significant reduction in COVID-19 infections reported in the group that wore surgical masks: 42 of 2,392 participants (1.8%) developed COVID-19 in the intervention group compared with 53 of 2,470 participants (2.1%) in the control group (odds ratio [OR] = 0.82 in favour of surgical masks, 95% CI: 0.54 to 1.23, p = 0.33). Results were similar when participants reporting nonadherence to mask wearing were excluded from the analysis (OR = 0.84 in favour of masks, p=0.40). Relatively few participants developed COVID-19, likely as the study was conducted when national restrictions were in place (there were social distancing recommendations, and cafes and restaurants were closed) and the intervention only lasted one month, which reduced the precision of the results. Additionally, only 46% of the intervention group properly wore the surgical masks, which may also have reduced the precision of the results as this may have reduced the potential effectiveness of the masks. COVID-19 outcomes were self-reported, which may have affected the results in either direction.

Main findings

One RCT provides direct evidence that face coverings (surgical and cloth face coverings) can be effective at reducing COVID-19 transmission when used as universal masking (9.3% relative reduction in symptomatic COVID-19 seroprevalence for a 29% increase in face covering use), particularly for surgical masks (11.2% relative reduction) and older people (34.7% relative reduction in people at least 60 years), and that interventions to increase face covering use can also increase social distancing. Another RCT was inconclusive, reporting a non-significant reduction in COVID-19 infections from wearer protection using surgical masks, but the results lacked precision due to an insufficiently large sample size and low prevalence in the study population, so few participants developed COVID-19.

Evidence from contact tracing studies (Table C.2)

Eight contact tracing studies (one preprint, rated as either low (19, 20, 22, 24, 26) or medium (21, 23, 25) quality), where contacts of known COVID-19 cases were found and tested for COVID-19, assessed the effectiveness of face coverings for reducing transmission of COVID-19 from people with COVID-19 to members of their household and close contacts: 3 studies assessed face coverings as source control (22, 25, 26), 3 studies assessed face coverings as wearer protection (19, 20, 23), and 2 studies assessed both (21, 24). These studies were conducted in Asia before summer 2020 (20 to 23), Germany (26) and Pakistan (19) in July and October 2020, and the US in 2021 (24, 25).

A case-control study by Doung-ngern and others (rated as medium quality, n=211 primary cases and n=839 close contacts) assessed whether face coverings were effective as wearer protection during close contact in boxing stadiums, nightclubs and an office in Thailand in March to May 2020 (23). Wearing a face covering at all times during contact events was associated with a lower risk of testing positive for COVID-19 (confirmed by RT-PCR) compared to not wearing face coverings (adjusted OR = 0.23, 95% CI: 0.09 to 0.60). People who wore face coverings at all times during contact events were more likely to practice social distancing (p = 0.03) and hand washing (p<0.001), and were more likely to report contact duration of less than 15 minutes (p<0.001). Many contacts (34%) could not be reached, and data collection on face covering use was collected via telephone interviews more than one month after the contact events, which may have affected the results in either direction.

A prospective cohort study by Liu and others (rated as medium quality, n=15 primary cases and n=50 household contacts) assessed whether face coverings worn by paediatric primary cases were effective as source control in reducing transmission of COVID-19 to household contacts in the US in December 2020 to February 2021 (25). Transmission of COVID-19 (confirmed by RT-PCR) was lower in households where the paediatric case wore a face covering while at home (4 of 23 household members, secondary attack rate [SAR] = 17%) compared to those who did not (13 of 27 household members, SAR = 48%, p=0.02 for difference).

A retrospective cohort study by Wang and others (rated as medium quality, n=335 household contacts in 124 families) assessed whether face coverings were effective as both wearer protection and source control in reducing transmission to household contacts in China in February to March 2020 (21). Face covering use by at least one household member (primary case or household contact) before the primary case developed COVID-19 reduced secondary transmission of COVID-19 (confirmed with clinical, epidemiological or laboratory testing) within the household compared to families where no household members wore a face covering (adjusted OR = 0.21, 95% CI: 0.06 to 0.79, p=0.02).

A case-control study by Arif and others (preprint, rated as low quality, n=100 COVID-19 positive contacts, n=200 COVID-19 negative contacts) assessed whether face coverings were effective as wearer protection by comparing contacts who were positive with COVID-19 (confirmed by RT-PCR) with those that were not, in Pakistan in October 2020 (19). Contacts with COVID-19 were less likely to report wearing a face covering during contact events (91 of 100, 91%)

compared with contacts without COVID-19 (69 of 200 controls, 35%: OR = 19.2, 95% CI: 9.11 to 40.4, p<0.01).

A retrospective cohort study by Hong and others (rated as low quality, n=41 primary cases) assessed whether face coverings worn by pre-symptomatic primary cases returning from Wuhan were effective as source control in reducing transmission of COVID-19 to close contacts in China in January to March 2020 (22). Transmission of COVID-19 (confirmed by RT-PCR) was lower in contacts where the primary case wore a face covering (10 of 123 close contacts, SAR = 8.1%) compared to those where the primary case did not (14 of 74 close contacts, SAR = 19.0%, p<0.001 for difference).

A retrospective cohort study by Rebmann and others (rated as low quality, n=265 primary cases and n=378 close contacts) assessed whether face coverings were effective as wearer protection and as source control in reducing transmission of COVID-19 to close contacts in a university in the US in January to May 2021 (24). Most contacts (89%) were not vaccinated at the time of their exposure. Transmission of COVID-19 (confirmed by RT-PCR) was lower in contacts where either the primary case or the contact (or both) wore a face covering (2 of 26 close contacts, SAR = 7.7%) compared to any unmasked exposure (114 of 352 close contacts, SAR = 32.4%, adjusted OR = 4.9, 95% CI: 1.4 to 31.1).

A retrospective cohort study by Sugimura and others (rated as low quality, n=820 close contacts) assessed whether face coverings were effective as wearer protection during contact events in Japan in March to May 2020 (20). Wearing a face covering was associated with a lower risk of testing positive for COVID-19 (confirmed by RT-PCR) compared to not wearing a face covering (adjusted relative risk [RR] = 0.6, 95% CI: 0.3 to 0.9). Many contacts (43%) were not included in the analysis as they did not have data for both face covering use and RT-PCR testing, which may have affected the results in either direction.

A retrospective cohort study by Galow and others (rated as low quality, n=414 household contacts) assessed whether face coverings worn by primary cases were effective as source control in reducing transmission of COVID-19 to household contacts in Germany in June 2020 (26). Transmission of COVID-19 (confirmed by seropositivity) was lower in contacts where the primary case wore a face covering (SAR = 8%) compared to households with no measures in place (SAR = 53%, p=0.0001 for difference).

Use of face coverings during contact events was determined by interviewing contacts (in person or by telephone) in almost all contact tracing studies, increasing the reliability of the studies' assessments of face covering use. However, Liu and others (25) assessed face covering use through online surveys, which may have reduced the reliability of the assessment, and Galow and others (26), did not report their data collection method. In all studies, there is a high risk that factors other than face covering use affected the results (in either direction) as people who are more likely to wear face coverings are likely different in many ways than people that are not, for example they may engage more or less with other behaviours that are likely to reduce transmission of COVID-19, such as hand washing and social distancing. For instance, Doung-ngern and others (23) found that people who wore face coverings at all times during contact events were more likely to practice social distancing (p = 0.03) and hand washing (p<0.001), and were more likely to report contact duration of less than 15 minutes ($p<0.001$). All studies measured self-reported face covering use, which may be less reliable than direct observation as some participants may have responded differently depending on the questions asked and whether the participant felt they could answer completely truthfully. Additionally, some studies reported that many contacts could not be reached to provide data, which may have affected the results in either direction.

As such, these results provide less direct evidence of the effectiveness of face coverings than the RCTs, but provide evidence for the difference in COVID-19 transmission between people who did and did not wear face coverings during contact events. People who wear face coverings may differ from those who do not, in terms of both their attitudes and behaviours. This in turn may influence other actions they take that either increase, or decrease their risk of exposure. For example, those who wear face coverings may be more cautious generally about keeping a distance from others or conversely, they may be more likely to feel comfortable in close contact with others as they feel ‘protected’ by the face covering.

Main findings

All 8 contact tracing studies suggested that contacts of primary cases were less likely to develop COVID-19 if either the primary case or the close contact, or both, wore a face covering. However, as all studies were observational, factors not considered by the authors in the analysis could have impacted upon the results, for example other associated mitigation measures such as hand washing and social distancing.

Evidence from studies in school and summer camp settings (Table C.3)

Three studies (one preprint, all rated as low quality) assessed whether wearing a face covering was effective in schools in the UK, US and Germany in autumn and winter 2020 (29, 30), and in a summer camp in the US in summer 2020 (28), and one further study (preprint, rated as low quality) was included but unable to provide evidence due to its design (27). The studies assessed face covering use in children (students or summer camp attendees) and adults (teachers or staff). One study assessed face coverings as wearer protection (30), and 2 studies as universal masking (28, 29).

A prospective cohort study by Cooper and others (rated as low quality, n=320 students and n=99 staff members) assessed whether face coverings were effective as universal masking in 4 schools in the US in Autumn to Winter 2020 (29). Face covering use was observed through systematic observation (trained observers visited 3 to 5 times in one week and quantified face covering use in different locations) and COVID-19 incidence confirmed by RT-PCR. All 4 schools had good compliance for in-classroom face covering use (91.3%), and there was no statistically significant correlation between average face covering use and COVID-19 incidence within each school.

A cross-sectional study by Theuring and others (rated as low quality, n=177 primary school students, n=175 secondary school students and n=142 staff members) assessed whether face coverings were effective as wearer protection in 12 primary and 12 secondary schools in Germany in November 2020 (30). Face covering use by students and teachers in the preceding 2 weeks was determined through an electronic survey, and COVID-19 incidence was confirmed by RT-PCR. Staff and students who reported often or always wearing a face covering were less likely to test positive for COVID-19 (4 of 277 participants, 1.4%) than those who reported never to sometimes wearing a face covering (5 of 35 participants, 14.3%, OR = 11.4, 95% CI: 2.28 to 59.6). Many students did not complete the survey (65% of students participated), and many staff and students did not respond to individual questions on the survey (response rate: 55% to 68% for individual items), which may have affected the results in either direction.

A cross-sectional study by Suh and others (preprint, rated as low quality, n=486 US summer camps comprising 89,635 campers) assessed whether face coverings were effective as universal masking in 486 summer camps in the US in Summer 2020 (28). Face covering use by campers and staff, and confirmed or suspected COVID-19 cases within the camps, were determined through an online survey: one participant completed a survey for each camp, with some participants completing surveys for more than one camp. In camps where both campers and staff always wore face coverings (n=126 camps), both campers (OR = 0.27, 95% CI: 0.10 to 0.73) and staff (OR = 0.13, 95% CI: 0.06 to 0.31) were less likely to develop COVID-19 compared to in camps where campers and staff never wore face coverings (n=118 camps). A single participant responded for one or more camps detailing both face covering use and COVID-19 cases, which may be less reliable than asking individuals about their own face covering use and COVID-19 infections, especially as use of face covering in camps was not validated. The classification of ‘confirmed or suspected COVID-19 cases’ was not defined, which may have also affected the results in either direction.

One further cross-sectional study by Marchant and others (preprint, rated as low quality, n=353 staff members) assessed whether face covering use by teachers was associated with at least one COVID-19 case within each teacher’s school, including data from 59 primary schools in Wales in October to December 2020 (27). Face covering use by teachers was determined through an online survey, and COVID-19 incidence within the teachers’ school was determined by linking to national-scale RT-PCR testing data for all staff and pupils within the school. It is not possible to use the results of this study to estimate the effectiveness of face coverings as source control nor wearer protection. Source control cannot be assessed, as if the teacher responding to the survey had COVID-19 during this study, then the outcome (at least one COVID-19 case in the teacher’s school) would have been positive regardless of whether the teacher wore a face covering at school. Wearer protection also cannot be assessed, as if another person in the teacher’s school had COVID-19, then the outcome would also have been positive, regardless of whether the teacher wore a face covering at school. The results of this study are available in Table C.3, though they should be interpreted as the association between COVID-19 levels in schools and teachers’ face covering use and not as the effectiveness of face coverings to reduce transmission of COVID-19 in schools.

In all studies, there is a high risk that factors other than face covering use affected the results (in either direction) as people who are more likely to wear face coverings are likely different in many ways than people that are not, for example they may engage more or less with other behaviours that are likely to reduce transmission of COVID-19, such as hand washing and social distancing. All studies, except Cooper and others (29), measured self-reported face covering use, which may be less reliable than direct observation as some participants may have responded differently depending on the questions asked and whether the participant felt they could answer completely truthfully. Additionally, some studies reported face covering use or outcome measurements at the level of the school or camp rather than individual level, which may be less reliable than reporting at the individual level. It is unclear whether face covering use was at least partially a response to the COVID-19 level in the schools or summer camps, which means the results may reflect the effect of COVID-19 levels on likelihood of wearing face coverings, as well as the effectiveness of face coverings to reduce COVID-19 transmission.

Due to these limitations, these results provide less direct evidence of the effectiveness of face coverings than either the RCTs or contact tracing studies, but still provide evidence on the difference in COVID-19 transmission between people who did and did not wear face coverings in school and summer camp settings.

Main findings

Three studies set in schools and a summer camp had mixed results, with 2 studies suggesting face coverings were associated with reduced COVID-19 transmission and one study suggesting no statistically significant effect. One further study set in schools was unable to provide evidence due to its design. The studies were all of low quality, and as the studies were all observational, factors not considered by the authors in the analysis could have impacted the results. The interpretation of these results should be considered less as the effectiveness of face coverings to reduce COVID-19 transmission, and more as the association between COVID-19 and people who did and did not wear face coverings in schools and summer camps.

Evidence from other observational association studies (Table C.4)

Eleven other observational studies (9 rated as low quality, one rated as medium quality (38), and one rated as high quality (17)), 6 preprint and one non-peer-reviewed report, were conducted to assess the association between a range of factors (including face covering use) and COVID-19 outcomes (assessed by RT-PCR or antibody tests, or self-report). These studies primarily conducted surveys, which can provide some evidence for the effectiveness of face covering use (17, 31 to 40). All 11 studies assessed face coverings as wearer protection.

A prospective cohort study by the Office for National Statistics (non-peer-reviewed report, rated as high quality, n=114,700) has been ongoing in the UK since July 2020, with data for this study coming from 29 August 2021 to 11 September 2021 (17). Participants were more than 2 years of age and representative of the UK population, and had a negative RT-PCR test in the previous 10 to 35 days. Face covering use in enclosed spaces (over the previous 35 days) and COVID-19 incidence (confirmed by RT-PCR) were assessed weekly by in-person interview for the first 5 weeks after a participant entered into the study, then monthly. Compared to people who always wore a face covering in enclosed spaces, people who never wore face coverings were more likely to be diagnosed with COVID-19 (OR = 1.59, 95% CI: 1.27 to 1.98).

A prospective cohort study by Lalwani and others (preprint, rated as medium quality, n=1,638 adults) was conducted in Brazil in August to November 2020 (38). Face covering use during contact with people with COVID-19 was assessed by an electronic survey, and COVID-19 seroconversion (developing antibodies to COVID-19) was assessed with 2 blood tests. Of the people who had contact with someone with COVID-19, slightly fewer people who wore a face covering during the contact developed COVID-19 (93 of 604 participants, 15.4%) compared with people who did not wear a face covering (238 of 1,620 participants, 14.7%), but this difference was not tested statistically.

A prospective cohort study by Flegr and others (preprint, rated as low quality, n=5,164 adults) was conducted in the Czech Republic and Slovakia in October 2020 to March 2021 (35). Face covering use was assessed by an initial online survey between October 2020 and March 2021, and COVID-19 incidence (self-reported, not confirmed) was assessed in a follow-up online survey in March 2021. There was a negative correlation between face covering use in the first survey and risk of COVID-19 in the follow-up survey, meaning people who were more likely to wear a face covering were less likely to develop COVID-19 (partial Kendall Tau = -0.04, $p<0.0001$).

A case-control study by Gonçalves and others (rated as low quality, n=198 cases and n=420 controls) was conducted in Brazil in April to June 2020 (31). Cases with COVID-19 (confirmed by RT-PCR or antibody testing) were identified through a local public health agency, and controls who were seronegative for COVID-19 were taken from a representative community survey. Face covering use was assessed by interview (telephone for cases, in person for controls). Compared to not wearing face coverings, sometimes or always wearing a face covering was associated with decreased risk of COVID-19 (adjusted OR = 0.10, 95% CI: 0.03 to 0.25). There was little evidence that face covering use was associated with social distancing (OR = 0.96, 95% CI: 0.60 to 1.58).

A prospective cohort study by Kwon and others (rated as low quality, n=134,597 adults) was conducted in the US in March to July 2020 (34). Face covering use was assessed by a smartphone app and COVID-19 incidence was predicted from symptoms entered into the app. Compared to people who wore face coverings none of the time, people who wore face coverings some of the time (hazard ratio [HR] = 0.27, 95% CI: 0.19 to 0.39), most of the time (HR = 0.35, 95% CI: 0.28 to 0.43) and all of the time (HR = 0.36, 95% CI: 0.30 to 0.44) were less likely to develop symptoms that predicted COVID-19 (p for trend < 0.001).

Six cross-sectional surveys (4 preprints (33, 36, 37, 40), all rated as low quality) were conducted in the US (32, 33, 39), Canada (40), Bangladesh (36) and Peru (37) in summer and autumn 2020. Face covering use was self-reported and COVID-19 status was either self-reported (if confirmed by RT-PCR (32, 33, 36)) or directly measured (if confirmed by seropositivity (37, 39, 40)). Most studies found no statistically significant association between face covering use and COVID-19 outcomes (32, 33, 36, 39), although one study suggested people who always wore a face covering were less likely to be seropositive than people who did not (OR = 0.65, 95% CI: 0.47 to 0.88) (37), and one study suggested children who wore a face covering often or always were less likely to be seropositive than children who wore a face covering never, rarely or occasionally (p=0.03) (40).

As all of these studies were observational, there is a high risk in almost all these studies that factors other than face covering use affected the results as people who are more likely to wear face coverings are likely different in many ways than people that are less likely, for example they may engage more or less with other behaviours that are likely to reduce transmission of COVID-19, such as hand washing and social distancing. The study by the Office of National Statistics (17) accounted for this issue well, so the risk in this study is lower, although some risk remains. All studies measured self-reported face covering use, which may be less reliable than direct observation as some participants may have responded differently depending on the questions asked and whether the participant felt they could answer completely truthfully. It is unclear whether face covering use was at least partially a response to the COVID-19 level in the areas in which the studies were conducted, which means the results may reflect the effect of COVID-19 levels on likelihood of wearing face coverings, as well as the effectiveness of face coverings to reduce COVID-19 transmission. The results of all surveys may be affected by who chose to participate in the surveys. Some studies used COVID-19 antibodies as the outcome, which may detect and represent COVID-19 infections that occurred before the period concerning face covering use.

Due to these limitations, these results provide less direct evidence of the effectiveness of face coverings than either the RCTs or contact tracing studies, but still provide evidence on the difference in COVID-19 transmission between people who did and did not wear face coverings in the community.

Main findings

Eleven observational association studies had mixed results, with 6 studies suggesting face coverings were associated with reduced COVID-19 transmission and 5 suggesting no statistically significant association. Nine studies were of low quality, and in all studies factors not considered by the authors in the analysis could have impacted the results, although this risk is less in the study by the Office of National Statistics (17) as it was accounted for well. The interpretation of these results should be considered less as the effectiveness of face coverings specifically to reduce COVID-19 transmission, and more as the association between COVID-19 and people who wear and do not wear face coverings.

Cost effectiveness

One study assessed the cost-effectiveness of their interventions to increase face covering use in Bangladesh (16). The total cost estimates for the intervention were $17.00 per adult regularly wearing a cloth face covering and $9.49 per adult regularly wearing a surgical mask because of the intervention (estimates in US dollars). If implemented at scale (across the whole of Bangladesh, leveraging mass and social media, and producing surgical masks at scale), the intervention was estimated to cost $1.50 per person for one month of intervention. The authors assumed that the intervention decreased the number of COVID-19-related deaths by 35% for people aged 60 years and older and 23% for people aged 50 to 60 years, with no change for people aged less than 50 years, and only the effects of COVID-19 on mortality were considered. This led to an estimated cost per life saved between $332,161 (lower bound: assuming total COVID-19-related deaths were the number of reported COVID-19 deaths), $106,487 (mid-range: assuming total COVID-19-related deaths accounted for 50% of excess deaths) and $63,408 (upper bound: assuming total COVID-19-related deaths accounted for 100% of excess deaths) without at scale implementation of the intervention, and between $52,502 (lower bound), $16,831 (mid-range) and $10,022 (upper bound) with at-scale implementation.

These cost effectiveness estimates are not directly generalisable to the UK, as the effectiveness of face coverings to prevent COVID-19-related mortality estimates and the cost of any intervention will differ between the UK and Bangladesh. Additionally, the study only considered the effect of face coverings on COVID-19-related mortality, not including the cost of morbidity, so will underestimate the true cost-effectiveness of the intervention.

No other studies assessed the cost effectiveness of face coverings to reduce the transmission of COVID-19.

Inequalities

There was limited evidence on inequalities that could be extracted from the studies. However, evidence from an RCT suggests that older people may benefit more than younger people from universal wearing of face coverings (16). Evidence from 2 prospective cohorts suggested that the effectiveness of face coverings as wearer protection was similar for men and women (35), and for people living in communities with different levels of social distancing (34). We found no further results relevant to inequalities in the included studies.

Limitations

Our review was limited to evidence from the COVID-19 pandemic; we did not include evidence from other infectious diseases. Sources of evidence included existing rapid reviews and databases of peer-reviewed and preprint articles. We did not conduct an extensive search of other sources (such as websites of public health organisations).

Only the 2 RCTs provide direct evidence regarding the effectiveness of face coverings for reducing the spread of COVID-19; the 23 observational studies provide more indirect evidence by comparing people who are likely to wear face coverings with those who are not. The results of the RCTs may not be generalisable to the current UK setting, as the populations, dominant COVID-19 variant and wider context (including local restrictions, other protective measures and behaviours such as social distancing, and vaccine rates) were different. In all observational studies, factors not considered by the authors in the analysis could have impacted the results, including changes in community transmission unrelated to the face covering interventions and other mitigation measures being in place concurrently, such as hand washing and social distancing, although some studies accounted for this well. Additionally, the selection of participants may have influenced the results for surveys. In most studies, the type of face covering, and whether the face covering was worn correctly, was not recorded. The type of face covering, how and when it was used varied across studies, so it is difficult to use evidence from across the different studies to produce a summary estimate of how effective face coverings are likely to be, in general. This is also likely to vary depending on the type of face covering, when and where they are used (that is, the type of contact and setting), and how they are used.

Risk of bias was assessed in each individual study by using a formal risk of bias tool assessment. However, the evidence has not been graded, meaning it has not been possible to describe the strength of evidence in a transparent way.

As with all reviews, the evidence identified may be subject to publication bias, whereby null or negative results are less likely to have been published by the authors.

Eleven of the 25 studies identified were not peer-reviewed (9 preprints and 2 non-peer-reviewed reports) and should be treated with caution as they have not been subject to either peer-review or publishing standards and may change before publication. In addition, our rapid review is limited by the fact that we are reviewing evidence from an emerging field that spans less than 2 years. Studies conducted in the COVID-19 context are conducted at pace with the aim of providing evidence in a timely manner, which can impact the quality of the studies.

Conclusions

Evidence from 2 RCTs and 23 observational studies predominantly suggest that face coverings can reduce the spread of COVID-19 in the community, through both source control and wearer protection, as well as universal masking.

There was direct evidence from one RCT that face coverings (surgical masks and cloth face coverings) are effective when used as universal masking (9.3% relative reduction in symptomatic COVID-19 seroprevalence for a 29% increase in face covering use), particularly for surgical masks (11.2% relative reduction) and older people (34.7% relative reduction in people at least 60 years), and that the interventions to increase face covering use were associated with an increase in social distancing. Another RCT reported a non-significant reduction in COVID-19 infections from wearer protection using surgical masks, though as relatively few participants developed COVID-19, the study was not sufficiently large enough to reach robust conclusions and was therefore inconclusive. Therefore, while the results of the RCTs may not be directly generalisable to the current UK setting, one RCT provided direct evidence that face coverings were effective at reducing COVID-19 transmission when used as universal masking, while one other RCT was inconclusive for the use of face coverings as wearer protection.

All 8 contact tracing studies suggested that contacts of primary cases were less likely to develop COVID-19 if either the primary case or the close contact, or both, wore a face covering. Three studies set in schools and a summer camp and 11 other observational association studies had mixed results for the effectiveness of face coverings (typically worn as wearer protection), with 8 studies suggesting face coverings were associated with reduced COVID-19 transmission and 6 studies suggesting no statistically significant effect.

The results of all observational studies could have been affected by factors not considered by the authors, including changes in community transmission and other mitigation measures in place, such as hand washing and social distancing, although some studies accounted for this well. The very large effect sizes seen in some studies may be due to not accounting for these other factors, and therefore may have inflated the estimated effect of face coverings. In most studies, the type of face covering, and whether the face covering was worn correctly, was not recorded, which may have also affected the results. As such, the interpretation of the observational study results should be considered less as the effectiveness of face coverings to reduce COVID-19 transmission, and more as the association between people who do and do not wear face coverings and COVID-19 transmission.

These results are broadly in line with the results of our previous review, although the addition of RCTs and substantially more individual-level observational studies increases the certainty of the results, as our previous review included mainly ecological and descriptive studies.

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Disclaimer

UKHSA's rapid reviews aim to provide the best available evidence to decision makers in a timely and accessible way, based on published peer-reviewed scientific papers, unpublished reports and papers on preprint servers. Please note that the reviews: i) use accelerated methods and may not be representative of the whole body of evidence publicly available; ii) have undergone an internal, but not independent, peer review; and iii) are only valid as of the date stated on the review.

In the event that this review is shared externally, please note additionally, to the greatest extent possible under any applicable law, that UKHSA accepts no liability for any claim, loss or damage arising out of, or connected with the use of, this review by the recipient or any third party including that arising or resulting from any reliance placed on, or any conclusions drawn from, the review.

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Annexe A. Methods

This report employed a rapid review approach to address the review question:

“What is the effectiveness of face coverings when used in the community?”

Our rapid review approach follows streamlined systematic methodologies (14). In particular, relevant rapid reviews were used as a source for primary studies published before 13 July 2021 and a literature search was undertaken for primary studies published between 22 September 2020 and 14 September 2021; 10% of the screening on title and abstract for records identified though the literature search were screened in duplicate; full text screening, screening of studies from previous reviews, data extraction and risk of bias assessment were performed by one reviewer and checked by another.

Notes

Our previous reviews included 2 review questions (question 1 “What is the effectiveness of face coverings when used in the community” and question 2 “What is the efficacy of different types of face coverings for use in community settings”); only question one will be addressed in the present review.

Our previous reviews assessed a wide range of study designs, including ecological studies, descriptive studies and laboratory studies; these studies are excluded from the present review in order to focus on higher level evidence such as interventional studies, cohort studies, case control studies and cross-sectional studies.

Protocol

A protocol was produced by the project team before the literature search began, specifying the review question and the inclusion and exclusion criteria. The protocol is available in Annexe D.

Sources searched

Primary studies were identified through 2 different sources:

- searching the bibliographies of relevant rapid reviews
- literature search of Ovid Medline, Ovid Embase, WHO COVID-19 database, Arxiv, bioRxiv, medRxiv, Research Square and SSRN

Search strategy

Searching of bibliographies

We have previously conducted 2 rapid reviews on effectiveness of face coverings in community settings (10, 11), that were further updated by WC19EC in July 2021 (12). As the present review focuses on higher level studies (ecological studies and descriptive studies were excluded) and assessed only evidence on the effectiveness of face coverings (question 1 from our previous reviews; question 2 on efficacy of different types of face coverings not addressed), it was agreed to assess the overall body of evidence that meet our new inclusion criteria (see Table A.1) and therefore to use these reviews to identify primary studies. These reviews were used to identify primary studies published (or available as preprint) up to 22 September 2020, and peer-reviewed primary studies published up to 13 July 2021:

- update 1 of our previous rapid review on face coverings (11); search date up to 22 September 2020; 31 primary studies included, of which 17 reported on effectiveness of face coverings; individual- and population-level studies were included, as well as both published and preprints publications
- a rapid review by WC19EC on face coverings (12); search date up to 13 July 2021; considering both primary and secondary evidence:
    - primary evidence: search conducted from 2 June (the cut-off from Chou and others) up to 13 July 2021, identifying 2 primary studies
    - secondary evidence: our previous review (11) and a rapid review by Chou and others (13) (we therefore also searched the bibliography of Chou and others (13))

Literature search

Due to the differences in inclusion criteria of the rapid reviews used to identify primary studies in relation to publication status (see previous section), 2 searches were conducted:

- searches of Ovid Medline, Ovid Embase and WHO COVID-19 database were conducted for peer-reviewed studies published between 13 July 2021 and 14 September 2021
- searches of preprint servers (Arxiv, bioRxiv, medRxiv, Research Square and SSRN) were conducted via the NLM Covid portfolio interface (https://icite.od.nih.gov/covid19/search/) between 22 September 2020 and 15 September 2021

Search terms covered main aspects of the review question. The search strategy for Ovid Medline is presented below.

The 9 studies that had been identified as preprints were last checked on 6 October 2021 to see whether they had been published as a peer-reviewed journal article. One study had been peer-reviewed and accepted (28), but the published paper was not yet available, so no updates to our review were made; no update was found for the other studies.

Search strategy Ovid Medline

1. mask*.tw,kw.
2. (face-mask* or facemask*).tw,kw.
3. ((face or head) adj2 cover*).tw,kw.
4. (face-cover* or facecover*).tw,kw.
5. (cloth* adj2 (cover* or protect*)).tw,kw.
6. (respirator or respirators).tw,kw.
7. (mouth adj2 (cover* or protect*)).tw,kw.
8. (nose adj2 (cover* or protect*)).tw,kw.
9. Masks/
10. N95 Respirators/
11. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12. exp coronavirus/
13. exp Coronavirus Infections/
14. ((corona* or corono*) adj1 (virus* or viral* or virinae*)).ti,ab,kw.
15. (coronavirus* or coronovirus* or coronavirinae* or CoV or HCoV*).ti,ab,kw.
16. (2019-nCoV or 2019nCoV or nCoV2019 or nCoV-2019 or COVID-19 or COVID19 or CORVID-19 or CORVID19 or WN-CoV or WNCoV or HCoV-19 or HCoV19 or 2019 novel* or Ncov or n-cov or SARS-CoV-2 or SARSCoV-2 or SARSCoV2 or SARS-CoV2 or SARSCov19 or SARS-Cov19 or SARSCov-19 or SARS-Cov-19 or Ncovor or Ncorona* or Ncorono* or NcovWuhan* or NcovHubei* or NcovChina* or NcovChinese* or SARS2 or SARS-2 or SARScoronavirus2 or SARS-coronavirus-2 or SARScoronavirus 2 or SARS coronavirus2 or SARScoronovirus2 or SARS-coronovirus-2 or SARScoronovirus 2 or SARS coronovirus2).ti,ab,kw.
17. (respiratory* adj2 (symptom* or disease* or illness* or condition*) adj10 (Wuhan* or Hubei* or China* or Chinese* or Huanan*)).ti,ab,kw.
18. ((seafood market* or food market* or pneumonia*) adj10 (Wuhan* or Hubei* or China* or Chinese* or Huanan*)).ti,ab,kw.
19. ((outbreak* or wildlife* or pandemic* or epidemic*) adj1 (Wuhan* or Hubei or China* or Chinese* or Huanan*)).ti,ab,kw.
20. or/12-19
21. 11 and 20

Inclusion and exclusion criteria

Article eligibility criteria are summarised in Table A.1.

Table A.1. Inclusion and exclusion criteria

[A] These studies are excluded, however, they were coded at the screening stage to be drawn upon if required (for instance, if insufficient evidence)

	Included	Excluded
Population	All populations	
Settings	All community settings, including households	Healthcare settings
Context	COVID-19 pandemic	Other infectious diseases
Intervention or exposure	All types of face covering, including (but not limited to) handmade and commercial cloth face coverings (cloth, cotton, gauze, etc), surgical masks and respirators	Studies comparing effectiveness of surgical masks to N95 respirators
Outcomes	• COVID-19 transmission and cases • COVID-19 outbreak Measures: • incidence of COVID-19 • prevalence of COVID-19 • attack rate and secondary attack rate • reproduction number	• deaths associated with COVID-19 • disease progression • prevalence and rates of asymptomatic, pre-symptomatic or symptomatic COVID19
Language	English	
Date of publication	1 January 2020 to 15 September 2021	
Study design	• interventional studies • observational studies (cohorts, case controls and cross-sectional studies)	• systematic or narrative reviews • guidelines • opinion pieces • modelling studies • laboratory studies • ecological studies [A] • descriptive studies
Publication type	Published and preprint	

Screening

Searching of bibliographies

The primary studies included in the relevant rapid reviews were screened by one reviewer and checked by a second to identify the studies that reported on effectiveness of face coverings.

Literature search

Title and abstract screening was completed by 2 reviewers: 10% of the eligible studies were screened in duplicate (disagreements were resolved by discussion) and the remainder were screened by one reviewer.

Full text screening was conducted by one reviewer and checked by a second. A list of excluded studies with reasons for exclusion is presented in Annexe B.

The PRISMA diagram showing the flow of citations is provided in Figure A.1.

Data extraction and risk of bias assessment

Data extraction was done by one reviewer and checked by a second. Only results directly relevant to the review questions were extracted.

Studies were assessed using the quality criteria checklist (QCC) for primary research (15). This risk of bias tool can be applied to most study designs (observational and interventional), and is therefore suitable for rapid reviews of mixed type of evidence. It is composed of 10 validity questions based on the criteria and domains identified by the Agency for Healthcare Research and Quality to assess the methodological quality of a study (that is, the extent to which a study has minimised selection, measurement and confounding biases) (42). In the QCC tool, 4 questions are considered critical (on selection bias, group comparability and confounding, interventions or exposure and outcome). A study will be rated as high quality if the answers to the 4 critical questions are 'yes' (and at least one additional 'yes'). The study will be rated as low quality if 2 or more of the critical questions are answered 'no' or if at least 50% of the remaining questions are answered 'no'. Otherwise, the study will be rated as medium quality. Judgments were made on case by case for questions answered as 'unclear'. To note that we report these ratings as 'quality' ratings for consistency with the name of the tool, although here quality needs to be understood as 'methodological quality' as part of a risk of bias assessment.

Risk of bias assessment was done by one reviewer and checked by a second. QCC ratings are reported in the data extraction tables (Annexe C).

A formal grading of evidence was not undertaken, however if evidence was considered to be limited (due to the number of studies) or of low quality (due to QCC rating) or provide low level of evidence (due to research design), this was highlighted. Preprint or publication status was also considered in determining this.

Variations across populations and subgroups, for example cultural variations or differences between ethnic, social or vulnerable groups was considered, where evidence is available.

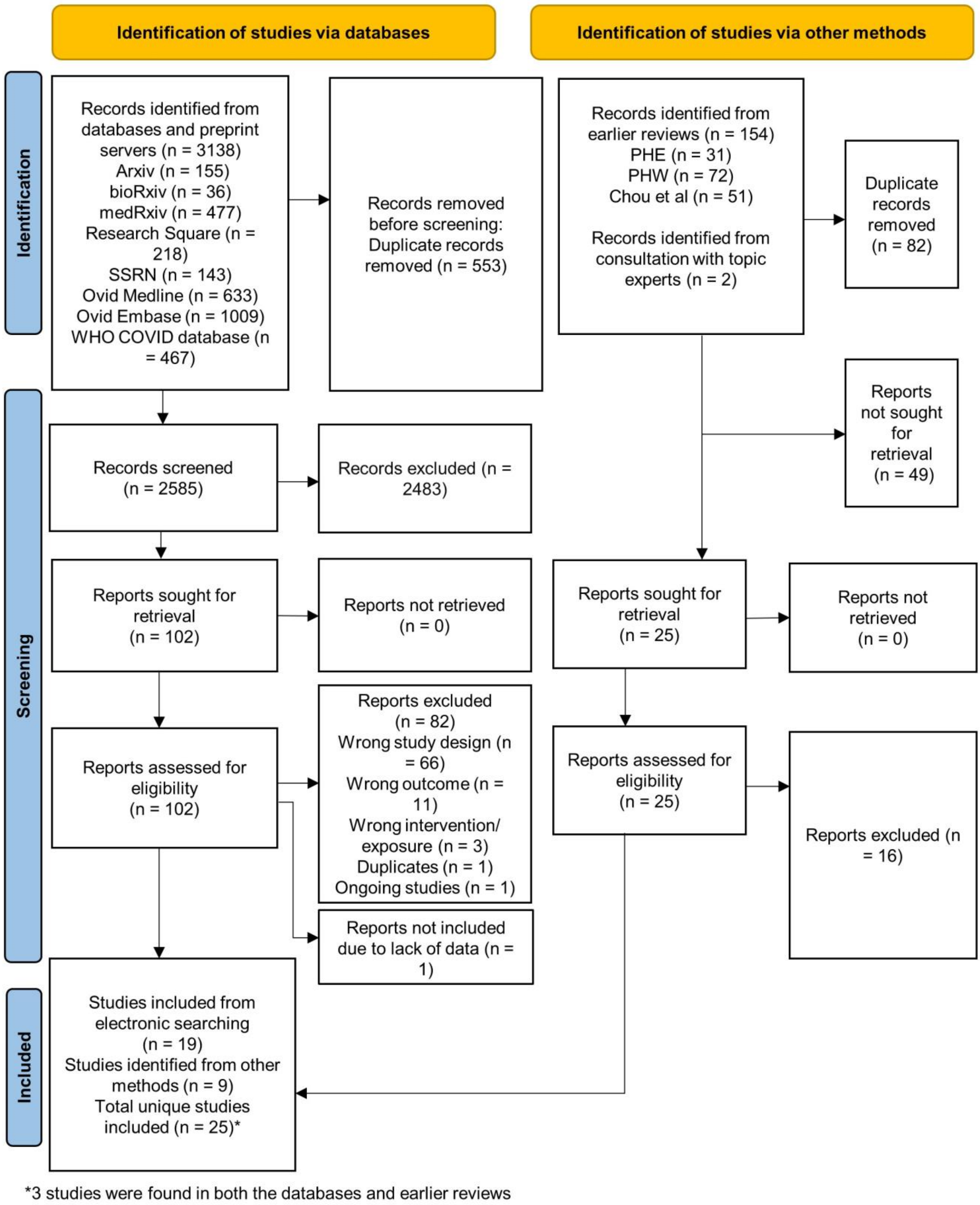

Figure A.1. PRISMA diagram

Figure A.1. PRISMA diagram – alt text
A PRISMA diagram showing the flow of studies through this review.

From identification of studies via databases and registers, n=3,138 records identified from databases:

- Arxiv (n=155)
- bioRxiv (n=36)
- medRxiv (n=477)
- Research Square (n=218)
- SSRN (n=143)
- Ovid Medline (n=633)
- Ovid Embase (n=1,009)
- WHO COVID database (n=467)

From these, records removed before screening:

- Duplicate records removed (n=553)

n=2,585 records screened, of which n=2,483 were excluded, leaving n=102 papers sought for retrieval (all were retrieved).

n=102 papers assessed for eligibility, of which, n=82 reports were excluded:

- wrong study design (n = 66)
- wrong outcome (n = 11)
- wrong intervention or exposure (n = 3)
- duplicate (n=1)
- ongoing studies (n=1)

n=1 additional report not included due to lack of data (n=1)

From identification of studies via other methods, n=154 records identified:

- PHE (Public Health England) (n=31)
- PHW (Public Health Wales) (n=72)
- Chou and others (n=51)
- records identified from consultation with topic experts (n=2)

From these, n=82 duplicate records removed.

n=25 reports sought for retrieval (all were retrieved) and assessed for eligibility, of which n=16 were excluded.

n=25 total unique papers included in this report (n=19 from electronic searching, n=9 from identification of studies via other methods, n=3 were found in both databases and earlier reviews).

Annexe B. Excluded studies

Reference	
Wrong study design (ecological studies) (n=39 studies)	
1	Adjodah D and others. 'Association between COVID-19 Outcomes and Mask Mandates, Adherence, and Attitudes.' medRxiv. 2021.
2	An B and others. 'Effects of Early Mask Mandates and Other Policy Interventions on COVID-19 Infections.' Research Square. 2021.
3	An B and others. 'How Early? Worldwide Evidence from Early Mask Mandates and Other Policy Interventions on COVID-19 Infection and Death.' SSRN. 2021.
4	Aravindakshan A and others. 'The Impact of Mask-Wearing in Mitigating the Spread of COVID-19 During the Early Phases of the Pandemic.' medRxiv. 2021.
5	Barari M and others. 'An Empirical Analysis of COVID-19 Response: Comparison of US with the G7.' SSRN. 2021
6	Bruckhaus A and others. 'Post-lockdown infection rates of COVID-19 following the reopening of public businesses.' Journal of Public Health. 2021;23:23.
7	Chernozhukov V and others. 'Causal Impact of Masks, Policies, Behavior on Early Covid-19 Pandemic in the U.S.' Arxiv. 2020.
8	Chernozhukov V and others. 'The Association of Opening K-12 Schools with the Spread of COVID-19 in the United States: County-Level Panel Data Analysis.' Arxiv. 2021.
9	Damette O. 'Zorro versus Covid-19: fighting the pandemic with face masks.' medRxiv. 2021.
10	Fischer CB and others. 'Mask adherence and rate of COVID-19 across the United States.' medRxiv. 2021.
11	Guerra DD and others. 'Mask mandate and use efficacy for COVID-19 containment in US States.' medRxiv. 2021.
12	Guy GP, Jr and others. 'Association of state-issued mask mandates and allowing on-premises restaurant dining with county-level COVID-19 case and death growth rates - United States, March 1-December 31, 2020.' Morbidity and Mortality Weekly Report. 2021;70(10):350-4.
13	Jones RD. 'COVID-19 Trends in Florida K-12 Schools, August 10 – November 14, 2020.' medRxiv. 2020.
14	Joo HMGF and others. 'Decline in COVID-19 hospitalization growth rates associated with statewide mask mandates - 10 states, March-October 2020.' Morbidity and Mortality Weekly Report. 2021;70(6):212-6.
15	K Sruthi C and others. 'How Policies on Restaurants, Bars, Nightclubs, Masks, Schools, and Travel Influenced Swiss COVID-19 Reproduction Ratios.' medRxiv. 2020.
16	Karaivanov A and others. 'Face masks, public policies and slowing the spread of COVID-19: Evidence from Canada.' Journal of Health Economics. 2021;78.
17	Kosfeld R and others. 'The Covid-19 containment effects of public health measures - A spatial difference-in-differences approach.' medRxiv. 2021.

18	Krishnamachari B and others. 'The role of mask mandates, stay at home orders and school closure in curbing the COVID-19 pandemic prior to vaccination.' American Journal of Infection Control. 2021;49:1036-42.
19	Lansiaux E and others. 'Assessing the efficiency of COVID-19 NPIs in France: a retrospective study using a novel methodology.' Research Square. 2021.
20	Maloney MJ. 'MASK MANDATES REDUCE COVID-19 MORTALITY: Analysis of 37 States and the District of Columbia, with a further analysis of the impact of demographic and medical factors on efficacy.' medRxiv. 2021.
21	Maloney MJ and others. 'Mask mandates can limit COVID spread: Quantitative assessment of month-over-month effectiveness of governmental policies in reducing the number of new COVID-19 cases in 37 US States and the District of Columbia.' medRxiv. 2020.
22	Mandelman F. 'COVID-19 International Evidence: Some Notable Puzzles.' SSRN. 2020.
23	Matzinger P and others. 'Strong impact of closing schools, closing bars and wearing masks during the COVID-19 pandemic: results from a simple and revealing analysis.' medRxiv. 2020.
24	Mehl Madrona L and others. 'Understanding SARSCOV-2 propagation, impacting factors to derive possible scenarios and simulations.' medRxiv. 2021.
25	Oster E and others. 'COVID-19 Mitigation Practices and COVID-19 Rates in Schools: Report on Data from Florida, New York and Massachusetts.' medRxiv. 2021.
26	Politis MD and others. 'Spatially refined time-varying reproduction numbers of SARS-CoV-2 in Arkansas and Kentucky and their relationship to population size and public health policy, March – November, 2020.' medRxiv. 2021.
27	Rader B and others. 'Mask-wearing and control of SARS-CoV-2 transmission in the USA: a cross-sectional study.' The Lancet Digital Health. 2021;3:e148-e57.
28	Reinhart E and others. 'Association of Jail Decarceration and Anticontagion Policies With COVID-19 Case Growth Rates in US Counties.' JAMA network open. 2021;4(9):e2123405.
29	Saki M and others. 'Interrupted time series analysis of the implementation of social distancing policy, its lifting and the mandate of wearing face masks in Iran to mitigate against COVID-19.' Research Square. 2020.
30	Sasser P and others. 'Reported COVID-19 Incidence in Wisconsin High School Athletes During Fall 2020.' medRxiv. 2021.
31	Schauer SG and others. 'Analysis of the Effects of COVID-19 Mask Mandates on Hospital Resource Consumption and Mortality at the County Level.' Southern Medical Journal. 2021;114(9):597-602.
32	Shacham E and others. 'Association of County-Wide Mask Ordinances with Reductions in Daily CoVID-19 Incident Case Growth in a Midwestern Region Over 12 Weeks.' medRxiv. 2020.
33	Suhud NA and others. 'Using A Socio-Ecological System (SES) Framework to Explain Factors Influencing Countries' Success Level in Curbing COVID-19.' medRxiv. 2020.
34	Tao S and others. 'The Impact of Non-Pharmaceutical Interventions on the Second Wave of COVID-19: Insights from an Artificial Intelligence-Based, Cross-Country Study.' SSRN. 2021.
35	Valev D. 'Relationships of total COVID-19 cases and deaths with ten demographic, economic and social indicators.' medRxiv. 2020.

36	Wu SX and others. 'Inconsistent with the Intent of Public Health Strategies on Incidence Rates and Case-Fatality Ratio between States with Extra Stay-at-Home and Mandating Face Masks Orders and States Only Following CDC Recommendations During COVID-19 Pandemic in the US.' SSRN. 2020.
37	Zhou C. 'Evaluating System for Effectiveness of Mask Mandates and the Most Influential Factor in Each State in the U.S.A.' Journal of Physics: Conference Series. 2021;1994(1).
38	Zhu R and others. 'The effects of different travel modes on COVID-19 transmission in global cities.' Research Square. 2021.
39	Lessler J and others. 'Household COVID-19 risk and in-person schooling.' medRxiv. 2021.
Wrong study design (other study designs) (n=27 studies)	
40	Abbas M and others. 'Revisiting the evidence for physical distancing, face masks, and eye protection.' The Lancet. 2021;398:661-3.
41	Assche SBV and others. 'In-person schooling and COVID-19 transmission in Canada's three largest cities.' medRxiv. 2021.
42	Banda J and others. 'Controlling the first wave of the COVID–19 pandemic in Malawi: results from a panel study.' medRxiv. 2021.
43	Brainard J and others. 'Introduction to and spread of COVID-19-like illness in care homes in Norfolk, UK.' Journal of public health (Oxford, England). 2021;43:228-35.
44	Chen H and others. 'A cross-country core strategy comparison in China, Japan, Singapore and South Korea during the early COVID-19 pandemic.' Globalization and Health. 2021;17.
45	Cheng HY and others. 'Proactive and blended approach for COVID-19 control in Taiwan. Biochemical and Biophysical Research Communications.' Biochemical and Biophysical Research Communications. 2021;538:238-43.
46	Cheng Y and others. 'High efficacy of face masks explained by characteristic regimes of airborne SARS-CoV-2 virus abundance.' medRxiv. 2021.
47	Denpetkul T and others. 'Effects of face masks and ventilation on the risk of SARS-CoV-2 respiratory transmission in public toilets: a quantitative microbial risk assessment.' bioRxiv. 2021.
48	Fogh K and others. 'Testing Denmark: A Danish nationwide surveillance study of COVID-19.' medRxiv. 2021.
49	Katz SE and others. 'Low In-School COVID-19 Transmission and Asymptomatic Infection Despite High Community Prevalence.' Journal of Pediatrics. 2021.
50	Kollepara PK and others. 'Unmasking the mask studies: Why the effectiveness of surgical masks in preventing respiratory infections has been underestimated.' Journal of Travel Medicine. 2021;6:06.
51	Leech G and others. 'Mass mask-wearing notably reduces COVID-19 transmission.' medRxiv. 2021.
52	Llibre JM and others. 'SARS-CoV-2 transmission in an indoor mass-gathering live music event. A randomized clinical trial.' Research Square. 2021.
53	Pedersen MG and others. 'Data-driven estimation of change points reveals correlation between face mask use and accelerated curtailing of the first wave of the COVID-19 epidemic in Italy.' Infectious Diseases. 2021;53:243-51.

54	Reynolds C and others. 'Factors affecting the transmission of SARS-CoV-2 in school settings.' medRxiv. 2021.
55	Scott N and others. 'The introduction of a mandatory mask policy was associated with significantly reduced COVID-19 cases in a major metropolitan city.' PLoS ONE. 2021;16(7):e0253510.
56	Tam K-M and others. 'Influence of State Reopening Policies in COVID-19 Mortality.' Arxiv. 2020.
57	Tam SY and others. 'Rationale for Mass Masking in Controlling the COVID-19 Pandemic.' Frontiers in Public Health. 2021;9:665708.
58	Xiao M and others. 'Double-zero-event studies matter: A re-evaluation of physical distancing, face masks, and eye protection for preventing person-to-person transmission of COVID-19 and its policy impact.' Journal of Clinical Epidemiology. 2021;133:158-60.
59	Xie S and others. 'Evaluating Effectiveness of Public Health Intervention Strategies for Mitigating COVID-19 Pandemic.' Arxiv. 2021.
60	Yang W and others. 'Effectiveness of Non-pharmaceutical Interventions to Contain COVID-19: A Case Study of the 2020 Spring Pandemic Wave in New York City.' medRxiv. 2020.
61	Yasutaka T and others. 'Assessment of COVID-19 risk and prevention effectiveness among spectators of mass gathering events.' medRxiv. 2021.
62	Zhang J and others. 'Transmission of SARS-CoV-2 during air travel: a descriptive and modelling study.' Annals of Medicine. 2021;53(1):1569-75.
63	Zhang Z and others. 'Disease transmission through expiratory aerosols on an urban bus.' Arxiv. 2020.
64	Salines G. 'COVID-19: how effective are physical distance, face masks, and eye protection in preventing transmission?' Environnement Risques & Sante. 2021;20(3):321.
65	Savage MP and others. 'Social Intervention by the Numbers: Evidence behind the Specific Public Health Guidelines in the COVID-19 Pandemic.' Population Health Management. 2021;24:299-303.
66	Swannell C. 'Mandating masks single most effective control measure in Melbourne's COVID-19 second wave.' Medical Journal of Australia. 2021;215(4):147.
Wrong outcome (n=11 studies)	
67	Anan T and others. 'Association between COVID-19 infection rates by region and implementation of non-pharmaceutical interventions: A cross-sectional study in Japan.' medRxiv. 2021.
68	Britton T. 'Quantifying the preventive effect of wearing face masks.' Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences. 2021;477(2251).
69	Cintra NMF and others. 'The quiet before the storm: negligence and inappropriateness in face mask use in the community preceded devastating second wave of COVID-19 in Brazil.' Infect Control Hosp Epidemiol. 2021:1-6.
70	Ho KMA and others. 'Spatiotemporal droplet dispersion measurements demonstrate face masks reduce risks from singing: results from the COvid aNd FacEmaSkS Study (CONFESS).' medRxiv. 2021.

71	Nelson TL and others. 'Low prevalence of COVID-19 Exposure is Coincident with Self-reported Compliance with Public Health Guidelines among Essential Employees at an Institute of Higher Education.' medRxiv. 2021.
72	Nelson TL and others. 'Association Between COVID-19 Exposure and Self-reported Compliance With Public Health Guidelines Among Essential Employees at an Institution of Higher Education in the US.' JAMA network. 2021;4(7):e2116543.
73	Nguyen M. 'Mask Mandates and COVID-19 Related Symptoms in the US.' Clinicoeconomics Outcomes Research. 2021;13:757-66.
74	Park JY and others. 'Changes in respiratory virus infection trends during the COVID-19 pandemic in South Korea: the effectiveness of public health measures.' Korean Journal of Internal Medicine. 2021;36(5):1157-68.
75	Pro G and others. 'US trends in mask wearing during the COVID-19 pandemic depend on rurality.' Rural and remote health. 2021;21:6596.
76	Reyne B and others. 'Wearing masks and establishing COVID-19 areas reduces secondary attack risk in nursing homes.' medRxiv. 2020.
77	Vancini RL and others. 'A Sociodemographic Profile of Mask Use During the COVID-19 Outbreak Among Young and Elderly Individuals in Brazil: Online Survey Study.' Journal of Medical Internet Research Aging. 2021;4(3):e28989.
Wrong intervention/exposure (n=3 studies)	
78	Cheng HY and others. 'Taiwan's COVID-19 response: Timely case detection and quarantine, January to June 2020.' Journal of the Formosan Medical Association. 2021;120:1400-4.
79	Esposito S and others. 'Epidemiology of SARS-CoV-2 Infection Evaluated by Immunochromatographic Rapid Testing for the Determination of IgM and IgG Against SARS-CoV-2 in a Cohort of Mask Wearing Workers in the Metal-Mechanical Sector in an Area With a High Incidence of COVID-19.' Frontiers in public health. 2021;9:628098.
80	Triukose S and others. 'Effects of public health interventions on the epidemiological spread during the first wave of the COVID-19 outbreak in Thailand.' PLoS ONE. 2021;16.
Ongoing studies (n=1 study)	
81	Georgia Institute of Technology. 'Reducing Spread of COVID-19 in a University Community Setting: Role of a Low-Cost Reusable Form-Fitting Fabric Mask.' ClinicalTrials.gov. 2021.
Duplicates (n=1 study)	
82	Goncalves MR and others. 'Social Distancing, Mask Use and the Transmission of SARS-CoV-2: A Population-Based Case-Control Study.' SSRN. 2020.

Annexe C: Data Extraction Tables

Table C.1. Randomised Controlled Trials

Acronyms used: CI = Confidence Interval, HR = Hazard ratio, IRR = Incidence Rate Ratio, OR= Odds Ratio, RCT = Randomised Controlled Trial, RR = Risk Ratio, RT-PCR =Reverse Transcription Polymerase Chain Reaction, SAR = Secondary Attack Rate, SD = Standard Deviation

Reference	Study design	Methods	Findings	Risk of bias
Abaluck and others, 2021 (16) The Impact of Community Masking on COVID-19: A Cluster-Randomized Trial in Bangladesh NON-PEER-REVIEWED REPORT	Study design: Cluster RCT (at the village level) Objective: To identify strategies to increase face covering use, and assess the impact of face coverings on symptomatic SARS-CoV-2 infections (assessment of the use of face coverings as universal masking) Participants: n=342,126 adults (from 600 villages) Sex: 49% male Mean age: 39 years Settings: Villages, Bangladesh Study Period: November 2020 to January 2021 Mask type: surgical masks and cloth face coverings	Primary outcome: Symptomatic seroprevalence of SARS-CoV-2 Secondary outcomes: 1. Prevalence of proper face covering use 2. Prevalence of physical distancing 3. COVID-19 symptoms (WHO criteria) Intervention group: 300 villages (comprising 178,288 adults). Each intervention village received: 1. One-time face covering distribution and promotion at households 2. Face covering distribution in markets on 3-6 days per week 3. Face covering distribution at mosques on three Fridays during weeks 1-4 4. Face covering promotion in public spaces and markets (weekly or biweekly) 5. Role-modelling and advocacy by local leaders Intervention villages were further randomised to different village-level and household-level cross-randomisations Control group: 300 villages (comprising 163,838 adults); no intervention. Duration: 8 weeks, follow-up to 5 months for face covering outcomes Exposure measurements: Face covering use (including proper use) and social distancing, assessed at public locations in each village through direct observation at baseline and	27,166 participants (7.9%) reported COVID-like symptoms. Of these, 10,952 participants (40.3%) consented to have their blood tested for SARS-CoV-2 (no significant difference in consent rates between groups, p=0.24). Of these, 9,977 blood samples (91.1%) were tested for SARS-CoV-2 antibodies. Face covering use at 8 weeks: • 13.3% in control villages • 42.3% in intervention villages (regression-adjusted estimate: 28.8% higher, 95% CI: 27% to 31%) Physical distancing: • 24.1% in control villages • 29.2% in intervention villages (regression-adjusted estimate 5.1% higher, 95% CI: 4% to 6%) • The increase was similar in cloth and surgical mask villages Participants reporting COVID-like symptoms: • control village: 8.6% (n=13,893) • intervention villages: 7.6% (n=13,273) (relative reduction: 11.9%, p<0.001) • cloth face covering villages: 7.9% (relative reduction: 8.5%, p=0.048) • surgical mask villages: 7.5% (relative reduction: 13.6%, p<0.001) Seroprevalence (omitting participants who did not consent) • control villages: 0.76% • intervention villages: 0.68% (relative reduction: 9.3%, 95% CI: 0.3% to 18.3%, p=0.043) • cloth face covering villages: 0.74% (relative reduction: 5.0%, 95% CI: 10.9% to 20.9%, p=0.54) • surgical mask villages: 0.67% (relative reduction: 11.2%, 95% CI: 0.3% to 22.0%, p=0.043)	Bias: Missing information bias: Only people symptomatic of COVID-19 were tested. Only 40% of those symptomatic consented to be tested. The analysis may be biased if face covering use affects having symptoms of COVID-19 (from COVID-19 or another respiratory infection). QCC rating: Medium

		once per week on weeks 1, 2, 4, 6, 8, 10, and 20 to 27 weeks after the intervention Outcome measurements: Symptom reporting by phone survey or in-person at weeks 5 and 9. Blood samples collected from participants who reported COVID-like symptoms (up to 10 to 12 weeks) and tested for seropositivity (presence of SARS-CoV-2 IgG antibodies) Statistical analysis For intervention effect: Generalised linear model with a normal family (and identity link), clustering at the village level to estimate the effect of the intervention on symptomatic seropositivity, controlling for baseline face covering use in each village and baseline respiratory symptom rates For face covering effect: As above, but instrumenting face covering use with the intervention	Only 40% of participants consented to a blood test, so true seroprevalence figures (but not the relative reductions) may be approximately 2.5 times larger. The decline in symptomatic seroprevalence in the intervention villages was highest in older participants in villages with surgical masks: • up to 40 years: relative reduction = 3.4% reduction (95% CI: -9.9% to 16.7%, p=0.62) • 40 to 50 years: relative reduction = -0.2% (95% CI: -19.1% to 18.7%, p=0.98) • 50 to 60 years: relative reduction = 23.0% (95% CI: 0.59 to 0.95, p=0.01) • 60 years and over: relative reduction = 34.7% (95% CI: 0.46 to 0.85, p=0.001) Instrumental variable regression analysis: an increase from 0% of villagers to 100% of villagers properly wearing a face covering would result in a 32% decrease in symptomatic seroprevalence (p<0.05).	
Bundgaard and others, 2020 (18) Effectiveness of Adding a Mask Recommendation to Other Public Health Measures to Prevent SARS-CoV-2 Infection in Danish Mask Wearers	Study design: RCT Objective: To assess whether recommending wearing a surgical mask outside the home reduces the wearers' risk of developing COVID-19 infection (assessment of the use of face coverings as wearer protection) Participants: n=4,862 adults (81% of 6,024 randomised) Sex: 64% female Mean age: 47 years (SD: 14 years) Participants needed to spend at least 3hours per day outside home and not wear a face covering at work to be included; participants seropositive at baseline excluded Settings: Community setting, Denmark	Outcome: SARS-CoV-2 infection, defined by RT-PCR, antibody test or hospital-based diagnosis Intervention group: n=2,392, 50 surgical masks provided for use outside the home Control group: n=2,470, no surgical masks provided by study (no mask mandate in place, and community face covering use was less than 5%) Outcome measurements (both groups): Self-administrated antibody testing at baseline and one month. Self-collected oropharyngeal or nasal swab for RT-PCR testing at one month and if symptomatic Data collection 4 weekly online surveys to assess surgical mask wearing and other recommendations, adherence, symptoms, exposures, and others.	46% of participants in the intervention group wore surgical masks as recommended, 47% predominantly as recommended, and 7% not as recommended. SARS-CoV-2 (positive RT-PCR or antibody test or COVID-19 diagnosis) • control: 2.1% (n=53 of 2,470) • intervention: 1.8% (n=42 of 2,392) • OR = 0.82 in favour of wearing surgical masks (95% CI: 0.54 to 1.23, p = 0.33) SARS-CoV-2 (positive RT-PCR only) • Control: 0.2% (n=5 of 2,470) • Intervention: 0.0% (n=0 of 2,392) Per-protocol analysis, SARS-CoV-2 (positive RT-PCR or antibody test or COVID-19 diagnosis) • Control: 2.1% (n=53 of 2,470) • Intervention: 1.8% • OR = 0.84 in favour of wearing surgical masks (95% CI: 0.55 to 1.26, p = 0.40)	Bias: Selection bias: Participants were unlikely to be representative of the general population Measurement bias: Surgical mask use and COVID-19 outcomes were self-reported QCC rating: Medium

	Study Period: April and May 2020 (during this period, social distancing recommendations in place; cafe and restaurants closed up to 18 May 2020) Mask type: surgical masks	Duration: 1 month Statistical analysis: Logistic regression to estimate odds ratios (ORs). Per-protocol analysis excluded participants reporting nonadherence to surgical mask wearing		

Table C.2. Contact tracing studies

Acronyms used: CI = Confidence Interval, HR = Hazard ratio, IRR = Incidence Rate Ratio, OR= Odds Ratio, RCT = Randomised Controlled Trial, RR = Risk Ratio, RT-PCR =Reverse Transcription Polymerase Chain Reaction, SAR = Secondary Attack Rate, SD = Standard Deviation

Reference	Study design	Methods	Findings	Risk of bias
Arif and others, 2021 (19) PREPRINT Measuring odds of various COVID-19 infection prevention & control measures among the contacts traced during trace test and quarantine activities at district Quetta (An un-matched case control study).	Study type: Case-control Objective: To assess how infection prevention and control measures affect the odds of infection in contacts of primary COVID-19 cases (assessment of the use of face coverings as wearer protection) Participants: n=300 COVID-19 contacts (randomly selected from 600 contacts) Sex: 66% male Age: 1 to 35 years: 65%; more than 35 years: 34% Cases: n=100 RT-PCR positive contacts Controls: n=200 RT-PCR negative contacts Settings: Quetta, Pakistan Study Period: October 2020	Outcome: COVID-19, as confirmed by RT-PCR Cases: RT-PCR positive contacts (asymptomatic or symptomatic) Controls: RT-PCR negative contacts Exposure: Face covering use during all contact with the primary case Data collection: Interview with structured questionnaire completed by Quetta Provincial Disease Surveillance & Response unit Statistical analyses: Odds ratios (ORs)	91 of 100 cases did not wear face coverings during contact with COVID-19 positive primary cases (91%), compared with 69 of 200 controls (35%): unadjusted OR = 19.19, 95% CI: 9.11 to 40.41, $p < 0.01$.	Confounding: There is a very high chance of bias from confounding as the analysis was unadjusted Other bias: Recall and information bias: It is unclear how long after identification as a contact that participants were interviewed Measurement bias: Face covering use was self-reported and binary (yes or no) QCC rating: Low
Doung-ngern and others, 2020 (23) Case-Control Study of Use of Personal Protective	Study type: Case-control Objective: To investigate the effectiveness of personal protective measures (wearing a face covering, handwashing, and social distancing) during a contact with a pre-	Outcome: Whether the contact who had activities with, or was in the same location as, a person with confirmed COVID-19 developed COVID-19, as confirmed by RT-PCR Cases: Contacts who tested positive for SARS-CoV-2 by 21 April 2020	29 of 210 cases (14%) and 198 of 823 controls (24%) always wore a face covering during contact events, and 102 of 210 cases (49%) and 500 of 823 controls (61%) never wore a face covering during contact events Wearing a face covering at all times during contact events was associated with a lower risk of	Confounding: There is likely bias from residual confounding, as face covering use was associated with other personal protective measures. Other bias:

Reference	Study design	Methods	Findings	Risk of bias
Measures and Risk for SARS-CoV 2 Infection, Thailand	symptomatic case of COVID-19 to reduce transmission of COVID-19 exposed person (assessment of the use of face coverings as wearer protection) Participants: n=1,050 asymptomatic contacts of COVID-19 cases from 3 major clusters in March 2020 (from a total of 1,706 contacts) Cases: n=211 participants; 53% above 40 years of age; 69% male Controls: n=839 participants Sex: 52% male Age: 41% above 40 years of age Settings: Community (boxing stadiums, nightclubs and an office), Thailand Study Period: March to May 2020	Controls: Contacts who did not test positive for SARS-CoV-2 by 21 April 2020 Exposure: Wearing a face covering by the contact, categorised as: "Never", "Sometimes" and "Always". Additionally, the type of face covering worn by the contact, categorised as: "None", "Nonmedical masks only", "Nonmedical and medical" and "Medical mask only" Data collection: Contacts of COVID-19 cases were identified using contact tracing records and were questioned via telephone (30 April to 27 May 2020) about their face covering use and other infection control practices (for example, handwashing, social distancing) during contact periods with the primary case Statistical analyses: Multilevel mixed-effects logistic regression to estimate odds ratios (ORs) with random effects for location and primary cases adjusting for sex, age category and sharing dishes or cup, with an additional analysis testing for an interaction between face covering type and compliance with face covering wearing. Multiple imputation was used to account for missing data	subsequently developing COVID-19 compared to not wearing a face covering (adjusted OR = 0.23, 95% CI 0.09 to 0.60) There was less evidence that wearing a face covering for some of the time during contact events was associated subsequently developing COVID-19 compared to not wearing a face covering (adjusted OR = 0.87, 95% CI 0.41 to 1.84) People who wore face covering at all times during contact events were more likely to practice social distancing ($p = 0.03$) and hand washing ($p < 0.001$), and were more likely to report contact duration of less than 15 minutes ($p < 0.001$) There was little evidence the type of face covering worn was associated with COVID-19 infection compared with no face covering (nonmedical mask OR = 1.29, 95% CI: 0.48 to 3.45, nonmedical or medical mask OR = 1.03, 95% CI: 0.26 to 4.07, medical mask OR = 0.61, 95% CI: 0.25 to 1.49), and there was no evidence of an interaction between face covering wearing and face covering type	Selection bias: There was selection into the records for contact tracing, and selection into the study Response bias: 583 of 1,706 contacts could not be reached (34%) Recall and information bias: Data collection for face covering use was collected via telephone interviews more than 1 month after potential exposure Measurement bias: Face covering use was self-reported QCC rating: Medium
Galow and others, 2021 (26) Lower household transmission rates of SARS-CoV-2 from children compared to adults	Study type: Retrospective cohort Objective: To evaluate risk factors and preventative measures associated with COVID-19 seroprevalence in households with at least one confirmed SARS-CoV-2 case (assessment of the use of face coverings as source control) Participants: n=414 household members (of a total of 470 participants) in 150 households:	Outcome: COVID-19 seropositivity, confirmed through IgG Assay Exposure: Face covering use by primary case Data collection: 5 ml of peripheral venous blood collected from each participant and information on demographics and infection prevention and control measures collected (data collection method not reported) Statistical analyses: Not reported	Seropositivity • 211 of 414 participants (51%) were seropositive • 143 of 211 seropositive participants (68%) reported previous positive RT-PCR • 84 of 150 households (56%) had no detected transmission • In 35 of 150 households (23%), every member tested positive Face covering use • in 19 of 139 households (14%), the primary case wore a face covering	Confounding: There is a very high chance of bias from confounding as the analysis was unadjusted Other bias: Selection bias: Voluntary enrolment. Not clear how many households were approached for involvement Recall and information bias: not clear when COVID-19 infection

Reference	Study design	Methods	Findings	Risk of bias
	• median household size = 3 (IQR: 2 to 4) • 66 of 150 of households (44%) included a household member less than 18 years old Settings: Dresden, Germany Study Period: June 2020		Secondary attack rate (SAR) • households where the primary case wore a face covering: SAR = 0.08 (95% CI: 0.0 to 0.19) • households with no infection prevention and control measures in place: SAR = 0.53 (95% CI: 0.43 to 0.63) • P value for difference = 0.0001 In households where all were seropositive, 5% used face coverings vs 39% had no measures in place (p=0.0065). In households with no onward transmission from the primary case, 79% used face coverings vs 39% had no measures in place (p=0.006)	occurred for households detected through seroprevalence studies; may lead to recall bias Measurement bias: Face covering use was self-reported QCC rating: Low
Hong and others, 2020 (22) Mask wearing in pre-symptomatic patients prevents SARS-CoV-2 transmission: An epidemiological analysis	Study type: Retrospective cohort Objective: To investigate the effectiveness of face coverings worn by pre-symptomatic COVID-19 cases at preventing transmission to close contacts (assessment of the use of face coverings as source control) Participants: n=197 close contacts of 41 individuals (from 63 individuals in total) with pre-symptomatic COVID-19 recently returned from Wuhan Settings: Community, Taizhou, China Study Period: January 2020 to March 2020	Outcome: Whether the contact of a pre-symptomatic COVID-19 case developed COVID-19, as confirmed by RT-PCR Exposure: Face covering use by primary contacts Data collection: Electronic medical records and self-reported questionnaire data (by interview) for both pre-symptomatic cases and close contacts Statistical analyses: Mann-Whitney U test or X^2 test with Fisher's exact probability performed for continuous and categorical variables respectively	28 pre-symptomatic COVID-19 cases reported they had worn face coverings and had 123 close contacts, and 10 of these contacts developed COVID-19 (8.1%) 13 pre-symptomatic cases reported they had not worn face coverings and had 74 close contacts, and 14 of these contacts developed COVID-19 (19.0%) P value for difference < 0.001	Confounding: There is a very high chance of bias from confounding as the analysis was unadjusted Other bias: Selection bias: 35% of COVID-19 cases returning from Wuhan did not provide data Measurement bias: Face covering use was self-reported QCC rating: Low
Liu and others, 2021 (25) Mask wearing in pre-symptomatic patients prevents SARS-CoV-2 transmission: An epidemiological analysis	Study type: Prospective cohort Objective: To assess the risk of SARS-CoV-2 transmission from a paediatric primary case to household contacts (assessment of the use of face coverings as source control) Participants: n=15 confirmed paediatric primary cases (less than 18 years) and 50 household contacts.	Outcome: COVID-19, confirmed by RT-PCR Exposure: Face covering use by primary case at home Data collection: Video observed self-collected swabs for RT-PCR. Daily symptom survey. Survey completed on enrolment and day 14 by household contacts to collect demographics, medical history and house characteristics and control measures taken.	17 of 50 household members developed COVID-19 over the study (SAR = 34%, 95% CI: 22 to 48%). Transmission was lower in contacts where the primary case wore a face covering at home (4 of 23 household members, SAR = 17%, 95% CI: 7% to 37%) compared with not (13 of 27 household members, SAR = 48%, 95% CI: 31 to 66%), p for difference = 0.02	Confounding: There is a very high chance of bias from confounding as the analysis was unadjusted. Other bias: Measurement bias: Face covering use was self-reported. Swab samples were self-collected by household members, though they were

Reference	Study design	Methods	Findings	Risk of bias
	Primary cases: Age: up to 5 years: 67%, 6 to 17 years: 33% Ethnicity: 47% White or Caucasian, 20% Hispanic or Latinx Contacts: Median age: 36 years (IQR: 8 to 42 years) 14% had underlying comorbidities. Settings: Los Angeles County, USA Study Period: December 2020 to February 2021	Statistical analyses: Differences in secondary attack rate (SAR) by characteristic were compared with chi-square test of proportions		observed to ensure proper technique. QCC rating: Medium
Rebmann and others, 2021 (24) SARS-CoV-2 Transmission to Masked and Unmasked Close Contacts of University Students with COVID-19 — St. Louis, Missouri, January–May 2021	Study type: Retrospective cohort Objective: To assess the impact of a modified quarantine protocol for close contacts that considered face covering use (assessment of the use of face coverings as source control and wearer protection) Participants: 378 close contacts of 265 COVID-19 positive students. Sex: 29% male 91% undergraduate; 89% unvaccinated Settings: Saint Louis University (SLU), USA Study Period: January to May 2021	Outcome: COVID-19, confirmed by RT-PCR Exposure: Face covering use (by primary case and contact) during contact with a positive COVID-19 case Data collection: Contact tracing by SLU contact tracing team Statistical analyses: Chi-square or Fisher's exact test for categorical variables, t-tests for continuous variables. Logistic regression to estimate odds ratios (ORs), adjusted for number of exposure incidents	114 of 352 contacts where neither the contact nor primary case wore a face covering tested positive (32.4%), compared with 2 of 26 contacts where either or both the contact and primary case wore a face covering (7.7%), OR = 4.9, 95% CI: 1.4 to 31.1	Confounding: There is likely bias from residual confounding, even after adjustment Other bias: Selection bias: Primary cases identified through symptomatic and optional (for those living off-campus during move-in), random (around 10% of on-campus living students) or student athletes and athletic staff surveillance testing Measurement bias: Face covering use was self-reported QCC rating: Low
Sugimura and others, 2021 (20) The Association between Wearing a Mask and COVID-19	Study type: Retrospective cohort Objective: To assess the relationship between face covering use and testing positive for COVID-19 in close contacts of COVID-19 patients (assessment of the use of face coverings as wearer protection)	Outcome: COVID-19, confirmed by RT-PCR Exposure: Face covering use during contact with COVID-19 positive cases Data collection: Cases and close contacts interviewed by public health centre staff, who	16.4% of close contacts who did not wear face coverings during contact were infected with COVID-19, compared with 7.1% of contacts who used face covering (adjusted RR = 0.6, 95% CI: 0.3 to 0.9)	Confounding: There is likely bias from residual confounding, even after adjustment Other bias: Selection bias: 43% of interviewees were not included due to incomplete data on face

Reference	Study design	Methods	Findings	Risk of bias
	Participants: n=820 (of 1434 contacts who provided information on face covering use and took a RT-PCR test) Sex: 53% male Age: 0 to 19 years: 2.1%, 20 to 59 years: 83%, 60 years and over: 15% Settings: Hiroshima Prefecture, Japan Study Period: 6 March to 31 May 2020	then filled in a COVID-19 reporting form and received a RT-PCR test Statistical analyses: Risk ratio (RR) estimated with Poisson regression, adjusted for gender and type of contact		covering use and RT-PCR test results Measurement bias: Face covering use was self-reported and binary (yes or no) QCC rating: Low
Wang and others, 2020 (21) Reduction of secondary transmission of SARS-CoV-2 in households by face covering use, disinfection and social distancing: a cohort study in Beijing, China	Study type: Retrospective cohort Objective: To study the use of non-pharmaceutical interventions such as face coverings and social distancing to prevent secondary transmission of COVID-19 within households (assessment of the use of face coverings as source control and wearer protection) Participants: 335 people in 124 families with at least one laboratory-confirmed case of COVID-19 (from a total of 181 families) Sex: 49% male Age: 18 to 59 years: 74%, 60 years and over: 26% Settings: Households, Beijing, China Study Period: February to March 2020	Outcome: Confirmed secondary transmission of SARS-CoV-2 within the family, defined using clinical, epidemiological and laboratory testing Exposure: Face covering use by the primary case after illness onset, and number of family members within each household wearing a face covering at home both before and after the primary case's illness (0 versus 1 or more) Data collection: 3-part structured questionnaire delivered by telephone interview. Data on primary cases were extracted from epidemiological reports from the Beijing Center for Disease Prevention and supplemented by telephone interview Statistical analyses: Multivariable logistic regression to estimate odds ratios (ORs), adjusting for if the primary case had diarrhoea, times of close contact with primary cases and frequency of chlorine or ethanol based disinfectant use frequency	41 of 124 families had secondary transmission (33%); 77 of 335 household members became infected with COVID-19 (secondary attack rate: 23%) In 38 of 83 families without transmission (46%) and 8 of 41 families with COVID-19 transmission (20%), the primary case always wore a face covering at home after the primary case's COVID-19 onset (unadjusted OR versus never wore a face covering = 0.30, 95% CI: 0.11 to 0.82, p = 0.02). Wearing a face covering after illness onset was not statistically significant in the multivariable regression 27 of 81 families without transmission (33%) and 4 of 40 families with COVID-19 transmission (10%) had at least one family member (contacts) who wore a face covering before the primary case's COVID-19 onset (unadjusted OR = 0.22, 95% CI: 0.07 to 0.69, p = 0.009) Face covering use by at least one household member (primary case or family member) before the primary case developed COVID-19 reduced secondary transmission within the household compared to families where no members wore a face covering (adjusted OR = 0.21, 95% CI: 0.06 to 0.79, p = 0.02)	Confounding: There is likely bias from residual confounding, even after adjustment Other bias: Recall bias and information bias: telephone interview used to collect information Selection bias: Some households refused to participate (9%) and other households were excluded without a clear reason (23%) Measurement bias: Face covering use was self-reported QCC rating: Medium

Table C.3. Childhood settings

Acronyms used: CI = Confidence Interval, HR = Hazard ratio, IRR = Incidence Rate Ratio, OR= Odds Ratio, RCT = Randomised Controlled Trial, RR = Risk Ratio, RT-PCR =Reverse Transcription Polymerase Chain Reaction, SAR = Secondary Attack Rate, SD = Standard Deviation

Reference	Study design	Methods	Findings	Risk of bias
Cooper and others, 2021 (29) SARS-CoV-2 acquisition and immune pathogenesis among school-aged learners in four diverse schools	Study type: Prospective cohort Objective: To understand COVID-19 infection in schools, the serological and cellular mechanisms in children in response to COVID-19 infection, and to measure the compliance to school-based mitigation measures (assessment of the use of face coverings as source control and wearer protection) Participants: n=320 students (181 and 300 students in the first and second cycles, respectively) and n=99 staff members Mean age (students): 10.5 (SD: 2.1), range 7 to 17 years Settings: 4 schools, Orange County, US Study Period: Autumn to Winter 2020	Outcome: COVID-19, confirmed by RT-PCR Measured during 2 testing cycles: 1. early Autumn term (low community prevalence) 2. around 6 to 8 weeks later (surge in community prevalence) Exposure: Face covering use Data collection: In both cycles, participants gave a brief medical history, underwent COVID-19 symptom screening, and received a RT-PCR test for SARS-CoV-2 and phlebotomy for serological and other immunological markers of SARS-CoV-2 infection. Trained observers visited schools 3-5 times per week and performed systematic observation of COVID-19 mitigation Statistical analyses: Correlation between average face covering compliance in the 4 schools and SARS-CoV-2 positivity	91.3% face covering compliance across all 4 schools. No students tested positive for COVID-19 during the first cycle; 17 positive test results were observed among 300 students tested during the second cycle (5.7%) No correlation was observed between in-classroom face covering compliance and SARS-CoV-2 positivity	Confounding: There is a very high chance of bias from confounding as the analysis was unadjusted Other bias: Selection bias: Unclear what proportion of students agreed to take part in the study QCC rating: Low
Marchant and others, 2021 (27) PREPRINT COVID-19 mitigation measures in primary schools and association with infection and school staff wellbeing: an observational survey linked with	Study design: Cross-sectional Objective: To evaluate the association between mitigation measures performed by teachers within primary school settings (including face covering wearing) and COVID-19 cases (school level), cold symptoms (individual level), and mental health outcomes (individual level). Note: It is not possible to use the results of this study to estimate the effectiveness of face coverings as source control nor wearer protection,	Outcome: COVID-19 cases (staff or pupil) in the respective school of the staff participant, measured using national-scale RT-PCR test results data Exposure: Staff face covering use Data collection: Online survey for primary school staff, linked to national-scale testing data for all staff and pupils within the respective school of the staff participant. Statistical analysis: Logistic regression to estimate odds ratios (ORs), with one or more COVID cases in a school versus no cases as	87 of 353 participants (24.7%) were in a school with a linked COVID-19 positive test Face covering use: • none: 56.1% • face covering: 31.4% • visor: 11.3% • 83% of schools had at least 80% agreement of responses at the school-level Univariable analysis (compared to no face covering): • face covering: OR = 2.82 (95% CI: 1.11 to 7.14) • visor: OR = 1.65 (95% CI: 0.47 to 5.74) Multivariable analysis (compared to no face covering):	Confounding: There is likely bias from residual confounding, even after adjustment. Possibility of reverse causation (COVID-19 cases in school causing increased staff face covering use) Other bias: Selection bias: Convenience sample with around 5% of schools in Wales represented, although all primary schools in Wales were contacted

Reference	Study design	Methods	Findings	Risk of bias
routine data in Wales, UK	see the main review for details. Participants: n=353 primary school staff members (from 384 survey respondents) Settings: 59 primary schools, Wales, UK Study period: Oct to Dec 2020	the outcome, adjusted for school size, proportion of pupils eligible for free school meals, clustered by school	• face covering: OR = 2.10 (95% CI: 0.87 to 5.05) • visor: OR = 1.42 (95% CI: 0.40 to 5.2)	Information bias: COVID-19 data came from national-scale RT-PCR test data, so asymptomatic cases may have been missed Measurement bias: Face covering use was self-reported QCC rating: Low
Suh and others, 2021 (28) PREPRINT (accepted for publication, but not available as of 7 October 2021) Effectiveness of Non-Pharmaceutical Interventions on Child and Staff COVID-19 Cases in US Summer Camps	Study design: Cross-sectional Objective: To evaluate the association between several non-pharmaceutical interventions (including face coverings) and COVID-19 cases at US summer camps (assessment of the use of face coverings as source control and wearer protection) Participants: n=486 US summer camps, comprising n=89,635 children (campers) Settings: Summer camps, US Study period: Summer 2020	Outcome: Confirmed and suspected COVID-19 cases in campers and staff Exposure: Face covering use ("always", "often", "sometimes", "rarely", or "never") Data collection: Online survey (one respondent per camp or per multiple camps) Statistical analysis: Risk ratios (RRs)	COVID-19 cases • camps: 74 had at least 1 confirmed case; 127 had at least 1 confirmed or suspected case; 5 had more than 5 cases, of which 3 experienced an outbreak (more than 3 cases in a week) • campers: 30 confirmed; 111 suspected and confirmed • staff: 72 confirmed; 191 suspected and confirmed Face covering use • 33% of campers always wore face coverings • 69% of staff always wore face coverings Camper face covering policy, always compared to not always • campers: RR = 0.36 (95% CI: 0.14 to 0.95) • staff: RR = 0.17 (95% CI: 0.08 to 0.40) Staff face covering policy, always compared to not always • campers: RR = 0.39 (95% CI: 0.19 to 0.80) • staff: RR = 0.38 (95% CI: 0.24 to 0.60) Staff face covering policy, compared to camps where neither campers nor staff wore face coverings • campers: RR = 0.51 (95% CI: 0.22 to 1.14) • staff: RR = 0.55 (95% CI: 0.33 to 0.92) Camper and staff face covering policy, compared to camps where neither campers nor staff wore face coverings • campers: RR = 0.27 (95% CI: 0.10 to 0.73) • staff: RR = 0.13 (95% CI: 0.06 to 0.31)	Confounding: There is a very high chance of bias from confounding as the analysis was unadjusted Other bias: Selection bias: Survey distributed online with volunteer participants Information bias: One participant responded for each camp, or multiple camps, with no verification of data Measurement bias: Face covering use and COVID-19 outcomes were self-reported QCC rating: Low

Reference	Study design	Methods	Findings	Risk of bias
Theuring and others, 2021 (30) SARS-CoV-2 infection and transmission in school settings during the second COVID-19 wave: a cross-sectional study, Berlin, Germany, November 2020	Study design: Cross-sectional Objective: To assess SARS-CoV-2 infections and sero-reactivity in Berlin schools and connected households and prevention measures put in place (assessment of the use of face coverings as wearer protection). Participants: n = 1,119 participants n=177 primary school students: median age: 11 years, 47.7% female n=175 secondary school students: median age: 15 years, 54.3% female n=142 staff: median age: 47 years, 71.8% female n=625 household members: median age: 42 years, 51.2% female (data not used) Settings: 24 Berlin schools (12 primary and 12 secondary). Study period: November 2020	Outcome: COVID-19, confirmed by RT-PCR. SARS-CoV-2 seropositivity, confirmed through ELISA Exposure: Frequency of face covering use in school and in public Data collection: Students and staff: in-school visit to collect medical history, temperature, oro-nasopharyngeal swabs and finger-prick blood samples. Participants away due to illness or quarantine were visited at home Electronic questionnaire (child, adolescent or adult), which asked about face coverings use in the preceding 2 weeks When a SARS-CoV-2 case was detected, the case's school sub-cohort and household self-retested 1 week later Statistical analysis: Proportions and odds ratios (ORs)	9 of 338 students (2.7%) and 1 of 140 staff members (0.7%) tested positive for SARS-CoV-2 on RT-PCR 4 of 277 participants (1.4%) who reported often or always wearing a face covering at school tested positive for SARS-CoV-2 on RT-PCR, compared with 5 of 35 participants (14.3%) who reported never to sometimes wearing a face covering at school, OR = 11.38, 95% CI: 2.28 to 59.64	Confounding: There is a very high chance of bias from confounding as the analysis was unadjusted Other bias: Selection bias: low participation rate (65% of students participated), and low questionnaire response rate (55% to 68% for individual items) Measurement bias: Face covering use was self-reported QCC rating: Low

Table C.4. Other observational association studies

Acronyms used: CI = Confidence Interval, HR = Hazard ratio, IRR = Incidence Rate Ratio, OR= Odds Ratio, RCT = Randomised Controlled Trial, RR = Risk Ratio, RT-PCR =Reverse Transcription Polymerase Chain Reaction, SAR = Secondary Attack Rate, SD = Standard Deviation

Reference	Study design	Methods	Findings	Risk of bias
Bérubé and others, 2021 (33) PREPRINT Imprecise assessment of mask use may obscure associations with SARS-CoV-2 positivity	Study design: Cross-sectional study Objective: To evaluate factors associated with face covering use, including state policy, location (indoor and outdoor) and demographic variables, as well as the relationship between face covering use and COVID-19 positivity in the past 2 weeks (assessment of the use of face coverings as wearer protection) Participants: n=3,058 adults (of 4,361 adults who started the survey) Median age: 47 years (IQR: 33 to 64 years) Gender: 47% male Race: 56% White or Caucasian, 21% Black or African American, 14% Hispanic or Latino, 6% Asian or Pacific Islander, 3% other Settings: Florida, Illinois, and Maryland, US Study period: 16 September to 15 October 2020	Outcome: Self-reported COVID-19 infection, confirmed through a positive RT-PCR test in the preceding 2 weeks Exposure: Face covering use (always, sometimes, or never) and face covering removal in community settings (always, sometimes, or never) Data collection: Online survey Statistical analysis: Logistic regression to estimate odds ratios (ORs), adjusted for the number of locations a participant has visited and demographic variables	281 participants had received RT-PCR test in the last 2 weeks (9% of total sample). Of those, 65 were positive for COVID-19 (23% of those who received a test) Participants who received RT-PCR test in the last 2 weeks (n=281) Face covering use indoors, compared to always: • sometimes: adjusted OR = 0.94 (95% CI: 0.38 to 2.28) • never: adjusted OR = 0.81 (95% CI: 0.17 to 3.39) Face covering use outdoors, compared to always: • sometimes: adjusted OR = 1.07 (95% CI: 0.45 to 2.53) • never: adjusted OR = 1.05 (95% CI: 0.26 to 3.88) Frequency of face covering removal, compared to never or rarely (quartile 1): • sometimes (quartile 2): adjusted OR = 12.2 (95% CI: 1.15 to 128.3) • often (quartile 3): adjusted OR = 10.1 (95% CI: 1.13 to 90.4) • always (quartile 4): adjusted OR = 9.92 (95% CI: 1.16 to 85.1) Total sample A model that included participants who did not receive a RT-PCR test in the past 2 weeks as negative for COVID-19 had similar results. However, the association between frequency of face covering removal and being positive for COVID-19 was not statistically significant	Confounding: There is likely bias from residual confounding, even after adjustment Other bias: Selection bias: recruited through online platform. Subsample used for main analysis only included participants who had received a RT-PCR test in the last 2 weeks Measurement bias: Face covering use and COVID-19 outcomes were self-reported QCC rating: Low
Flegr and others, 2021 (35) PREPRINT Effects of 105 biological, socioeconomic,	Study type: Prospective cohort Objective: To assess factors that may affect SARS-CoV-2 infection risk (assessment of the use of face coverings as wearer protection)	Outcome: Self-reported COVID-19, with possible responses: COVID-19 negative: "No", "No, but I was in quarantine" COVID-19 positive: "Yes, I was diagnosed with it" NA: "Yes, but I was not diagnosed with it", "I am awaiting test results"	Correlation between face covering use and risk of SARS-CoV-2 infection at the end of fourth wave of the pandemic: partial Kendall Tau = -0.04, $p<0.0001$ Women: partial Kendall Tau = -0.03 Men: partial Kendall Tau = -0.06	Confounding: There is a very high chance of bias from confounding as the analysis was unadjusted Other bias: Selection bias: Sample was self-selected from

Reference	Study design	Methods	Findings	Risk of bias
behavioural, and environmental factors on the risk of SARS-CoV-2 infection and a severe course of Covid-19: A prospective longitudinal study	Participants: n=5,164 (of 8,084 who completed both questionnaires). n=1,746 men (34%, mean age: 42.1, SD: 12.3) n=3,411 women (66%, mean age: 43.5, SD: 12.0) Settings: Czech Republic and Slovakia Study Period: First questionnaire: October 2020 to March 2021 Second questionnaire: March 2021	Exposure: Abiding by face covering wearing policy, with the possible responses: "No (on principle", "No (due to indolence)", "Yes, but not strictly", "Yes, I really strive", "Yes, strictly, and I try to convince people in my vicinity to do the same" Data collection: Self-reported online survey. Participants were recruited using a voluntary Facebook-based snowball method from a group of Czech and Slovak nationals willing to participate in evolutionary psychology and evolutionary parasitology research studies Statistical analyses: Partial Kendall correlation, contingency table tests and t-tests		a Facebook-based snowball method survey Loss to follow up: of the 30,000 unique completed first questionnaires only 12,600 provided their email for follow up. Of these only 8,084 completed the second questionnaire Survivorship bias: those who became severely ill or died due to any reason (including COVID) less likely to complete both questionnaires Measurement bias: Face covering use and COVID-19 outcomes were self-reported QCC rating: Low
Gonçalves and others, 2021 (31) Social Distancing, Mask Use, and Transmission of Severe Acute Respiratory Syndrome Coronavirus 2, Brazil, April–June 2020	Study design: Case-control study Objective: To assess the associations between social distancing and face covering use with symptomatic SARS-CoV-2 infection (assessment of the use of face coverings as wearer protection) Participants: Cases: n=198 adults (from a total sample of 271 cases) Sex: 44% male Mean age: 46 years (SD: 17 years) Controls: n=420 adults (from a total sample of 1,396 controls) Sex: 39% male Mean age: 50 years (SD: 18 years) Settings: Community setting, Porto Alegre, Brazil	Outcome: COVID-19, confirmed by RT-PCR or antibody testing Cases: COVID-19 cases who tested positive for SARS-CoV-2 in Porto Alegre between 23 May and 19 June, identified through a local public health agency. Mainly symptomatic cases as testing was restricted to symptomatic patients at the time Controls: Participants of a representative community survey in Porto Alegre (conducted 26-28 June 2020) who were seronegative for SARS-CoV-2 Exposure: Face covering use ("yes" or "no" for cases, "yes", "sometimes" or "no" for controls) Data collection: Interviews, either by telephone (cases) or at the participant's residence (controls)	Wearing a face covering was associated with decreased COVID-19 infection compared with not wearing a face covering (OR = 0.10, 95% CI: 0.03 to 0.25) This effect was smaller when assuming that controls who answered "sometimes" when asked whether they wore a face covering when leaving their home would have said "no" rather than "yes", as "sometimes" was not an option for cases (OR = 0.36, 95% CI: 0.17 to 0.74 No interaction was seen between face covering use and social distancing, that is, there was little evidence that the effect of face covering use on COVID-19 infection varied by whether participants practiced more or less social distancing (OR = 0.96, 95% CI: 0.60 to 1.58)	Confounding: There is some risk of bias from residual confounding, even after adjustment Other bias: Selection bias: The response was low (55% for cases, 49% for controls). Healthcare workers were excluded from cases but not controls (estimated 5% of controls may have been healthcare workers) Measurement bias: Cases and controls were asked about face coverings at different times, with different possible responses, in different locations. Face covering use was self-reported

Reference	Study design	Methods	Findings	Risk of bias
	Study period: April to June 2020	Statistical analysis: Logistic regression to estimate odds ratios (ORs), with sex, age, educational attainment, race, income, household size and social distancing score as covariables		Other bias: The outcome was symptomatic SARS-CoV-2 infection QCC rating: Low
Huamani and others, 2021 (37) PREPRINT Population-based seroprevalence of SARS-CoV-2 antibodies in a high-altitude setting in Peru	Study design: Cross-sectional Objective: To assess population-based COVID-19 seroprevalence in Cusco at the end of the first wave. (assessment of the use of face coverings as wearer protection) Participants: n=1924 from 712 families Gender: 57.1% women Mean age: 42.5 years (SD: 16.5) 33.3% from Cusco City; 45.5% from the periphery of Cusco; 21.2% from Quillabamba Settings: Cusco, Peru Study period: September 2020	Outcome: COVID-19 seroprevalence (IgM and IgG), confirmed by Chemiluminescence tests Exposure: Face covering and face shield use during quarantine Data collection: Written survey and blood samples completed by field staff visiting each household over three weekends in September Statistical analysis: Prevalence estimates: Poisson distribution adjusted for clusters at household level Factors associated with positivity: logistic regression to estimate odds ratios (ORs), adjusted for age, gender and study setting	Seroprevalence • 637 were seropositive (adjusted prevalence = 33.1%, 95% CI: 30.1% to 36.4%) • 318 of 712 families had at least one positive member (adjusted prevalence = 44.6%, 95% CI: 41.0% to 48.3%) • all family members were positive in 141 of 712 families (adjusted prevalence = 19.8%, 95% CI: 17.0% to 22.8%) Face covering use, compared to not always • face shield: adjusted OR = 0.62 (95% CI: 0.46 to 0.84) • face covering: adjusted OR = 0.65 (95% CI: 0.47 to 0.88)	Confounding: There is likely bias from residual confounding, even after adjustment Other bias: Measurement bias: Face covering use was self-reported and binary (yes or no) QCC rating: Low
Kwon and others, 2021 (34) Association of social distancing and masking with risk of COVID-19	Study design: Prospective cohort Objective: To estimate the association between social distancing and face covering use, and the risk of COVID-19 (assessment of the use of face coverings as wearer protection) Participants: n=134,597 (with data for face coverings, out of 198,077 participants in the cohort, and 277,739 participants in total) Settings: Smartphone app users, US Study Period: March to July 2020	Outcome: Predicted COVID-19 (COVID-19 status predicted from symptoms entered into the smartphone app) Exposure: Face covering use outside the house, categorised as: "none of the time", "sometimes", "most of the time", and "always" Follow-up time: First login to the app to 16 July; mean follow-up time: 31 days Data collection: Self-reported via the smartphone app Statistical analysis: Cox proportional hazard regression models to estimate hazard ratios (HRs), stratified by age, state and calendar date, with race, sex, population density,	1,194 participants (0.89%) were predicted to have developed COVID-19 over 4,209,236 person-days of follow-up Compared to individuals who wore face coverings none of the time, the HRs for predicted COVID were: • sometimes: 0.27 (95% CI: 0.19 to 0.39) • most of the time: 0.35 (95% CI: 0.28 to 0.43) • all of the time: 0.36 (95% CI: 0.30 to 0.44) • P value for trend < 0.001 These results were very similar for individuals living in communities with poor social-distancing (as assessed by Unacast, which looks at smartphone-based GPS activity of devices in an area) The study reported that the results remained similar after adjustment for observed COVID-19 incidence.	Confounding: There is some risk of bias from residual confounding, even after adjustment Other bias: Selection bias: selection of participants into the study depended on access to a smartphone, and participants were recruited through general and social media outreach Measurement bias: Face covering use and COVID-19 symptoms were self-reported. Predicted COVID-19 used as the outcome rather than observed COVID-19

Reference	Study design	Methods	Findings	Risk of bias
	Cohort or registry name: COVID Symptom Study smartphone app	current smoking, work as a frontline healthcare worker, interaction with suspected or documented COVID-19, history of diabetes, heart disease, lung disease and kidney disease, and neighbourhood deprivation index as covariables		QCC rating: Low
Lalwani and others, 2021 (38) PREPRINT High anti-SARS-CoV-2 antibody seroconversion rates before the second wave in Manaus, Brazil, and the protective effect of social behavior measures: Results from the DETECTCoV-19 cohort	Study type: Prospective cohort Objective: To assess seroconversion incidence in the DETECTCoV-19 cohort and associated risk factors (assessment of the use of face coverings as wearer protection) Participants: n=1638 (of 3,057 initially recruited) Gender: 37% male Age: 18 to 29 years: 22.7%; 30 to 39 years: 25.6%; 40 to 49 years: 21.6%; 50 to 59 years: 17.8%; 60 years and over: 12.2% Settings: Manaus, Brazil Study Period: August to November 2020	Outcome: COVID-19 seropositivity, confirmed by IgG assay Exposure: Face covering use during contact with COVID-19 cases Data collection: Electronic questionnaire filled in by trained interviewers and blood sample collected: • first visit between August and October • second visit between October and November During second visit, information on social distancing, medication, symptoms and prior diagnosis using an electronic questionnaire. RT-PCR or antigen test result was collected if available Statistical analyses: Chi-square or Fisher's exact test to evaluate association between seroconversion incidences and independent variables Poisson regression to estimate crude Relative Risk (RR) and crude Incidence Rate Ratios (IRR) Multivariate model to estimate adjusted IRR, adjusted for: age, sex, social distancing, working remote vs on-site, household members with COVID-19, COVID-19 contacts, symptoms, and COVID-19 diagnosis	214 of 1638 participants (13.1%) seroconverted between first and second visit Had contact with COVID-19 cases since August No: 778 of 1620 (48.0%) • seroconverted = 70 of 778 (9%) Yes, with face covering: 604 of 1620 (37.3%): • seroconverted = 93 of 604 (15.4%) • IRR (compared to no contact) = 1.20, 95% CI: 0.90 to 1.60; p = 0.22 Yes, without face covering: 238 of 1620 (14.7%): • seroconverted = 48 of 238 (20.2%) • IRR (compared to no contact) = 1.25, 95% CI: 1.09 to 1.45; p = 0.002	Confounding: There is likely bias from residual confounding, even after adjustment. Other bias: Selection bias: original cohort recruited using online and university website advertising; 18% of participants withdrew from the study before the second visit. Measurement bias: Face covering use was self-reported QCC rating: Medium
Lopez and others, 2021 (39)	Study design: Cross-sectional Objective: To assess seroprevalence in employees of a school system and the risk factors associated	Outcome: COVID-19 seropositivity, confirmed by IgG antibody tests Exposure: Face covering use while in public	22 of 753 (2.9%) tested positive for SARS-CoV-2 antibodies. No statistically significant association found between self-reported face covering use history and	Confounding: There is likely bias from residual confounding, even after adjustment. Other bias:

Reference	Study design	Methods	Findings	Risk of bias
Seroprevalence of anti-SARS-CoV-2 IgG antibodies in the staff of a public school system in the midwestern United States	(assessment of the use of face coverings as wearer protection). Participants: n=753 employees of Lake Central school corporation during the 2018 to 2019 or 2019 to 2020 school years Gender: 15% male Age: 18 to 35 years: 20.3%; 36 to 50 years: 38.2%; 51 to 65 years: 37.5%; 66 years and over: 4.0% Settings: Lake Central School Corporation (LCSC) public school system, Indiana, US Study period: Five days in July 2020	Data collection: Self-completed questionnaire on sociodemographic characteristics and blood samples for antibody testing Statistical analysis: Seroprevalence with binomial confidence intervals, corrected for uncertainties in test sensitivity and specificity Relative risks (univariate analysis). Multivariable logistic regression, controlled for gender, age, travel history (proxy for risk taking behaviour), school type, and role in LCSC	seropositivity (Risk Ratio = 0.63, 95% CI: 0.16 to 4.3, p = 0.57).	Selection bias: 40% of eligible staff members did not participate in the study. Measurement bias: Face covering use was self-reported and binary (yes or no). QCC rating: Low
Manny and others, 2020 (40) PREPRINT Increased mask use and fewer gatherings associated with lower SARS-CoV-2 seropositivity among young school-age children	Study design: Cross-sectional Objective: To evaluate COVID-19 seroprevalence among 8 to 13-year-old children, as well as factors and non-pharmaceutical interventions (including face covering wearing) associated with seropositivity (assessment of the use of face coverings as wearer protection) Participants: n=565 (one child per household) Sex: 52% female Mean age: 10.5 years (SD: 1.6, range: 8 to 13 years) Settings: Edmonton, Canada Study period: August to October 2020 (interim results for first 2 months of the study, all results from baseline)	Outcome: COVID-19 seroprevalence (IgG), confirmed by Chemiluminescence tests Exposure: Face covering use (“never”, “rarely”, “occasionally”, “often”, or “always”) during 3 timeframes: • January to March 2020 • April to August 2020 • September 2020 to current Data collection: Survey completed by the parents, and blood collection from the children Statistical analysis: Fisher’s exact test; logistic regression to estimate odds ratios (ORs), adjusted for age and whether the child returned to in-person school	Seropositivity • one was seropositive (IgG at least 1.4), 8 (1.6%) were likely to be seropositive (IgG between 0.8 and 1.4) Univariate analysis, face covering use: • never, rarely and occasionally: 5 of 188 (4.2%) • often and always: 4 of 423 (0.9%) • P for difference = 0.03 Face covering and gatherings interaction: • no face covering, attended less than 6 large gatherings: 2 of 46 (4.4%) • face covering, attended less than 6 large gatherings: 0 of 184 (0%) • no face covering, attended at least 6 large gatherings: 3 of 70 (4.3%) • face covering, attended at least 6 large gatherings: 4 of 226 (1.8%) • P for differences = 0.02 Multivariate analysis, odds of being likely seropositive per gathering with and without mask use:	Confounding: There is likely bias from residual confounding, even after adjustment Other bias: Recall bias: parents were asked to remember their child’s face covering use up to 9 months prior Selection bias: Voluntary sample recruited from a single centre Measurement bias: Face covering use was self-reported QCC rating: Low

Reference	Study design	Methods	Findings	Risk of bias
			• never, rarely or occasionally wore a face covering at gatherings: OR = 9.7 (95% CI: 2.4 to 38.9, p = 0.001) • often or always wore a face covering at gatherings: OR = 1.02 (95% CI 1.00 to 1.04), p = 0.007	
Office for National Statistics, 2021 (17) NON-PEER-REVIEWED REPORT Coronavirus (COVID-19) Infection Survey technical article: analysis of populations in the UK by risk of testing positive for COVID-19, September 2021	Study design: Prospective cohort Objective: To evaluate risk factors for testing positive for COVID-19 in the UK (assessment of the use of face coverings as wearer protection) Participants: n=114,700 (out of 167,288 total participants; only participants with at least one negative RT-PCR test in the preceding 10 to 35 days included in analysis); children at least 2 years and adults; representative sample of the UK Settings: Private residential households, UK Study period: July 2020 to September 2021, data for this analysis from 29 August 2021 to 11 September 2021	Outcome: COVID-19 cases, confirmed through RT-PCR Exposure: Face covering use in enclosed spaces ("always", "not needed", "sometimes", or "never"); maximum value across all visits in the preceding 35 days used, excluding the visit when the outcome was assessed Data collection: Every week for first 5 weeks after a participant entered the study, then monthly: • Coronavirus Infection Survey Questionnaire • ose and throat swabs for RT-PCR Statistical analysis: Logistic regression to estimate odds ratios (ORs), adjusted for age, sex, ethnicity, region, urban or rural address, deprivation, household size, whether the household was multigenerational, vaccination status, prior infection, regular lateral flow test frequency, disability, smoking status, social distancing	1,128 out of 114,700 participants tested positive for COVID-19 between 29 August and 11 September (1.0%). Face covering use, compared to always wearing a face covering in enclosed spaces • not needed (did not leave house): OR = 1.56 (95% CI: 1.01 to 2.31) • sometimes: OR = 1.07 (95% CI: 0.86 to 1.32) • never: OR = 1.59 (95% CI: 1.27 to 1.98)	Confounding: There is some risk of bias from residual confounding, even after adjustment, although the analysis accounted for this well Other bias: None identified QCC rating: High
Tahura and others, 2021 (36) PREPRINT Risk of COVID-19 infection and work place exposure of front-line mass media professionals	Study design: Cross-sectional study Objective: To evaluate the risk of work-place exposure to COVID-19 of mass-media professionals, and factors associated with exposure, including participant characteristics, comorbidities, and face covering use (assessment of the use of face coverings as wearer protection) Participants: n=199 mass media professionals (print, broadcast and	Outcome: COVID-19, confirmed by RT-PCR (compared to suspected, test negative and healthy participants) Exposure: Type of face covering (no face covering, cloth face covering, surgical mask, reused surgical mask or respirator) Data collection: Online survey Statistical analysis: Chi-squared test, logistic regression to estimate odds ratios (ORs), adjusted for age, gender, symptoms, co-	Unadjusted logistic regression, compared to respirators (39 of 93 participants tested positive for COVID-19, 42%): No face covering: • 3 of 9 participants tested positive for COVID-19 (33%) • OR = 0.69 (95% CI: 0.16 to 2.94), p = 0.62 Home-made or cloth face covering: • 4 of 14 participants tested positive for COVID-19 (29%) • OR = 0.55 (95% CI: 0.16 to 1.89), p = 0.34	Confounding: There is likely bias from residual confounding, even after adjustment Other bias: Selection bias: Online snowball sampling used to recruit participants Information bias: Only some participants were tested, and people with suspected COVID-19 infections were treated the same as people with negative

Reference	Study design	Methods	Findings	Risk of bias
	online) Sex: 78% male Mean age: 33.6 years (SD: 4.7, range: 24 to 48 years) Settings: Bangladesh Study period: May 2020 to June 2020	morbidities, smoking status, contact tracing, seeking of maximum medical care support, media type, and job role	New medical or surgical mask: • 20 of 48 participants tested positive for COVID-19 (42%) • OR = 0.99 (95% CI: 0.49 to 2.01), p = 0.98 Reused medical or surgical mask: • 12 of 35 participants tested positive for COVID-19 (34%) • OR = 0.32 (95% CI: 0.32 to 1.63), p = 0.43 Adjusted odds ratios not reported as they were not statistically significant	tests Measurement bias: Face covering use was self-reported QCC rating: Low
Van den Broek-Altenburg et al 2021 (32) Jobs, Housing, and Mask Wearing: Cross-Sectional Study of Risk Factors for COVID-19	Study design: Cross-sectional Objective: To estimate the prevalence of COVID-19 in a hospital service area and identify factors that affect the risk of infection, including face covering use (assessment of the use of face coverings as wearer protection) Participants: n=435 adults (from a survey of 1,694 adults) Sex: 40% male Mean age: 51 years (SD: 0.6 years) Settings: Community setting (members of a hospital service area), Vermont, USA Study period: June 2020	Outcome: COVID-19 infection, confirmed by RT-PCR (prevalence) or antibody tests (incidence) Exposure: Face covering use Data collection: Survey questions, and all included participants provided samples for COVID-19 RT-PCR and antibody testing Statistical analysis: t-test	Of 12,000 patients invited to participate, 1,674 completed the survey (14.4%). Of these, 454 patients (27%, 3.8% of total invites) provided samples to test for COVID-19 infection 10 patients (2.2%) tested positive for SARS-CoV-2 on antibody testing, and 1 patient (0.2%) tested positive for SARS-CoV-2 on RT-PCR testing 50% of COVID-19 positive patients and 70% of COVID-19 negative patients wore face coverings outside work (p = 0.26)	Confounding: There is a very high chance of bias from confounding as the analysis was unadjusted Other bias: Selection bias: Only 3.8% of those invited to participate in the survey were included in the analysis Measurement bias: Face covering use was self-reported QCC rating: Low

Annexe D: Protocol

Review question

What is the effectiveness of face coverings to reduce the spread of COVID-19 in the community?

Notes

We (the COVID-19 Rapid Evidence Service) have conducted 2 rapid reviews on face coverings and transmission of COVID-19 in the community: the original review (search up to 5 June 2020) (10) and the update 1 (search up to 22 September 2020) (11), and we have now been asked to update this rapid review (update 2).

Our review has recently been updated by Public Health Wales (PHW; search up to 13 July 2021) (12), so we will use their review as a source of evidence (taking into account that they have not consistently searched for preprints and for lower level observational studies such as ecological studies and descriptive studies) and will run some searches to update their review, see more details below.

Main differences between this update (update 2) and our previous versions are that the focus of update 2 is on effectiveness, the question about efficacy of different types of face coverings will not be addressed, and ecological studies and descriptive studies will be excluded (but we will include preprints).

Table D.1 Inclusion and exclusion criteria

	Included	Excluded
Population	All populations	
Settings	All community settings, including households	Healthcare settings
Context	COVID-19 pandemic	Other infectious diseases
Intervention or exposure	All types of face covering, including (but not limited to) handmade and commercial cloth masks (cloth, cotton, gauze, etc), surgical masks and respirators	
Outcomes	• COVID-19 transmission and cases • COVID-19 outbreak Measures: • incidence of COVID-19 • prevalence of COVID-19 • attack rate and secondary attack rate • reproduction number	• deaths associated with COVID-19 • disease progression • prevalence and rates of asymptomatic, pre-symptomatic or symptomatic COVID19
Language	English	
Date of publication	• 1 January 2020 to present	
Study design	• interventional studies • observational studies (cohorts, case controls and cross-sectional studies)	• systematic or narrative reviews • guidelines • opinion pieces • modelling studies • laboratory studies • ecological studies [A] • descriptive studies
Publication type	Published and preprint	

[A] These studies are excluded, however, they will be coded at the screening stage to be drawn upon if required (for instance, if insufficient evidence)

Identification of studies

Our previous reviews on face coverings and COVID-19 will be used to identify studies published up to 22 September 2020 (search date of our last review (11)). For studies published since our last search, evidence will be identified through 3 sources:

- peer-reviewed studies published between 22 September 2020 and 13 July 2021: the PHW rapid review will be used as a source of evidence (12)
- peer-reviewed studies published since 13 July 2021 (search date of the PHW review): we will search Medline, Embase, WHO COVID-19 Research Database
- preprints published since 22 September 2020: we will search preprint servers Arxiv, bioRxiv, medRxiv, Research Square and SSRN searched via NLM COVID portfolio

Search strategy Ovid Medline

1. mask*.tw,kw.
2. (face-mask* or facemask*).tw,kw.
3. ((face or head) adj2 cover*).tw,kw.
4. (face-cover* or facecover*).tw,kw.
5. (cloth* adj2 (cover* or protect*)).tw,kw.
6. (respirator or respirators).tw,kw.
7. (mouth adj2 (cover* or protect*)).tw,kw.
8. (nose adj2 (cover* or protect*)).tw,kw.
9. Masks/
10. N95 Respirators/
11. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12. exp coronavirus/
13. exp Coronavirus Infections/
14. ((corona* or corono*) adj1 (virus* or viral* or virinae*)).ti,ab,kw.
15. (coronavirus* or coronovirus* or coronavirinae* or CoV or HCoV*).ti,ab,kw.
16. (2019-nCoV or 2019nCoV or nCoV2019 or nCoV-2019 or COVID-19 or COVID19 or CORVID-19 or CORVID19 or WN-CoV or WNCoV or HCoV-19 or HCoV19 or 2019 novel* or Ncov or n-cov or SARS-CoV-2 or SARSCoV-2 or SARSCoV2 or SARS-CoV2 or SARSCov19 or SARS-Cov19 or SARSCov-19 or SARS-Cov-19 or Ncovor or Ncorona* or Ncorono* or NcovWuhan* or NcovHubei* or NcovChina* or NcovChinese* or SARS2 or SARS-2 or SARScoronavirus2 or SARS-coronavirus-2 or SARScoronavirus 2 or SARS coronavirus2 or SARScoronovirus2 or SARS-coronovirus-2 or SARScoronovirus 2 or SARS coronovirus2).ti,ab,kw.
17. (respiratory* adj2 (symptom* or disease* or illness* or condition*) adj10 (Wuhan* or Hubei* or China* or Chinese* or Huanan*)).ti,ab,kw.
18. ((seafood market* or food market* or pneumonia*) adj10 (Wuhan* or Hubei* or China* or Chinese* or Huanan*)).ti,ab,kw.
19. ((outbreak* or wildlife* or pandemic* or epidemic*) adj1 (Wuhan* or Hubei or China* or Chinese* or Huanan*)).ti,ab,kw.
20. or/12-19
21. 11 and 20

Screening

Screening on title and abstract will be undertaken in duplicate by 2 reviewers for at least 10% of the eligible studies, with the remainder completed by one reviewer. Disagreement will be resolved by discussion.

Screening on full text will be undertaken by one reviewer and checked by a second.

Data extraction

Summary information for each study will be extracted and reported in tabular form. Information will include country, setting, study design, objective, outcomes measures, participants, study period, results and any relevant contextual data (such as timing or level of community transmission at the time of the study). This will be undertaken by one reviewer and checked by a second.

Risk of bias assessment

Risk of bias will be assessed using the quality criteria checklist (QCC) for primary research which assesses the methodological quality of a study. This tool can be applied quickly to most study designs to consider core areas of potential bias. Risk of bias will be assessed by one reviewer and checked by a second.

Synthesis

This update 2 will be presented as a brief supplement to our previous reviews. A narrative synthesis will be provided only if time allows.

Variations across populations and subgroups, for example cultural variations or differences between ethnic, social or vulnerable groups will be considered, where evidence is available.

About the UK Health Security Agency

UKHSA is responsible for protecting every member of every community from the impact of infectious diseases, chemical, biological, radiological and nuclear incidents and other health threats. We provide intellectual, scientific and operational leadership at national and local level, as well as on the global stage, to make the nation health secure.

UKHSA is an executive agency, sponsored by the Department of Health and Social Care.

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