Public Health England

Protecting and improving the nation's health

Transmission of COVID-19 in school settings and interventions to reduce transmission

A rapid review (update 2)

Contents

Main messages

The purpose of this rapid review was to identify and examine evidence on coronavirus (COVID-19) transmission within school settings and the effects of school-based interventions in reducing transmission. This review includes 56 studies (23 preprints, 3 reports): 40 observational, one semi-experimental and 15 modelling studies (search up to 1 February 2021).

1. Evidence from 39 observational studies (11 preprints, 2 reports) predominantly suggests that transmission within schools can be limited when infection prevention and control (IPC) measures are in place. However, transmission may occur, especially in area of high transmission or when inadequate IPC measures are in place. These results are mainly based on descriptive observational studies (which have no comparator group) and it was not always possible to determine transmission routes.

2. Evidence from 17 studies (12 preprints, one report), mainly modelling, suggests that implementing a combination of interventions including testing, isolation of cases and cohorting (no mixing outside classrooms and or reduced class sizes) in addition to other mitigations (physical distancing, face coverings, increased ventilation) might reduce the likelihood and size of outbreaks within schools. However modelling studies have limitations, particularly due to the uncertainty of COVID-19 transmission in children and the emergence of new variants, and the evidence was mainly not peer-reviewed.

3. Both observational evidence and results from modelling studies suggest that transmission within school settings increases with community prevalence.

4. Higher quality, peer-reviewed evidence is needed to assess whether school settings are at particular risk of COVID-19 transmission and to assess the effectiveness of school-based interventions in reducing transmission. It is also essential to closely monitor the transmission of COVID-19 within school settings, especially with the emergence of new variants of concern.

Background

Since early in the COVID-19 pandemic, school closures have been implemented globally alongside wider measures to slow the spread of COVID-19. A variety of approaches have been adopted in relation to both closing and reopening of schools: for instance, schools remained open in Sweden over the course of the pandemic for children younger than 15 years old, while in Spain schools remained closed until September 2020. A recent systematic review, still in preprint, aimed at assessing the effects of school closures on community transmission based on 10 observational studies with data from 146 countries. The results were inconsistent, with some studies showing no effect of school closures and other suggesting important reductions in community transmission (1).

In addition to the risks linked to COVID-19, the adverse effects of school closures on children, especially those with special needs and those from more deprived background, but also on teachers and parents should also be considered. The adverse effects on children include, but are not limited to, poorer educational outcomes, social isolation, impaired physical and mental health, increased risk of violence and reduced access to services such as free school meals (2 to 5).

After a phased reopening from June 2020 where schools were partially reopened for some year groups, schools reopened in full in September 2020. Schools closed again in early January 2021 due to the rise in cases and to the uncertainties associated with the appearance of the variant B.1.1.7. Schools across England have since reopened in full on 8 March 2021. This rapid review was conducted in the lead up to reopening and has been used to inform an evidence summary published by the Department for Education (DfE) on the 22 February 2021 (6).

National guidance for schools during the COVID-19 pandemic is available on the government website and is regularly updated in line with the most recent recommendations (7). It includes recommendations on infection prevention and control (IPC) measures to implement in schools, although they are not legal obligations. As a result, IPC measures vary across schools. Results from the COVID-19 Schools Infection Survey (England) showed that in December 2020 almost all primary schools implemented the 10 measures recommended by the Department for Education. Few secondary schools implemented all 15 measures recommended for these settings although 91% implemented at least 12 measures. Across both primary and secondary schools in England, hand and respiratory hygiene, enhanced cleaning and a ‘bubble’ system were among the measures most regularly implemented. There was variation in how schools implemented the bubble system (also called ‘cohorting’), with most primary schools keeping students in bubbles of normal class sizes and most secondary schools implementing bubbles of an entire year group. Maintaining physical distance between students within bubbles was the least commonly implemented measure (8). At a European level, the measures most commonly recommended were physical distancing (such as separating tables in the classroom), staggered arrival times, cancellation of indoor activities, promoting hand hygiene and respiratory etiquette, ventilation, use of face coverings (older than 12 years, or secondary schools) and disinfection of school settings. The measures least commonly recommended were closing common play areas, reduced class sizes, temperature screening and testing (9).

In considering the safe reopening of schools there is a need to consider the extent to which transmission within schools has been reported and the most effective measures for reducing transmission both among students and staff. A number of reviews have examined the evidence on these topics. A rapid review was published in September 2020 by Public Health England (PHE) on transmission within school settings and effectiveness of school based interventions (search dates up to 27 July 2020) (10). The evidence at the time was limited due to number of studies and study design, but more studies have been published since this review was conducted. A recent rapid review was published by the National Collaborating Centre for Methods and Tools in Canada (search dates up to 11 January 2021) which identified 88 publications (primary and secondary evidence) on the role of daycares and schools in COVID-19 transmission (11). However, this review did not specifically assess the effectiveness of school-based interventions. A Cochrane scoping review on school-based interventions has been conducted (12), although it reports only on number of studies and the corresponding review expected to report on outcomes of studies (that is, effects of interventions) has not yet been published.

There is an urgent need to identify and examine the most recent evidence on both the role of schools in COVID-19 transmission and to assess the effectiveness of school-based interventions. This is an update of our previous rapid review and was conducted within a limited time frame (during February 2021) to provide evidence to inform school reopening on 8 March 2021.

Objective

The purpose of this rapid review was to identify and assess evidence on the extent to which transmission of COVID-19 has occurred within school settings, and on the effectiveness of school-based interventions in reducing transmission. This is an update of a previous version (10).

Main definitions

'School settings' refers to mainstream schools and academies and includes preschool and nurseries only if they are attached to a school. It excludes boarding schools.

IPC measures are designed to prevent the harm and to reduce the risk of transmission of an infectious agent. In the context of schools and COVID-19, IPC measures are those which contribute to limit the exposure to COVID-19 amongst students, teachers and non-teaching staff within school settings (13). There was no consistency in the literature in relation to these measures, which are sometimes also referred to as 'mitigation measures' or 'non-pharmaceutical interventions' (NPI). In the following, 'IPC measures' was used to describe any measures implemented which aim to reduce the risk of COVID-19 transmission.

'Face coverings' refers to any type of face covering that covers the mouth or nose (including medical masks and other types of face covering).

Methodology

This report employed a pragmatic approach to identify primary studies on COVID-19 transmission within school settings published up to 1 February 2021:

- relevant primary studies were extracted from the previous version of this rapid review (search up to 27 July 2020) on COVID-19 transmission and interventions to reduce transmission within school settings (10)
- recent and relevant systematic or rapid reviews (11,12) were identified and used as a source for additional primary studies (reducing time required for searching and screening)
- additional primary studies were identified through routine evidence monitoring (which commenced on 12 October 2020) that consists of fortnightly searches of Ovid Medline, Ovid Embase, medRxiv and WHO COVID-19

Primary studies related to the COVID-19 pandemic, published (or available as preprint) and meeting the inclusion criteria (Table 1, Annexe A) were included. Studies reporting on the effectiveness of school closure or opening on community transmission and studies reporting on paediatric cases as a proxy for school transmission were excluded from this update due to the focus on transmission within schools rather than on the impact in the community.

Risk of bias was assessed using a quality criteria checklist (QCC) for primary research (14) and studies were given a quality rating of high, medium or low. Modelling studies were not assessed.

Full details on the methodology are provided in Annexe A, including a flow diagram representing this pragmatic approach to identifying primary studies (Figure 1) and a PRISMA diagram for the systematic search conducted for the previous version of this rapid review (Figure 2).

Evidence

Of the 22 studies included in the previous version of this rapid review (10), 8 were considered relevant and included in this update. An additional 278 studies were identified via existing reviews and routine evidence monitoring. These were assessed for eligibility, and 48 were included in this update (see Annexe A for more details on methodology).

In total, 56 studies were included in this review. Of these 56 studies, 40 were observational, one was semi-experimental and 15 were modelling studies. Twenty-six of these studies were not peer-reviewed (23 preprints and 3 reports). An additional 7 studies (15 to 21) had been originally identified as preprints but have since been published as peer-reviewed articles. The evidence identified was mainly from Europe and the United States (US).

Full details of all studies can be found in Annexe B. When available, information about community transmission at the time of the study and on IPC measures in place within school settings were extracted. Self-isolation for cases (also described as 'quarantine'), testing and contact tracing were also in place in most settings (depending on strategies in place at national or local level), although details about these were not necessarily reported in the evidence table as they were not specific to school settings.

In the following summary of results, only key studies (based on relevance, study design and setting) are discussed in detail.

Q1. What is the transmission of COVID-19 within school settings?

Thirty-nine studies (11 preprints, 2 reports) related to transmission within school settings were identified (9, 15 to 20, 22 to 53). All studies identified were observational. Full details of these studies can be found in Table 2 (Annexe B).

Evidence from previous version of this rapid review

Eight observational studies (22 to 29) were reported in the previous version of this rapid review (10). Two were retrospective cohort studies (both preprints, rated low) (24,25), one was a cross-sectional study (rated high) (28), and 5 were epidemiological investigations, of which one rated high (27), 2 medium (26,29) and 2 low (22,23).

Results of these studies suggested that COVID-19 transmission may occur within school settings for both primary and secondary school-aged children, but this was highly contextual and dependent on i) levels of community transmission, ii) extent of IPC measures in place, and iii) extent of close contact with an index case. The results were limited by the heterogeneity between studies.

New evidence

Thirty-one new observational studies were identified for this update (9,15 to 20,30 to 53); 9 were preprints (30,31,38 to 41,47,48,52) and 2 were non peer-reviewed reports (9,44). The evidence identified was mainly descriptive: prevalence and surveillance studies (which may report on infection rates or seroprevalence but cannot provide evidence on transmission routes, unless epidemiological investigation is conducted) and epidemiological investigations (which may report on transmission routes but often lack generalisability). Only 8 studies provided analytical results of relevance for this review question (15,19,20,36 to 38,41,48).

Across the studies identified, outcome measures were mainly based on virus detection (RT-PCR; mostly nasopharyngeal swabs) although 3 studies (2 of them from the same cohort) only assessed seroprevalence (the proportion of participants who were seropositive for SARS-CoV-2 antibodies) (19,31,48). With the exception of 2 studies from Asia (50,53) and 2 studies reporting on the same cohort in Australia (43,44), all studies had been conducted within the US and Europe including 4 studies from England (15,30,37,41).

The quality of the evidence was mixed, with 10 studies rated high (17,18,20,33,37,38,41 to 43,47), 10 rated low (16,31,32,35,40,46,48,50,52,53) and the 11 remaining studies rated medium. The main sources of bias were risk of selection bias and of information bias. Different sources of selection bias were identified, especially in relation to selection of participating schools (for instance, some studies only included schools who volunteered to participate) and follow-up of contacts (for instance, not all contacts identified participated to testing). Information bias was present for both determining exposure to COVID-19 (including recall bias and lack of information for when and where contact with a COVID-19 case might have happened) and outcome measurements (including difference in outcome measures and case definitions).

The evidence identified was highly heterogenous. Some studies were conducted towards the beginning of the pandemic when schools and wider communities were unlikely to have IPC measures in place, while others were conducted later on when IPC measures were in place both within schools and within the wider communities. Studies were conducted in different countries and at different timepoints in their epidemics (that is, with different levels of community transmission) which limits the generalisability of the results and or the ability to compare between studies. In addition, some studies were conducted at reduced school attendance, so it is not clear whether the results would be applicable to schools at full attendance. Finally, some studies reported on asymptomatic testing of all school contacts while others were based on symptomatic testing only.

Studies examining transmission in schools in England

Of the studies conducted in England, one was a cohort study (41) and 3 were surveillance studies (15,30,37). All 4 studies were based on national surveillance data collected between June 2020 and December 2020. Schools in the UK partly reopened in June 2020 for the Summer half-term (Years 1, 6, 10 and 12 only) and fully reopened at the beginning of September for the Autumn 2020 term. In October 2020, a system of local restrictions based on incidence rates in the community was introduced until a national lockdown was reinstated between 5 November and 2 December 2020. Schools remained opened during the Autumn term (even during lockdown), with some IPC measures in place, including physical distancing and hand washing, although reduced class sizes and cohorting was not always feasible to implement during full school attendance.

One study (preprint, rated high) (41) reporting on the sKIDS cohort (COVID-19 surveillance in school KIDs study) included data collected between June and November

2020 from 131 primary schools. In June to July 2020, weekly infection rates (RT-PCR confirmed cases per 100,000) was 3.9 (95% confidence interval [CI] 0.10 to 21.8) in students and 11.4 (95% CI 1.4 to 41.2) in staff. Seroprevalence was at its highest level in June (13.6%; 95% CI 12.3% to 15.1%) and at its lowest in November (10.4%; 95% CI 8.8% to 12.3%). Seroconversion between time points (participants newly seropositive) was 5% or less for both students and staff, and seropositivity was not associated with school attendance during lockdown (when schools were still open while community prevalence was high). The study authors concluded that infection risk was low for students and staff attending primary school during both the Summer half term (partial reopening) and the Autumn term (full opening).

One surveillance study (rated high) (37) reported that, in June-July 2020 (partial reopening; median daily attendance: 928,000 students), only 113 single cases, 9 coprimary cases (2 confirmed cases within 48h) and 55 outbreaks were recorded. The outbreaks resulted in 210 secondary cases, mainly in staff (73%). The incidence rate (per 100,000 per day) was 6.0 (95% CI 4.3 to 8.2) in primary school students, 6.8 (95% CI 2.7 to 14) in secondary school students and 27 (95% CI 23 to 32) in all staff. The number of single cases was associated with regional population density and the risk of outbreak increased by 72% (95% CI 28% to 130%) for every 5 cases per 100,000 population increase in community incidence.

Higher infection rates were reported in secondary school students compared to primary school students between July (partial reopening) and December 2020 (full reopening) (15). The results of this study (rated medium) also suggest that school return after half-term holidays in October 2020 was associated with a continuing increase in infection rates across all school settings while trends in infection rates in adults remained unchanged. Infection rates in children then decreased following the national lockdown on 5 November 2020 (one week after the decrease in adult rates) but increased again in both adults and children in December 2020 following the appearance of the new variant B.1.1.7. Regional infection rates between adults and children were strongly correlated both in periods of low and high community incidence.

Another surveillance study examined school outbreaks (defined as 2 or more laboratory-confirmed cases in a school within a 14 day period) between August and October 2020 (preprint, rated medium) (30). Most outbreaks included both staff and students, although attack rates were higher in staff than in students. Among students, attack rates were higher in secondary schools than in primary schools. In terms of outbreak sizes, between 2 and 35 cases were recorded in primary school outbreaks, compared to up to 100 in secondary schools.

Overall, these studies from England suggest that infection rates in students and in school staff follow the same trajectories as infection rates in the community, suggesting that school settings might not be associated with an increased risk of transmission. Infection rates and attack rates following an outbreak tended to be higher in secondary school-age children than in primary school-age children, and higher in staff than in children.

International studies examining SARS-CoV-2 infections and outbreaks in school settings

A cohort study from Austria (rated high) with 10,734 participants from primary and secondary schools (IPC measures in place included cohorting, physical distancing, increased ventilation and face coverings in communal areas and or if physical distancing not possible) reported an increase in infection prevalence from 0.39% in September to October 2020 to 1.39% in November 2020 (20). Infection prevalence was significantly associated with the 7-day regional incidence ($p<0.001$) and with the social deprivation index ($p=0.003$) but not with age or sex.

A case control study conducted in the US between September and November 2020 compared possible exposure to COVID-19 between 154 children with a positive RT-PCR result (‘cases’) and a control group comprised of 243 children with a negative RT-PCR result (adjusted for sex, age group and ethnicity) (36). IPC measures were reported to be in place and face coverings were recommended for students and staff. Close contact with a COVID-19 case was significantly more likely to be a family member ($p=0.02$) and significantly less likely to be a classmate ($p=0.04$) for cases than for controls. Cases were significantly more likely than controls to have had attended different types of social gatherings (‘community exposure’) while school exposure was not significantly associated with cases. This study rated medium, in part due to the risk of information bias for exposure measurement as the interviews of cases and controls were conducted on average 32 days after testing.

In their cross-sectional analysis (preprint; rated high) of a cohort conducted in Berlin in November 2020, Theuring and others reported that positive cases had been identified in 8 out of 24 classes, with one or 2 cases per class. IPC measures in places included hand hygiene, ventilation, face coverings required for students and staff outside the classroom but not necessarily inside (38). No significant association was found for socioeconomic strata, mode of transport to school or contacts (within versus outside school). After one week no secondary cases had been identified within the schools, suggesting that introduction of positive cases within school settings does not necessarily result in onward transmission.

Other studies reporting on SARS-CoV-2 infections and outbreaks were descriptive observational studies (see Table 2 for more detail) (9,16 to 18,32 to 35,39,40,42 to 47,49 to 53). Their results, in line with the studies described above, suggest that while positive cases can be detected among students and staff this does not necessarily result in onward transmission or outbreaks within schools. Although it was not always possible to determine the route of transmission (9,33,42,47), results of studies that aimed to assess transmission routes suggest that transmission was more likely to have happened outside of school settings (most notably within households) than within schools (33,35,47,50). In addition, results of epidemiological investigations suggest that when outbreaks did happen in schools, inadequate IPC measures were in place (40,45,51).

When there were cases and or outbreaks within schools, both students and staff were usually affected. Within the studies that compared attack rates or incidence rates between staff and students, the majority suggested higher rates in staff than in students (18,32,35,40,43,45). Among students, secondary school students were in most cases more affected than primary school children (in terms of number of cases and size of outbreaks).

Overall, these results suggest that COVID-19 transmission within school settings is likely to be limited but that transmission may occur, especially when inadequate IPC measures are in place.

Studies examining seroprevalence in school settings

Some studies have measured seroprevalence (proportion of participants seropositive to SARS-CoV-2 antibodies) in students and school staff to identify possible outbreaks and to assess whether schools were driving transmission by comparing seroprevalence in school settings with seroprevalence in the community. The use of these studies in understanding school transmission is limited as they do not necessarily allow an assessment of when and where transmission occurred.

Two studies reporting on the same cohort in Switzerland (2,831 students from 55 schools) showed seroprevalence levels ranging from 2.8% in June to July 2020 (round one) to 7.8% in October/November 2020 (round 2) (19,48). In the study reporting on round one, seroprevalence in students was similar to seroprevalence in adults in the same region (adjusted for age group and sex) (48). Seroconversion between June and October to November 2020 was of 4.5% (19).

A surveillance study from Germany reported seropositivity values ranging from 0.6% in June 2020 to 0.7% in October 2020 (2,045 participants from 13 schools; Saxony) (31) while results from a smaller cohort in Berlin (less than 400 students from 24 schools) suggest that seroprevalence increased from 1.3% in June to 2.0% in November 2020 (17,38). These levels of seroprevalence are lower than those observed in the English study described above where up to 10.4% of students were seropositive in June 2020 (41).

Seroprevalence and seroconversion varies by geographic location and tend to reflect community rates (19,41,48).

Variations across populations and subgroups

The evidence identified shows variations in incidence rates and in risk of transmission within school settings by geographic location. The results suggested that these variations are most likely due to variation in community prevalence, although other factors such as deprivation cannot be ruled out.

Results from a cohort study in Austria showed that odd ratios for COVID-19 infection were significantly higher for students in schools in area of high or very high social deprivation compared to those of low or moderate social deprivation (20). Results from a smaller cohort in Germany also suggested that infection rates were higher in classes located in lower socio-economic areas, however the differences were not statistically significant (38). Two of the studies identified were conducted in private school settings in the US (35,46). In one of the studies, infection rates in the private school were lower than in the state schools in the same area (46). The private school had strict IPC measures in place (including testing and the use of plastic barriers around students and teachers desks) but the measures in the state schools were not reported. In the second study, the private schools remained open while the state schools were closed (35). These results suggest inequalities between students in state schools compared to private schools, both in terms of infection rates and continued access to in-person education and social contact.

In England, students and staff of non-White ethnicity were more likely to be seropositive than those of White ethnicity (41). However, it is not possible to determine whether risk of transmission within school settings was higher for students and staff of non-White ethnicity, or whether these differences reflect the differences of COVID-19 risk between ethnic groups in the wider community (54).

These results suggest that there might be inequalities for risk of COVID-19 transmission within school settings, especially between private and state schools in the US. However, the focus of this review was on the transmission of COVID-19 within school settings and the search strategy did not include terms related to inequalities so this may not be reflected in a wide body of evidence.

Main findings

The evidence identified (mainly descriptive observational studies) suggests that, overall, COVID-19 infection rates in students and school staffs tend to follow the trend of infection rates in the community and that introduction of cases within school settings does not necessarily result in onward transmission. While transmission within school settings can be limited when mitigation measures are in place, transmission may occur, especially when inadequate IPC measures are in place or and in area of high transmission. Evidence from England suggests that the risk of outbreaks within school settings increases with community prevalence.

Q2. What is the effectiveness of interventions to reduce the transmission of COVID-19 within school settings?

Seventeen studies (12 preprints, one report) providing evidence on the effectiveness of school-based interventions to reduce transmission within schools were identified, of which 15 were modelling studies. Risk of bias was not assessed in modelling studies. Full details of these studies can be found in Table 3 (Annexe B).

Evidence from modelling studies

Fifteen modelling studies provided evidence on effectiveness of school-based interventions to reduce COVID-19 transmission within school settings (21,55 to 68), although only 2 had been peer-reviewed (21,55). One was a non-peer-reviewed report (61), and the 12 remaining studies were preprints. Most of the studies were conducted in North American or European settings, including 2 from the UK. The models more commonly used were agent-based models, using different assumptions and calibrated with different databases. There was also important heterogeneity between studies in relation to settings and scenarios implemented. There were also differences in terminology and definitions of interventions. For instance, some studies used the term 'cohorting' as a general term that encompasses different strategies to reduce class sizes, sometimes on different schedules (including alternative days for in-person teaching), while other used 'cohorting' only for strategies to reduce contacts outside of the class group. Self-isolation protocols (for individuals or for a whole class) were usually referred to as 'quarantine'.

Ten out of the 15 modelling studies assessed the effectiveness of a mix of interventions (57 to 61,63 to 66), such as reduced class size (including rota between in-person and remote instruction) combined with different testing strategies, non-pharmaceutical interventions (mainly face coverings, physical distancing and hand washing) and staff vaccination. The remaining studies focused on attendance level and or cohorting strategies (21,56,62), testing and or self-isolation strategies (55,67) and ventilation (68).

Overall, each individual intervention contributed to a reduction of COVID-19 within school settings although to varying degrees. Direct comparison of effectiveness between interventions was not possible due to the heterogeneity between studies, although based on this body of evidence, regular testing appears to be one of the most effective strategies. For instance, results of a study suggested that weekly testing was more effective in reducing secondary transmission than teacher vaccination or full class isolation as a result of a positive case (58). Another study suggested that 100% testing on the first week day (with isolation of cases and daily symptom screening), could reduce transmission by approximately 70% compared to not testing or no symptom screening (57).

Reducing class size also resulted in reduced school transmission compared with full class attendance and, among the different strategies, one of the most effective was a rota-system of alternative in-person and remote teaching (2 days or one week rotas) (21,58,62 to 64).

One study assessed the role of ventilation in reducing risk of airborne transmission within a classroom, suggesting that shorter but more frequent full window opening was more efficient to reduce airborne transmission than longer but less frequent ventilation (68).

Face coverings and physical distancing were generally considered as part of a package of non-pharmaceutical measures in combination with other interventions, so it was not possible to assess the effectiveness of these measures individually. While face coverings and physical distancing within school can help reducing transmission when implemented in addition to the measures previously mentioned (55) they are unlikely to be enough to control transmission within schools if implemented alone (65,66), except if community transmission is very low (61).

There is consistent evidence that combinations of interventions are required to achieve low transmission within school settings. In particular combinations of testing, isolation of cases and cohorting or reduced class size are effective in reducing school transmission (63,64). For instance, a study showed that when all year groups were attending school for in-person learning, combining NPI measures (face coverings, physical distancing and hand washing), cohorting (minimal contact outside classrooms) and testing would result in almost a 5-fold reduction in infection rates (60). Adding alternative rota to these measures had only a small impact on infection rates; further reduction of infection rate was achieved only when some year groups (middle and high schools) were fully moved to remote instruction (60). Another study suggested that alternative rota combined with strict mitigation measures (face coverings, no mixing outside classrooms, 2 meters between desks, and so on) could nearly eliminate transmission within school settings (61).

The modelling studies also suggest that there is a trade-off between the use of different measures (58,63,65). For instance, if reduced class size could not be implemented, it would be even more important to implement regular testing programmes with strict mitigations measures (including face coverings, physical distancing, hand hygiene and ventilation) (63). Rapid turnaround of test results appear as an important factor to control transmission (67) and even tests with low sensitivity could help reducing transmission if they provide rapid results (63). Fast turnaround is especially important if no other measures are in place, while turnaround time might not have a measurable impact if schools are operating in alternative rota (61).

Overall, the risk of outbreaks (number and size) is higher in high schools than in primary schools (58,61,64). Stricter measures are therefore needed in high schools than in primary schools to control transmission (64). These results are based on the assumptions that out-of-school contacts are higher in high school students than in primary school students, and that younger children are less susceptible to SARS-CoV-2 than teenagers and therefore would likely be impacted if new strains with different susceptibility in children were to emerge.

In line with the results reported for question one, community transmission appears to be an important factor for school transmission so stricter measures are needed when community transmission is high (56,58,61,64). Similarly, more aggressive control measures would be needed to mitigate the effects of more transmissible strains (64).

While all modelling studies are limited by the validity of their assumptions, this is a particular limitation in the context of COVID-19 as they are derived from emerging (and sometimes uncertain) evidence, including in relation to students behaviour and to the virus itself. Further limitations of modelling studies are that they do not always consider real-life settings and or simulate ideal scenarios. For instance, some studies modelled ideal testing programme with 100% sensitivity and real-time results. Another limitation of this body of evidence is the high number of preprints.

Evidence from semi-experimental and observational studies

Two non-modelling studies were identified (69,70). The outcomes of these 2 studies were not risk of transmission or infection rates but aerosol concentration (69) and number of contacts (70), which can be considered as indicators of risk of transmission. Full details of these studies can be found in Table 4 (Annexe B).

Curtius and others (rated low for quality) conducted a semi-experimental study in Germany to examine the role of air purifiers in reducing the aerosol concentration of classroom. Mobile air purified with HEPA filters (regular household models) were placed in a classroom while classes were held and aerosol concentration was measured (69). The results suggested that the air purifiers reduced the concentration of particles in the air for all particle sizes compared to a classroom without air purifiers. Based on theoretical calculations, this would correspond to a 6-fold reduction in virus potentially inhaled by a susceptible person present in the room for 2 hours. However, these results might have been overestimated due to differences between the two classrooms (for example number of classes held, set up of the classroom, and so on).

The second study (rated medium for quality) used a mixed method approach to quantify changes in contact patterns in primary schools when schools reopened in June 2020 (with mitigation measures in place) (70). Based on data provided by 27 teachers across England it was estimated that, compared to before lockdown, daily contacts in primary school students had been reduced by 53% to 62%, and by more than 60% between staff (up to 80% between teachers and non-teaching staff). The most common measures in place were reduced class size (less than 15 students in 90% of responses), physical distancing with visual indicators (76%) and staggered break times and school start times (50%). The results of this study do not allow for an assessment of the effectiveness of each measure independently and don't report on transmission, but it would be expected that reducing the amount of contacts would reduce the potential for COVID-19 transmission. This study was conducted when schools were partially opened (Years 1, 6, 10 and 12 only) and it is unclear how these results would be generalisable or feasible to implement with full school opening.

In addition, 2 of the studies included for question one provided observational evidence on effects of school-based interventions to reduce infection risk. In their case-control study (rated medium for quality), Hobbs and others found that cases were significantly less likely to report face coverings use by staff and students at school (64% versus 76%, OR 0.4, 95% CI 0.2 to 0.8) (36). Similarly, Theuring and others (preprint, rated high for quality) reported an association between face coverings use and infection prevalence (OR 11.4; 95% CI 2.3 to 59.6); although the wide confidence intervals reflect the uncertainties of this result, among other reasons due to the small number of cases (38).

A number of studies about feasibility of testing, and especially of self-collecting non-nasopharyngeal samples (such as anterior nares, saliva or anal) were identified (18,71 to

73), but did not meet the inclusion criteria for question 2 as they did not report on the effectiveness of these testing strategies to reduce transmission within school settings.

Main findings

The evidence on effectiveness of interventions to reduce COVID-19 transmission in school is mainly based on non-peer reviewed modelling studies. The studies suggest that implementing a combination of interventions including testing, isolation of cases and cohorting (no mixing outside classrooms and or reduce class sizes) in addition to other mitigations measures (physical distancing, face coverings, increased ventilation) are likely to reduce the likelihood and size of outbreaks within schools. However mathematical modelling has limitations, particularly due to the uncertainty of COVID-19 transmission in children and to the emergence of new variants.

Limitations

The approach implemented to identify studies does not constitute a systematic search and some relevant studies might have been missed. However, the combination of approaches used to identify studies (searches of recent relevant systematic and rapid reviews supplemented by searches of databases and consultation with topic experts) reduces the likelihood that relevant studies have been missed. 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.

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

Overall, the studies identified for question 1 are limited by their design as they were mainly descriptive observational studies, although many of the studies were relatively well conducted, with 25 out of 39 studies scoring medium or high for quality. The evidence for question 1 is also limited by the difficulties in identifying transmission routes when community transmission is high as only robust investigations allow to draw conclusions on whether onward transmission happened within school settings. Therefore, the results from studies reporting on infection rates or on seroprevalence might simply be reflecting the current situation in the community rather than providing evidence specifically on transmission within schools.

The studies identified for question 2 were mainly modelling studies, which are also limited by their design (assumptions, ideal scenarios not always taking into account real-life settings, and so on) and by the fact that the models are based on emerging evidence with important uncertainties.

For both questions, there was important heterogeneity between studies and generalisability of findings was often unclear (such as for studies conducted with limited school attendance). It should also be noted that studies conducted in the COVID-19 context are conducted at pace with the aim to provide evidence in a timely manner, but that it sometimes impacts on the quality of the studies, both in term of design (for example design not always clear or not specified by the authors, outcome measure not adequate for the objective of the study) and reporting (for example not always enough details provided, no clear methods).

While the evidence included in this review now spans just over a year, the evidence remains limited to mainly descriptive observational studies and modelling studies. It is nonetheless stronger than in our previous review given that there are more studies.

This body of evidence is also limited by the lack of peer-reviewed evidence as, out of the 56 included studies, 26 were not peer-reviewed (23 preprints and 3 reports). Preprints should be considered with caution as they have not been peer reviewed, nor subject to publishing standards and may be subject to change.

Conclusions

The evidence identified suggests that, overall, transmission within school settings can be limited when IPC measures are in place. However, transmission may occur, especially in areas of high transmission or when inadequate measures are in place. This is mainly based on descriptive observational studies which are limited by their design and are at risk of certain biases.

The evidence on effectiveness of school-based interventions is mainly based on non-peer reviewed modelling studies that suggest that implementing a combination of interventions based on testing, isolation of cases and cohorting (no mixing outside classrooms and or reduce class sizes) in addition to other mitigation measures (physical distancing, face coverings, increased ventilation) are likely to reduce the likelihood and size of outbreaks within schools. However mathematical modelling has limitations, particularly due to the uncertainty of COVID-19 transmission in children and to the emergence of new variants.

Observational evidence and results from modelling studies suggest that transmission within school settings increase with community prevalence.

Despite the high number of studies identified, the evidence remains limited to mainly descriptive observational studies and modelling studies. Higher quality, peer-reviewed evidence is needed to assess the transmission of COVID-19 and to assess the effectiveness of school-based interventions to reduce transmission in schools. It is also essential to closely monitor the transmission of COVID-19 within school settings, especially in the context of the emergence of new variants of concern.

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Disclaimer

PHE'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.

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Annexe A. Methods

This report aimed to address the review questions:

Q1. What is the transmission of COVID-19 within school settings?

Q2. What is the effectiveness of interventions to reduce the transmission of COVID-19 within school settings?

This is an update of our rapid review on COVID-19 transmission within school settings for which 2 versions have already been published (10,74). The update is based on the protocol developed for these previous versions, except for the search strategy and the quality assessment (more details about how it deviated and why is provided below). Screening and data extraction were performed based on our standard procedure, as per protocol.

Search strategy

Systematic literature searches were conducted for the previous versions of this review: up to 18 June 2020 for the original version (74) and up to 27 July 2020 for the update 1 (10). For this version (update 2), a pragmatic approach was implemented to identify primary evidence published since the previous version, based on 2 strategies designed to capture the full breadth of available evidence:

- **search updates**: primary studies published between 12 October 2020 and **1 February 2021** were identified through a monitoring protocol implemented that consists of fortnightly searches of Ovid Medline, Ovid Embase, medRxiv and WHO COVID-19
- **searching of reference lists**: relevant systematic (or rapid) reviews with search dates covering at least the period 27 July 2020 and 12 October 2020 were identified, and their reference lists searched to identify primary studies published between

In both cases, primary studies (peer-reviewed and preprints) were screened on full text and included if they met the inclusion criteria summarised in Table 1 below.

More detail about these strategies is provided below, with Figure 1 illustrating this process. The PRISMA diagram of the previous versions of this rapid review is provided in Figure 2.

1. Search updates

The evidence on schools and COVID-19 has been monitored since mid-October using a semi-automatic process. While this does not constitute a systematic search, it is a pragmatic approach we have implemented to monitor the evidence and update existing reviews in a timely manner.

Updates are conducted every 2 weeks and involve a search of Ovid Medline, Ovid Embase, medRxiv and WHO COVID-19. All records on COVID-19 are downloaded into a Smart Groups Endnote library (see search strategy for Ovid Medline in Box 1). This library contains Smart Groups with basic search strategies behind them, so when citations are imported it automatically moves those that match the search term 'school' into the appropriate Group.

The results are first screened by an Information Scientist based on title and abstract. The relevant citations are then exported to an Excel spreadsheet and screened by a reviewer on full text.

The search updates considered for this report cover papers published between 12 October 2020 to 1 February 2021. 167 records were screened on full text, of which 27 were included.

2. Searching of reference lists

To identify primary studies published between 27 July 2020 (cut-off date of our previous rapid review) and the 12 October 2020 (start of our search updates) we searched reference lists of relevant systematic reviews with search dates at least up to October 2020.

Systematic or rapid reviews were identified through a scoping search completed on 3 February 2021. Sources searched: COVID-19 review repositories, Lit-Covid, medRxiv, a spreadsheet of reviews compiled from Medline/Embase (using the pragmatic approach for search updates outlined above) and Google.

Two systematic reviews relevant to our review questions were identified:

- one rapid scoping review by Krishnaratne and others (Cochrane); search date up to 8 October 2020; 42 primary studies included (12)
- one living rapid review by the National Collaborating Centre for Methods and Tools; search date up to 11 January 2021; 66 primary studies included (11)

The 108 primary studies included in these 2 reviews were screened, of which 18 were included.

The reference lists of 2 additional systematic reviews (1,75) on schools and COVID-19 were also searched for completeness, but no unique studies were identified.

Three additional primary studies were identified through consultation with topic experts from PHE.

3. Evidence from previous versions of this rapid review

Two versions of this rapid review have already been completed: the original review included studies published up to 18 June 2020 and the update 1 up to 27 July 2020 (10,74). The review questions were the same for the 3 versions of the review. However, due to the lack of evidence available for question 2 when the 2 first versions were completed, evidence reporting on community transmission and on paediatric cases (rather than direct evidence on transmission within school settings) had been included. As evidence on transmission within school settings is now available for question 2, the 12 studies reporting on community transmission and on paediatric cases as a proxy for school transmission have been excluded from this update.

Therefore, only the 10 studies included for question 1 in the last version were considered for this update. Of these 10 studies, one was a report from the National Centre for Immunisation Research and Surveillance (NCIRS) COVID-19 in school settings in New South Wales (NSW), Australia. The results from this report have now been published as a peer-reviewed article which had been identified for this update (43). Similarly, a preprint by Armann and others that reported on data from May to June 2020, was included in the previous version of this review. A more recent version of the preprint study (with data up to October 2020) was identified for this update (31). In both cases, the 2 updated studies were considered as new evidence and the previous versions removed from the list of evidence from our previous review.

As a result, 8 studies from the previous version were included in this update.

This process is illustrated in Figure 2.

Inclusion and exclusion criteria

Article eligibility criteria are summarised in Table 1.

Table 1. Inclusion and exclusion criteria

	Included	Excluded
Population	• children aged 4 to 18 years • teachers, teaching assistants, school nurses, early years practitioners working in a school-attached service and other school settings workforce	• children aged 0 to 3 years • pupils aged 19 years or older • early years practitioners working outside school settings
Settings	Schools; defined as: • mainstream provision • day attendance • primary • secondary • reception, preschool and nurseries that are attached to a school • sixth form college • state and private funded day-attendance schools	• boarding schools • special schools • child minders, nannies and other home-based childcare • out of school settings for school age children for example youth groups • universities and colleges
Context	COVID-19 pandemic	Other diseases
Intervention / exposure	• school attendance • impact of infection prevention and control measures, including	

	Included	Excluded
	physical distancing measures, testing, reduced attendance, and so on	
Outcomes	• SARS-CoV-2 infection rate in students and staff • transmission of COVID-19 within school settings • COVID-19 outbreaks in schools	
Language	English	
Date of publication	1 January 2020 to 1 February 2021	
Study design	• experimental or observational studies • case series, case reports and outbreak investigations • modelling studies (Q2)	• systematic reviews • guidelines • opinion pieces
Publication type	Published and preprint	

Data extraction and quality assessment

Data extraction was done by one reviewer and checked by a second. Due to the limited time frame and the high number of studies identified for question 1, only main information was extracted (in a simplified template). For question 2, data extraction was performed using our usual template.

Each study was assessed for risk of bias using the Academy of Nutrition and Dietetics quality criteria checklist (QCC) for primary research (14). This tool, not specific to nutrition, can be applied to most study designs (observational and experimental), and is therefore suitable for rapid reviews of mixed type of evidence. It is composed of 10 validity questions based on the quality criteria and domains identified by the Agency for Healthcare Research and Quality (AHRQ) (76). In the QCC tool, 4 questions are considered critical (on selection bias, group comparability/confounding, interventions/exposure and outcome). A study will be rated 'high' if the answers to the 4 critical questions is 'yes' (and at least one additional 'yes'). The study will be rated as 'low' if 2 or more of the critical questions are answered 'no' and or if 50% or more of the remaining questions are answered 'no'. Otherwise, the study will be rated 'medium'. Judgments were made on case by case for questions answered as 'unclear' (some studies were downgraded to 'low' for having many 'unclear'; other studies were rated as 'high; even if one critical question responded as 'unclear' if all other questions were 'yes').

Risk of bias assessment was done by 2 reviewers but only partially in duplicate (40% of the studies were assessed in duplicate; disagreements were resolved by discussion). QCC rating included in data extraction tables, detail of assessment available on request. Modelling studies were not assessed.

A formal grading of evidence was not undertaken.

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

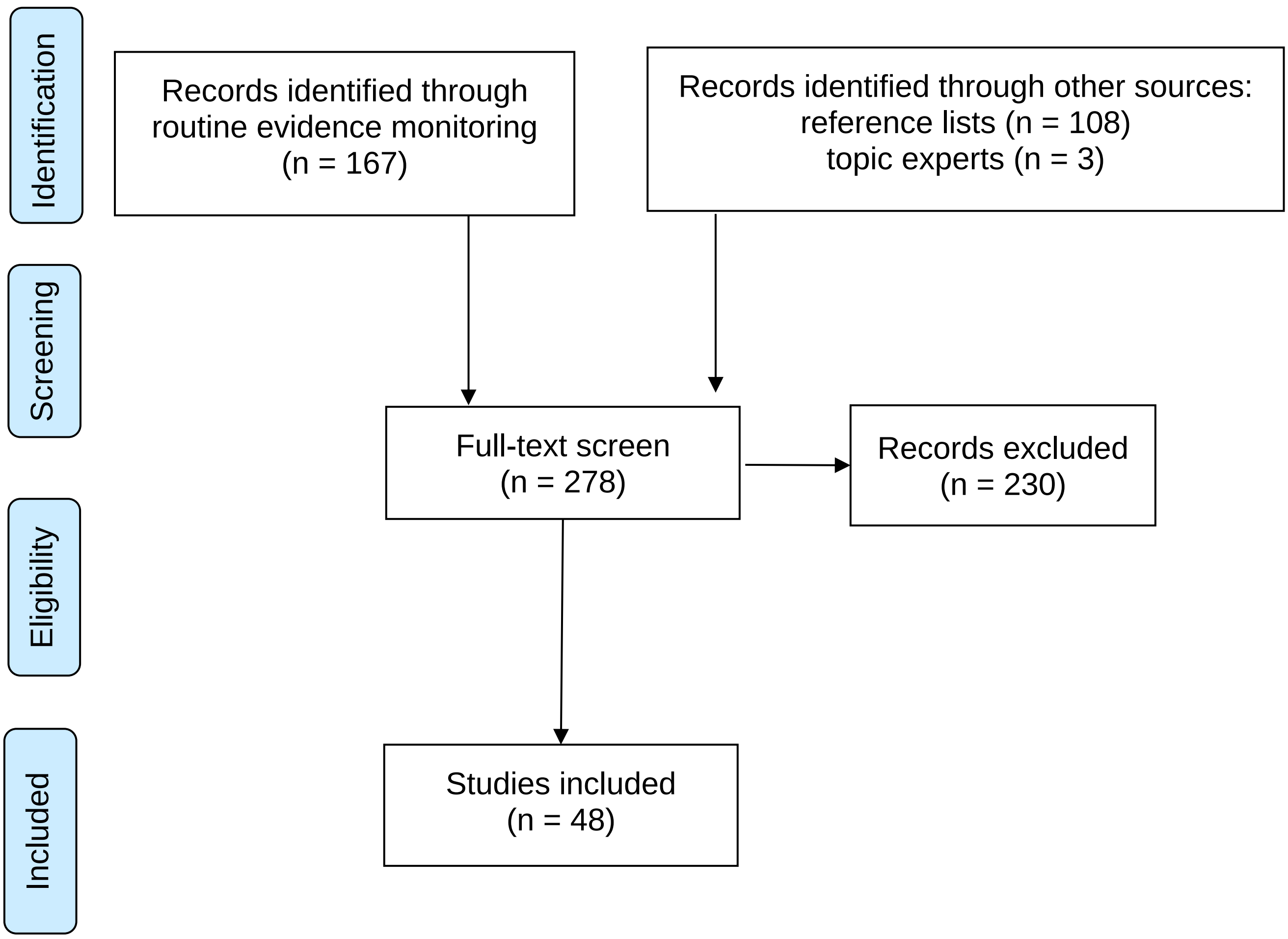

Figure 1. Flow chart diagram for update 2 searches (27 July 2020 to 1 February 2021)

Accessible text version of figure 1

A PRISMA diagram showing the flow of studies through this review, including n=278 studies identified through routine evidence monitoring, reference lists and topic experts.

Of n=278 records screened, n=230 were excluded, leaving n=48 papers included.

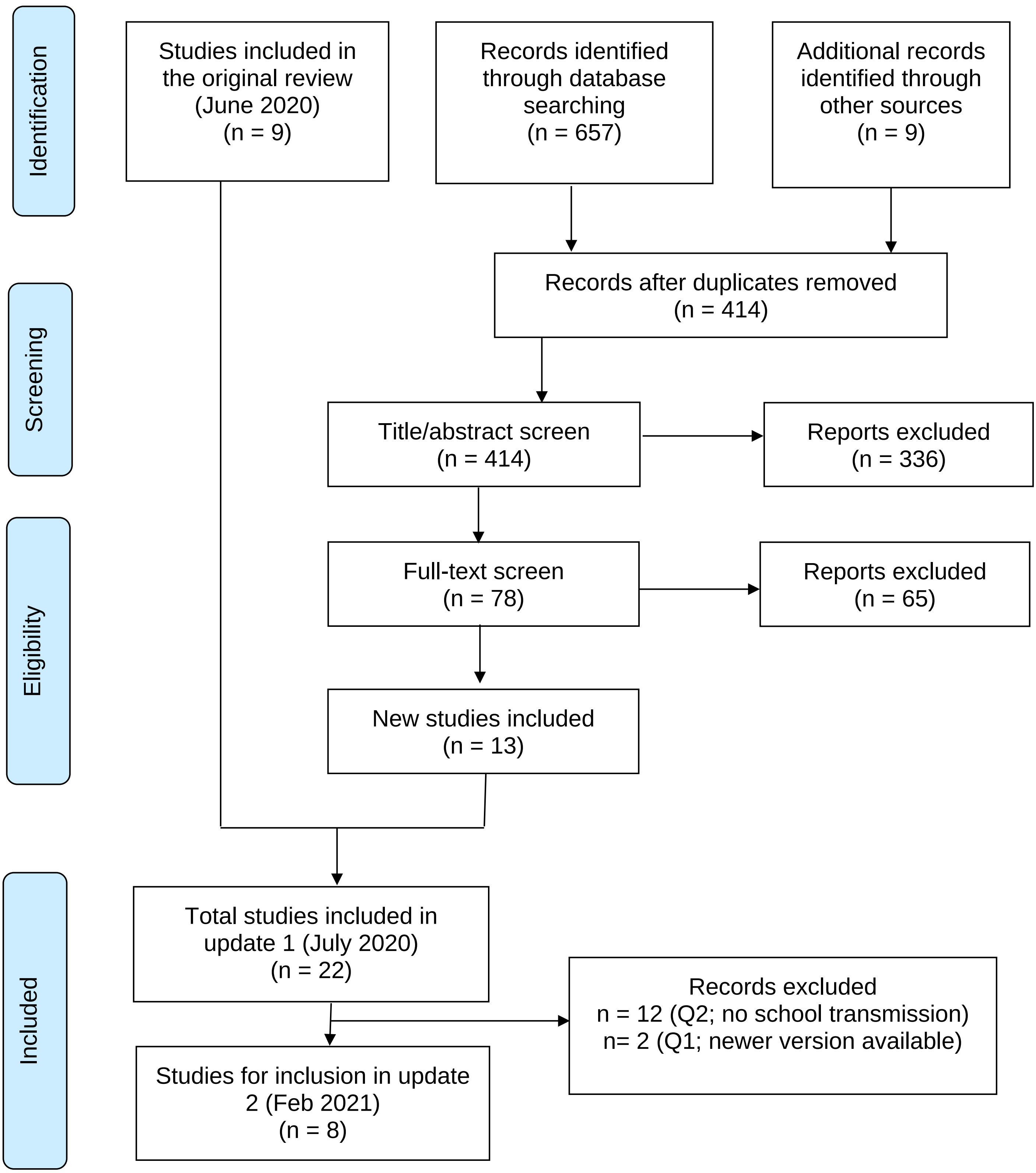

Figure 2. PRISMA diagram for the original review and the update 1 searches (1 January to 27 July 2020)

Accessible text version of figure 2

A PRISMA diagram showing the flow of studies through this review, including n=666 studies identified through database searching, and other sources.

From these, records removed before screening were:

Duplicate records removed (n=252)

n=414 records screened of which n=336 were excluded, leaving n=78 papers sought for retrieval.

n=65 papers were excluded, leaving n=13 papers included.

In total 22 studies were included in update 1 (the 13 studies included and 9 studies included in the original review [June 2020]).

Fourteen records were excluded leaving 8 studies included in update 2 (February 2021).

Box 1. Search strategy Ovid Medline

1. exp coronavirus/
2. exp Coronavirus Infections/
3. ((corona* or corono*) adj1 (virus* or viral* or virinae*)).ti,ab,kw.
4. (coronavirus* or coronovirus* or coronavirinae* or CoV or HCoV*).ti,ab,kw.
5. covid*.nm.
6. (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.
7. (respiratory* adj2 (symptom* or disease* or illness* or condition*) adj10 (Wuhan* or Hubei* or China* or Chinese* or Huanan*)).ti,ab,kw.
8. ((seafood market* or food market* or pneumonia*) adj10 (Wuhan* or Hubei* or China* or Chinese* or Huanan*)).ti,ab,kw.
9. ((outbreak* or wildlife* or pandemic* or epidemic*) adj1 (Wuhan* or Hubei or China* or Chinese* or Huanan*)).ti,ab,kw.
10. or/1-9

Annexe B. Data extraction

Table 2. Observational studies (question 1)

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
New evidence				
Aiano and others (30) PREPRINT (v2; 5 February 2021) QCC rating: medium	England 31 August to 18 October 2020 Community transmission at the time of the study not reported	Surveillance study Outbreaks identified through an online database; corresponding schools contacted for online questionnaire Purposive sampling strategy used to get national geographical representation Outbreak defined as 2 or more laboratory-confirmed cases in a school within 14 days	969 school outbreaks identified (450 primary, 3% of all primary schools; and 519 secondary, 15% of all secondary schools). 369 of these schools were contacted, of which 190 geographically representative schools completed the survey: 100 primary, 79 secondary and 11 combined. Schools were fully open. IPC measures: physical distancing, hand washing, cleaning of	- 2,425 cases reported in the 190 included schools - 59% of cases in primary and 27% in secondary schools were staff - most outbreaks included both staff and students - secondary school student attack rate (AR) (AR 1.20%; 95% Confidence Intervals (CI) 1.13% to 1.28%) significantly higher than in primary school student (AR 0.84%; 95% CI 0.75% to 0.94%) - AR in staff (4.85%; 95% CI 4.55% to 5.17%) higher than in students (1.08%; 95% CI 1.02% to 1.13%) - AR in teaching staff (5.76%; 95% CI 5.35% to 6.19%) higher than in nonteaching staff (3.31%; 95% CI 2.91% to 3.76%) - outbreak sizes: • primary schools: 2 to 35 cases • secondary schools: 2 to 100 cases - index cases: • teachers: 41% (77 of 190) • students: 46% (87 of 190) • non-teaching staff: 8% (16 of 190) - teacher more likely to be index case in primary (48%) than in secondary schools (32%) (p=0.027) - source of infection unknown for majority of cases

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
			classrooms. Masks advised outside classroom for students and staff in secondary schools. Primary schools could decide if adults should wear masks	
Armann and others (31) PREPRINT (v4; 29 November 2020) QCC rating: low	Saxony, Germany May/June (T1) and September to October (T2) 2020 Community transmission: 139 to 245 per 100,000	Seroprevalence study (the SchoolCoviDD19) Students and teachers from grades 8 to 11 in 13 secondary schools Seroprevalence (blood sample) at T1 and T2	1,538 students and 507 teachers enrolled T1: 1,538 students and 503 teachers T2: 1,334 students and 445 teachers IPC measures not reported	- seroprevalence: • T1: 0.6% (12/2045) 11 students, 1 teacher • T2: 0.7% (12/1779) 11 students and 1 teacher - seropositive individuals from 7 of 13 schools, with a maximum of 4 seropositive participants in one school - seroprevalence in individual schools ranged from 0 to 2.2%
Brandal and others (32) QCC rating: low	Oslo or Viken county, Norway August to November 2020 14-day incidence increasing: 19.3 to 94.9 cases per 100,000	Epidemiological investigation Index cases defined as PCR-confirmed, who had attended school before symptom onset/testing	13 index cases in primary schools (8 aged 5 to 10 years, 5 aged 11 to 13 years) IPC measures: strengthened hygiene, distancing, masks not recommended	- 13 index cases identified; 292 in-school contacts participated: • 234 students, of which 2 (0.9%) tested positive • 58 staff, of which 1 (1.7%) tested positive

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
		Possible in-school secondary cases identified through contact tracing and tested twice during quarantine (self-collected saliva sample, PCR)		
Buonsenso and others (16) QCC rating: low	Italy 14 September to 5 October 2020 2,000 new cases per day; increase in ICU admission and deaths	Prevalence study Analysis of an online database (daily input of cases in students based on media and institution reports) Note: high risk of bias for selection and for outcome classification as based on media report	All schools (n=65,104), including nurseries IPC measures: reduced class size (if not possible, ensure more than one metre between students), hand washing, face masks and class quarantined if confirmed case	- 1,350 cases reported (1,059 in students, 145 in teachers and 146 in other staff) in 1,212 schools (1.8% of Italian schools) - distribution of student cases: • 17.5% nursery/kindergarten • 22.2% elementary schools • 15.4% middle schools • 33.5% high schools • (rest: peer institutions or not available) - in more than 90% of the reported cases, only one case per school. A cluster with more than 10 cases was reported only in one high school - 192 schools were closed due to one or more cases
Buonsenso and others (51) QCC rating: medium	Italy September 2020 Community transmission at the time not reported	Epidemiological investigation following attendance of a 16 year old high school student at the paediatric emergency department of the local hospital.	A class of 26 students (16 years old, classmates of confirmed case)	- 9 positive cases out of the 26 students. - epidemiological investigation: • windows open but no ventilation system • less than one metre between desks (full class size) • no hand sanitizers in the class • students wore face masks in class (except for lunch break, that was taken at their desks)

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
Dub and others, 2020 (52) PREPRINT (v1; 30 July 2020) QCC rating: low	Helsinki, Finland March to June 2020 Community transmission at the time not reported	Epidemiological investigations of 2 cases in 2 different schools	Incident A: One 12 year-old index case, 121 contacts: 10 adults and 111 children. 74% participation Incident B: one middle-aged staff index, 63 contacts: 52 pupils, 11 staff. 81% participation IPC measures not described	- incident A: no contacts tested positive (nasopharyngeal and serum tests) - incident B (only serum testing): seroprevalence in contacts:14% in students, 11% in staff
ECDC (9) Technical report, not peer-reviewed QCC rating: medium	European Union Autumn 2020 term	Surveillance data from The European Surveillance System (TESSy) and online survey sent to all member states and the UK in November 2020 about COVID-19 cases in educational settings	17 countries responded to the survey All school settings largely opened during the study period, with IPC measures in place, addressing physical distancing, hygiene and safety (vary by countries)	- 12 of the 17 countries reported cluster outbreaks in school (more than 2 cases with epidemiological link) - one to more than 400 clusters reported per country - usually less than 10 cases per cluster, could be more than 80 - 11 of the 12 countries reported teachers included in clusters - by educational settings: total number of clusters reported; median number clusters/country; min-max number cases/cluster: • secondary schools: 1185; 37; 2 to 88 • primary school: 739; 36; 2 to 101 • preschools: 283; 8; 2 to 150

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
Ehrhardt and others (33) QCC rating: high	State of Baden-Württemberg, Germany 25 May to 5 August 2020 School reopened in phases starting on 4 May; all classes in by 15 June. Holidays started 28 July. Low community transmission	Epidemiological investigation All notification of cases (laboratory confirmed) searched to identify all cases in children and assess transmission for cases who attended schools in the 2 days before symptom onset or sampling of positive test	Children aged 0 to19 years IPC measures: reduced class size (50%), ventilation, hand hygiene, surface cleaning, sport, singing and wind instruments cancelled, and so on. No face masks in classroom (outside of classrooms in some schools). High schools only: physical distancing	- 557 cases in children identified, info on school attendance available for 453 cases (81%) - of these 453 cases, transmission route was mainly household (42%) or unknown (41%). School or childcare: 3.3% - 137 of the 453 cases attended schools at least one day in infectious period. 2,300 swabs taken from their close contacts (teachers and students). 6 of the 137 students have infected a total of 11 students (1 to 3 per index cases): • 3 in childcare • 1 in primary • 4 in secondary • 3 in vocational schools - estimated one secondary case per around 25 infectious school days - 4 additional secondary cases were identified, infected by teachers
Falk and others (34) QCC rating: medium	Wisconsin, USA 31 August to 29 November 2020 Cumulative incidence in study period: 5,466 per 100,000	Surveillance study and epidemiological investigation Information provided by schools (online survey) and public health officials (contact tracing) 17 schools participated (8 elementary and 9	4,876 students and 654 staff who attended school in-person (12% children were attending school virtually) IPC measures: mandatory masks for staff and students indoors, small classes, reduced	- 191 cases identified (133 students and 58 staff), corresponding to a cumulative incidence of 3,453 per 100,000 (lower than community incidence) - 7 (3.7%) student cases linked to in-school transmission: 5 in elementary schools, 2 in secondary. - 1 cluster of 3 in one class was reported. All other were individual cases - no in-school transmission reported between separated cohorts - no staff cases were linked to in-school transmission - more than 92% mask compliance in students reported by teachers (but low response rate)

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
		secondary) out of the 18 invited	mixing, physical distancing	
Fong and others (53) QCC rating: low	Hong Kong July 2020 Community transmission at the time not reported	Epidemiological investigation	20 children aged 5 to 17 years old, SARS-CoV-2 positive IPC measures in schools: daily temperature screening, face masks worn at all times, half day class, arrival spread in time or different entrance doors, extra space between desks and limited social, sport, or contact activities	- 15 cases linked to household/neighbourhood cases - 5 cases linked to clusters in school (1) and in a tutorial centre (1) - school-wide testing conducted for the 2 clusters and 7 of the 15 other cases, but no other cases were identified, suggesting limited onward transmission within school settings with IPC measures in place
Fricchione and others (35) QCC rating: low	Chicago, US 17 August to 4 October 2020 Moderate to high community incidence; state schools closed	Surveillance study (large private school system) Weekly analyses of COVID-19 cases (confirmed or probable) recorded in a school database, including probable transmission route	19,500 students and 2,750 staff in 91 schools and 3 high schools Private school open if strict IPC measures: daily symptom screening, hand hygiene, mandatory face mask, social distancing, cleaning	- 59 cases (39 students, 20 staffs) reported in 31 schools, with 1-8 cases per school - 47 of the 59 cases were school-associated (that is attended school); 3 clusters identified - 2 of the 3 clusters associated with non-adherence to physical distancing outside of the classroom - transmission within classroom could not be ruled out for the third cluster. - the most common location of transmission for school-associated cases were outside of school settings - attack rates for this school system: • students: 0.2% (versus 0.3% all children)

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
		Outbreaks defined as 2 or more cases with an epidemiological link	and disinfecting, contact tracing, quarantine of exposed cohorts, and so on	• staff: 0.5% (versus 0.7% working age adults)
Hobbs and others (36) QCC rating: medium	Mississippi, USA 1 September to 5 November 2020 Community transmission at the time not reported	Case control study to compare exposure to COVID-19 between children who tested positive (RT-PCR) and those who tested negative; exposures reported by parents or guardians (3 structured interviews by phone) Target sample size: 150 cases and twice the number of controls per stratum (controls matched to cases by age groups, sex and test interval) Odd ratios adjusted (aOR) for sex, age group and ethnicity	Children aged under 18 years 896 participants eligible, 397 took part (154 cases, 243 controls) IPC measures: use of face masks in school recommended for students and staff. Additional mitigation measures in place (but not described)	- school attendance in the 14 days before test not associated with positive results (aOR 0.8; 95% CI 0.5 to 1.3) - close contact with positive cases before infection: more likely to be a family member (p=0.02) and less likely to be a classmate (p=0.04) for cases than for controls. - cases more likely than controls to have attended social gatherings (aOR 2.4; 95% CI 1.1 to 5.5), children gatherings (aOR 3.3; 95% CI 1.3 to 8.4) or had visitors at home (aOR 1.9; 95% CI 1.2 to 2.9). - of those who attended school (n=236): • cases less likely to report mask wearing by staff and students at school (64% versus 76%, aOR 0.4, 95% CI 0.2 to 0.8) • controls more likely to be tested as a requirement to go back to school or day-care (p=0.01)
Hoch and others (39)	Munich, Germany	Surveillance study (Münchner Virenwächter study)	5 primary schools and 5 (6 in phase 2) nurseries	- phase 1: no infection detected

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
PREPRINT (v1; 26 January 2021) QCC rating: medium	Phase 1: 15 June to 26 July 2020 (low community incidence) Phase 2: 7 September to 1 November 2020 (high community incidence)	Schools and nurseries randomly selected; 20 children and 5 staff randomly selected in each institution weekly Oropharyngeal swabs (RT-PCR) taken by trained professionals; antibody testing done at 3 timepoints on staff; questionnaires filled by institution on IPC measures	Total of 3,169 swabs: 2,149 from children (1 to 11 years old; median: 7) and 1,020 from staff (aged 17 to 76; median: 41) 527 blood samples from staff IPC measures in primary schools: physical distancing, reduced class size/rota (only phase 1), hand washing, cancelation of common activities, face masks for adults (and for children on school premise but not in class)	- phase 2: 2 positive samples (one student, one teacher) in one primary school on week 12 (local 7-day incidence rate: 150 per 100,000 in general population): • testing on 36 close contacts: one additional case in one student of the same class (asymptomatic) • suspected index case: teacher - seroprevalence: all negative at timepoints 1 and 2; one positive at timepoint 3 - weekly swabs taken. 2/3169 swabs tested positive (one teacher and one of their pupils) - weekly testing programme well received by institutions
Hommes and others (17) QCC rating: high Follow-up to this study: (38)	Berlin, Germany 11 to 19 June 2020 Low community incidence	Cross sectional study (embedded in cohort study) 12 primary and 12 secondary schools randomly selected (stratified by socio-	193 primary school students (median age: 10 years old) 192 secondary school students (median age: 15 years old) 150 staff (112 teachers)	- inclusion rate of students per class: 65% - RT-PCR: one participant (0.2%) tested positive (16 years old, symptomatic) - seroprevalence: 7 students (1.3%) tested positive for IgG antibodies, 3 in the same secondary class. Age range: 9 to 17 years old

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
		economic level); one class per school Oro-nasopharyngeal swabs and blood samples collected by professionals; questionnaire completed by participants	IPC measures: hand hygiene, daily classroom cleaning, markings for distancing, reduced class size, staggered teaching hours, ventilation, face masks, canteen closure and no physical activities	
Ismail and others (37) QCC rating: high	England 1 June to 17 July 2020 COVID-19 alert level 4 up to 15 June, level 3 after.	Cross-sectional analysis of prospective surveillance study Analysis of national database of cases and outbreaks in educational settings; confirmed cases (RT-PCR) included if they had attended schools in the 2 days before symptom onset Outbreak defined as 2 cases in the same school within 14 days, epidemiologically linked.	- 38,000 early years settings (less than 5 years old) - 15,600 primary schools (5 to 11years old but only years 1 and 6 had returned) - 4,000 secondary school (11 to 18 years old, only years 10 and 12) Median daily attendance: 928,000 students IPC measures in place, including smaller classes	- 113 single cases (55 in children, 58 in staff), 9 coprimary cases and 55 outbreaks - outbreaks: • 27 in primary (but 13 involved only staff); 16 in early year settings (5 staff only); 7 in secondary (3 staff only); 5 in mixed settings (all staff only) • probable transmission direction: staff to staff (26), student to staff (16), staff to student (8), student to student (5) • secondary cases mainly in staff (73% of 210 cases). - secondary cases/outbreak: • student index case: max 6; median 1 (IQR 1 to 2) • staff index case: max 12; median 1 (IQR 1 to 5) - confirmed event rate per 1,000 settings per month: • early years:1.1 (0.75 to 1.4) • primary: 6.5 (5.3 to 7.9) • secondary: 4.5 (2.7 to 7.1) - confirmed case rate per 100,000 per day: • early years:18 (14 to 24) • primary: 6.0 (4.3 to 8.2)

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
		Coprimary cases defined as 2 confirmed cases within 48 hours (usually same household) Statistical analysis conducted to assess associations between events in educational settings and regional incidence	separated into distinct social bubbles, distancing and handwashing	• secondary: 6.8 (2.7 to 14) • staff: 27 (23 to 32) - risk of outbreak increased by 72% (28 to 130) for every 5 cases per 100 000 population increase in community incidence (p<0.0001) - number of single cases significantly associated with regional population density
Jones and others (40) PREPRINT (v1; 3 December 2020) QCC rating: low	Florida, USA 10 August to 14 November 2020 Community transmission at the time not reported	Surveillance study Data about confirmed daily cases, enrolment (both in person and virtual) and mask policies collected from Florida Department of Health database and independent school districts	Tests results from 10,088 students and 4,507 staff from primary and secondary schools IPC measures varied by district; 87% of students were in districts with mandatory mask mandates	- 969 outbreaks (450 primary and 519 secondary) reported, represented 3% primary schools and 15% secondary schools - incidence rate (per 1,000 students): • high school students: 12.5 • elementary and middle school students: 7.4 - larger outbreaks in secondary schools (2 to 100 cases) than in primary (2 to 35 cases) or combined (2 to 26 cases) - staff represented 59% of cases in primary schools, only 27% in secondary schools (p<0.001) - teachers more likely to be index case in primary schools (48 of 100) than secondary (25 of 79, 32% p=0.027) - staff incidence rates in districts without mask mandates was nearly twice the rate in districts with mask mandates. For students, rate was 38% higher

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
Kriemler and others (18) QCC rating: high	Switzerland 1 to 11 December 2020 High community transmission	Surveillance study (embedded in Ciao Corona Cohort Study, see (19,48)) 15 schools out of the 55 of the Ciao Corona Cohort Study invited (14 accepted) Testing: 2 buccal swabs collected, one for PCR and one for rapid diagnostic test (RDT). Done twice, one week apart (T1 and T2). Questionnaire (demographics and symptoms) also completed	Primary and secondary schools 1299 children invited (randomly selected classes), 49% participation: T1: 568 students T2: 602 students 66 teachers IPC measures: mandatory masks for 12+ outside classrooms; staggered breaks; no group events; stable class cohorts; physical distancing in rooms; contact tracing and quarantining. Implementation varied between schools	- PCR • T1: one child positive (prevalence: 0.2%; 95% CI 0 to 1.1%) (but tested negative on RDT) • T2: no positive sample - RDT • 7 children (1.1%) and 2 teachers (3.0%) positive (overall prevalence T1 + T2: 1.3%) • All 9 tests were false positive (negative on PCR and negative when RDT was repeated 2h to 2 days later) - the authors noted that false negative could not be ruled out due to testing technique used
Ladhani and others (41) PREPRINT (v2; 11	England <u>Round 1:</u> June 2020	Cohort study sKIDS: COVID-19 surveillance in school	<u>Total</u>: 12,026 participants (59.1% students, 40.9% staff).	<u>Round 1</u> - weekly infection rate (both arms): • students: 3.9 (95% CI 0.10 to 21.8) per 100,000 • staff: 11.4 (95% CI 1.4 to 41.2) per 100,000 - Seroprevalence (serology arm):

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
January 2021) QCC rating: high	Round 2: mid-July 2020 Round 3: end of November 2020 Community rates were low over the summer	KIDs study (131 primary schools) 2 arms: Swab arm (round 1 only): weekly nasal swabs (RT-PCR) for 4 or more weeks by local nurse/ first aider Serology arm (rounds 1 to 3): blood sampling as well as nasal swab by specialist team that come to school Multivariable logistic regression conducted, adjusting for sex, age, ethnicity, region and previous test results	Swab arm: 9,828 (86 schools) Serology arm: 2,198 (45 schools) At recruitment N-antibody positivity in staff and students in 45 schools was similar to community seroprevalence IPC measures included smaller class sizes, clustering of staff and students	• students: 11.1% (95% CI 9.2% to 13.5%) • staff: 15.1% (95% CI 13.3% to 17.1%) • overall: 13.6% (95% CI 12.3% to 15.1%) Round 2 (serology arm; 73.7% participation) - no positive samples from nasal swab - seroprevalence: • Students: 10.4% (95% CI 8.0% to 13.2%) • Staff: 13.1% (95% CI 11.1% to 15.5%) • Overall: 12.1% (95% CI 10.5% to 13.9%) Round 3 (serology arm; 61.9% participation) - one participant (staff) RT-PCR positive (0.1% 95% CI 0.0 to 0.6%) - seroprevalence: • students: 8.7% (95% CI 6.2% to 12.1%) • staff: 11.2% (95% CI 9.2% to 13.5%) • overall: 10.4% (95% CI 8.8% to 12.3%) Seroconversion • students rounds 2 to 3: 5.0% • students rounds 1 to 3: 4.1% • staff rounds 2 to 3: 5.0% • staff rounds 1 to 3: 4.3% - seropositivity associated with non-White ethnicity and with region but not with school attendance during lockdown or staff contact with students. Seroconversion also associated with region and ethnicity

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
Larosa and others (42) QCC rating: high	Reggio Emilia province, northern Italy 1 September to 15 October 2020 (preschools reopened on 1 September, other schools on 15 September) Second wave started in October	Surveillance study and epidemiological investigation Analysis of local public health database (contact tracing) to identify children 0 to 19 years old with potential exposure or contacts in school When case detected: school notified, and all school contacts tested (second test 14 days after). Secondary attack rates calculated	31,000 students (0 to 19 years old) attending school in the region Face masks mandatory in middle and high schools (expect when at desk); single desks more than 1 metre; class mixing minimised and no extracurricular activities; staggered entrance/exit	- 41 classes in 36 educational institutions notified (1,039 students and 209 staff): • 8 infant-toddler centres and preschools • 10 primary schools • 18 secondary schools - 1200 contacts identified, 1198 tested (994 students and 204 staff). 38 (3.8%) secondary cases identified (in 9 clusters), all children from primary and secondary schools. Attack rates: • secondary schools: 6.6% • elementary schools: 0.38% • overall: 3.2% - mean age index case: 13.3 years (10 to 17 years); mean age positive contacts: 13.2 years (10 to 18 years) - epidemiological investigations of the 9 clusters: the main cluster involved 5 classes in 3 high schools from same administration, probable index cases: 2 teachers working in all 3 schools. Another cluster in 1 high school had 7 secondary cases. Remaining clusters: 3 or less cases. Not always possible to assess transmission route
Macartney and others (43) QCC rating: high	New South Wales (NSW), Australia School term 1: 25 January to 10 April 2020 (up to 1 May for follow-up of contacts)	Surveillance study and epidemiological investigation Index cases in school and early childhood and care (ECDC) identified through NSW database. Cases (or parent or	Children (aged 18 years or less) and staff attending all educational setting in NSW (3,103 schools and 4,600 ECDC) State-wide guidance for physical	- 15 schools and 10 ECDC settings reported cases, for a total of 27 school index cases: • 15 staff: 4 in secondary and 4 in primary schools; 7 in ECDC • 12 students: 8 in secondary (14 to 16 years) and one in primary school (aged 10); 3 in ECDC (2 to 3 years) - 1,448 contacts identified, of which 44% were tested;18 secondary cases identified:

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
Follow-up to this study: (44)	Community transmission at the time not reported	carer), school staff and so on interviewed and close contact identified (self-isolated, but only tested if symptoms) School index case defined as first laboratory-confirmed case who attended school in the 24h before symptom onset	distancing, hygiene measures and educational facility cleaning Online learning started 23 March 2020 for all but those who needed to attend for those aged 5 and over (school attendance around 5%)	• 5 secondary cases in 3 schools • 13 secondary cases in one ECDC - secondary attack rates: • overall: 1.2% • child to child: 0.3% • child to staff: 1.0% • staff to child: 1.5% • staff to staff: 4.4%
Mensah and others (15) QCC rating: medium	England 13 July to 27 December 2020 Community transmission low at the start of the study (July); increased from August, national lockdown on 5 November	Surveillance study Analysis of all SARS-CoV-2 tests (RT-PCR) carried out on school aged children reported to Public Health England (weekly rates) to compare risks and trends in school children depending on holiday, schools re-opening and national lockdown. Statistical analysis: infection rates in students compared with rates in adults (16 to 64	All children aged 2 to 18 who were SARS-CoV-2 tested in England. Full reopening of school, full classes. IPC measures not reported	- regional infection rates between adults and preschool, primary and secondary children strongly correlated (p<0.001). - infection rates higher in secondary school students, followed by primary school students and then by preschool-aged children. For example, infection rate ratio with preschool rates as baseline (week 19 October 2020): • primary school: 1.91 (95% CI 1.74 to 2.09) • secondary school: 5.17 (95% CI 4.73 to 5.65) - infection rates in primary and secondary school-age children started to increase during the second half of August 2020 (before school reopening) and continued increasing after schools reopened, following trends in adults and young adults - school return after half-term (week 26 October 2020) associated with increase in infection rates across all

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
		years old) and young adults (18 to 29 years old)		educational settings (same rate as before half term). Trends in adult infection rates unchanged - adult rates decreased after national lockdown (5 November), followed one week after by decrease in school aged children - following emergence of new variant (B.1.1.7.), cases in both children and adults increased rapidly in December
Mossong and others (47) PREPRINT (v1; 26 October 2020) QCC rating: high	Luxembourg 4 May to 25 July 2020 General population incidence: - At peak (23 to 29 March): 208 per 100,000 - 20 to 26 July: 105 per 100,000	Surveillance study and epidemiological investigation Analysed national database (contact tracing) to identify school cases and assess possible transmission routes Trend analysis to compare infection rates in students and teachers with rates in adults in general population	All students and teachers in Luxembourg who tested SARS-CoV-2 positive Schools closed on 18 March and gradually reopened throughout May. Reduced class sizes with weekly rota up to 29 June, then full class up to summer holidays (15 July). Masks outside the classroom, no school sports or social activities. Canteens closed	- incidence rates 20 to 26 July (per 100,000): • students: 100 • teachers: 51 (less than general population but not significant) - incidence rates significantly lower in primary school children than in high school students during the first wave ($p<0.001$) but not during the second wave - 424 cases identified in students and teachers while schools were opened (May to July). Possible source: • 42.5%: household • 37.5%: unknown • 11.6%: school - of 228 cases that attended school: • 150 did not result in secondary transmission in schools • 29 resulted in 49 secondary cases (78% student-to-student, 14% teacher-to-student; 6% student-to-student and 2% teacher-to-teacher). An additional 12 tertiary cases identified (family members) - reproductive rate in schools: 0.27 (no significant difference between primary and secondary schools). - secondary cases per index case: 1 to 5

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
				- 82% of the 49 secondary cases were in quarantine when tested
NCIRS (44) Not peer-reviewed QCC rating: medium	New South Wales (NSW), Australia School term 2: 10 April to 3 July 2020 Community transmission at the time not reported	This is a follow-up study of (43). See (43) for methods and participants		- 6 school index cases identified (4 students, 2 staff) in 5 schools and one ECDC - 521 close contacts identified; 319 (61%) had nose or throat swab and 44 (8%) had antibody testing, none of them tested positive
Otte im Kampe and others (45) QCC rating: medium	Germany 28 January to 31 August 2020 Low incidence in general population Schools closed 16 March. Limited and phased reopening of schools from end of April; holidays from 22 June	Surveillance study Analysis of national database on COVID-19 school outbreaks. All laboratory cases (PCR) notified to surveillance system (mandatory), and contact tracing for each case by local public health authority. School outbreaks identified as 2 or more cases per school within a same grade (age range of 2 years)	Children aged 6 to 20 years IPC measures decided by states, usually include reduced class sizes and attendance, mix of in-person and online education, staggering timetables, hand hygiene, face masks, distancing, ventilation, and so on Note: the authors reported cases for those aged older than	- 48 outbreaks identified in schools, including 216 cases: • 102 cases aged older than 21 years • 45 cases 11 to 14 years old • 39 cases 15 to 20 years old • 30 cases 6 to 10 years old - less outbreaks when schools were partially open, but no significant difference for the average number of outbreaks before and after school closure (p=0.48): • before: 3.3 outbreaks per week; 6 cases per outbreak • after: 2.2 outbreaks per week; 4 cases per outbreak - largest number of case per outbreaks: 20 cases in 13 to 14 years old and 5 in those aged older than 21 years old (all before school closure, no IPC) - of the 48 outbreaks: 10 were only in those aged older than 21 years and 29 affected one grade in the school - 2 outbreaks affected more than one grade, but it was before school closure (no IPC)

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
			21 years without further information – it is assumed that these represent cases in school staff	
Smith-Norowitz and others (46) QCC rating: low	USA October to December 2020 Community transmission at the time not reported	Surveillance study Mandatory RT-PCR testing (nasopharyngeal swab); results sent by text message within 48 to 72 hours	701 girls (6 to 18 years old) and staff (19 to 80 years old) at a private school in Brooklyn Plastic barriers around student and teacher desks. Mask wearing, hand washing and 6-foot physical distancing enforced	- Total of 2,439 tests performed between October and December, of which 3 were positive (2 students, one teacher): 0.13% infection rate - no asymptomatic cases detected - lower incidence than in state schools (infection rate in October: 0.28%; November: 3%)
Theuring and others (38) PREPRINT (v1; 29 January 2021) QCC rating: high	Berlin, Germany 2 to 16 November 2020 High community transmission (7-day incidence was 185 to 210 per 100,000)	Cohort study (cross-sectional analysis) Same methodology as (17), except that for this round, household members were included (self-collected swabs for household members) For classes with infected students,	177 primary school students (median age 11 years) 175 secondary school students (median age 15 years) 142 staff members 625 household contacts Basic IPC (hand hygiene and	- infections detected in 8 of 24 classes, with 1 to 2 individuals affected in each. 6 cases in primary and 3 in secondary students - infection prevalence: • students: 2.7% (1.2% to 5.0%; 9 of 338) (3.5% in primary and 1.8% in secondary school students) • staff: 1.4% (0.2% to 5.1%; 2 of 140) - seroprevalence: • students: 2.0% (0.8% to 4.1%; 7 of 347) (1.1% in primary and 2.9% in secondary school students) • staff: 1.4% (0.2% to 5.0%; 2 of 141)

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
	This is a follow-up study of (17) which was conducted at low incidence	school contacts and connected household contacts were retested after one week Not adjusted for potential confounders	ventilation) in all classes. 15 of 24 classes did not require staff and students to wear masks in class (but obligatory outside for 22 of 24 classes). 75% classes had fixed cohorts but mixing with others outside class almost always possible	- after one week, no school-related secondary infections detected - secondary attack rates in connected households: 1.1% - based on a cross-sectional analysis comparing negative and positive index participants: • mask wearing at school: never to sometimes (14% positive) versus often to always (1.4% positive), OR 11.38 (2.28 to 59.64) • socioeconomic strata; hand washing, contacts within versus outside school, mode of transport to school: not significant
Ulyte and others (48) PREPRINT (v1; 18 September 2020) QCC rating: low Follow-up to this study: (19)	Zurich, Switzerland Study conducted 16 June to 9 July 2020 (reporting on exposure to SARS-CoV-2 from February to June 2020). Lockdown and school closure: 16 March to 10 May 2020.	Cohort study (Ciao Corona; cross-sectional analysis) Primary schools randomly selected; closest secondary school also included. Classes in participating schools randomly selected, stratified by school level. Antibody testing (IgG, IgA and IgM); blood samples taken in	2,585 students from 55 randomly selected schools (of the 156 invited). Participation was 45% (5% to 95% across classes). Children aged 6 to 16 years old (grades 1 to 2: 6 to 9 years old; grades 4 to 5: 9 to 13 years old; grades 7 to 8: 12 to 16 years old). Seroprevalence on a sample of 1,717 children compared to	- seroprevalence: 2.8%; 95% CrI 1.6% to 4.1%; ranging from 1.0% to 4.5% by district - by age group: • grades 1 to 2 = 3.8% (95% CrI 1.9% to 6.1%) • grades 4 to 5 = 2.5% (95% CrI 1.1% to 4.2%) • grades 7 to 8 = 1.5% (95% CrI 0.5% to 3.0%) - similar to seroprevalence of the adults' sample (adjusted for age group and sex) - 36 of 55 schools had at least one seropositive child - no difference in seroprevalence by sex Note: due to school closure and outcome measure, it is unclear whether this study provides evidence on transmission within school settings.

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
		school, questionnaires completed by parents Results adjusted for population-level grade and for geographic districts (CrI: credible intervals)	a random sample of 577 adults of the same region. IPC measures not reported.	
Ulyte and others (19) QCC rating: medium	Zurich, Switzerland June to November 2020 High community incidence in autumn 2020, but schools remained opened	Cohort study (Ciao Corona) This is a follow-up study of (48), same methodology Serological testing carried out twice: in June to July (T1) and October to November 2020 (T2) Semi-structured interviews with school principals when clusters detected	2,831 children aged 6 to 16 years from 275 classes in 55 schools. T1: 2,603 children T2: 2,552 children (228 newly enrolled) IPC measures (varied by schools): physical distancing, hand washing, cleaning of surfaces, staggered breaks, and masks for teachers and children older than 12 years old from October November	- seroprevalence: • T1: 2.4% (95% CrI 1.4% to 3.6%) • T2: (newly seropositive): 4.5% (95% CrI 3.2% to 6.0%) • ever seropositive (T1+T2): 7.8% (95% CrI 6.2% to 9.5%) - 40% (28 of 74) of the students that were seropositive at T1 were seronegative at T2 - newly seropositive children by district ranged from 1.7% to 15% (3.5% to 21% for ever seropositive) - no significant differences among age groups or sex - 7 classes in 5 schools had 3 or more new seropositive children, although not necessarily linked
Wada and others (50)	Japan 1 June to 31 July 2020 (from	Surveillance study: all schools in Japan asked to provide reports when	Students (more than 9 million) and teachers (more than 600,000) in elementary schools	- 207 cases reported in students. - transmission in school: one case in elementary school and 6 in junior high school - household transmission dominant route: 71% in elementary and 60% in junior high schools

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
QCC rating: low	reopening to holidays) Relatively low transmission (19,115 cases in this period)	positive cases reported within their settings. Possible routes of transmission assessed through public health centres (contact tracing)	(age 6 to 12 years) and junior high schools (age 13 to 15 years) IPC measures: face masks, hand washing, distancing. Teachers asked to avoid high-risk behaviours (for example social gatherings)	- 39 cases reported in teachers: 0 reported as transmission in schools, transmission route unknown in most cases (72% in elementary and 90% in junior high schools)
Willeit and others (20) QCC rating: high	Austria Round 1: 29 September to 22 October 2020 Round 2: 10 to 16 November 2020 7- day community transmission: Round 1: 75 per 100,000 Round 2: 419 per 100,000	Cohort study 250 schools randomly selected; within each school, 60 students randomly selected across classes plus random selection of teachers (target sampling proportion: one of 10 compared to number of students selected in a school) RT-PCR every 3 to 5 weeks for school year 2020 to 2021	Total: 10,734 participants from 245 primary and secondary schools (9,465 students, 1,269 teachers) Round 1: 10,156 participants from 243 schools Round 2: only 3,745 participants from 88 schools participated due to national lockdown starting on 17 Nov 2020	<u>Round 1</u> - prevalence: • overall: 0.39% (95% CI 0.28% to 0.55%) • in students: 0.37% (95% CI 0.26% to 0.53%) • in teachers: 0.57% (95% CI 0.25% to 1.32%) - 86.0% schools with 0 cases; 11.5% with one case; 2.5% with 2 cases <u>Round 2:</u> - prevalence: • overall: 1.39% (95% CI 1.04% to 1.85%); higher than at round 1 (OR 3.56; 95% CI 2.32% to 5.46%; p<0.001) • in students: 1.52% (95% CI 1.13% to 2.04%) • in teachers: 0.44% (95% CI 0.11% to 1.79%) - 59.1% schools with 0 cases; 26.1% with one case; 11.4% with 2 cases; 3.4% with 3 cases

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
		OR for SARS-CoV-2 infection estimated by mixed-effects logistic regression	IPC measures in place, including reduction of contacts (cohorting), physical distancing, increased ventilation and face masks (at round 1: only if distancing not possible; at round 2: at all times in communal areas)	- Multivariable model (adjusted for population density, regional incidence and deprivation): • 2-fold higher regional 7-day incidence: OR 1.64 (95% CI 1.38 to 1.96, p<0.001) • high or very high versus low or moderate social deprivation index: OR 2.14 (95% CI 1.30 to 3.53, p=0.003) - association with local population density significant in unadjusted model, but not adjusted - no significant association between primary versus secondary school, teacher versus students, sex or age
Zimmerman and others (49) QCC rating: medium	North Carolina, US 15 August to 23 October 2020 (first 9 weeks of in-person school) “considerable” community transmission (1 to 2 new cases per 1,000 per week)	Surveillance study: ABC Science Collaborative (ABCs) programme that supports schools with ICP measures, shares lessons learned, and so on. Includes webinars, Q and A sessions, weekly meetings, and so on Participating schools asked to monitor COVID-19 incidence and secondary transmission with support from health department.	More than 90,000 students and staff from 11 school districts enrolled in ABCs that were providing in-person instruction during the study period IPC measures: daily symptom screening, face mask for older than 5 years, hand washing, distancing, contact tracing, hybrid model (for example half class size, 2 days each)	- 773 infections (molecular testing) with only 32 secondary cases documented (contact tracing): • 6 districts: 0 secondary case • 2 districts: 1 secondary case • 3 districts had multiple secondary cases (clusters) - the 3 clusters occurred in pre-K (1) and special needs schools (2) and all were related to lack of face coverings (one cluster linked to students eating in close proximity). - secondary cases by settings: • pre-K: 6 secondary cases • elementary: 11 secondary cases • middle schools: 6 secondary cases • high schools: 5 secondary cases • K-12: 4 secondary cases - no cases of child-to-adult transmission reported

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
		Note: risk of selection bias and lack of generalisability		
Evidence from previous review				
Brown and others (22) QCC rating: low	US February to March 2020	Epidemiological investigation, conducted after a teacher attended school whilst symptomatic (24 to 27 February) All students who had attended class with this teacher were quarantined, and then invited to participate to a serological survey	Students (aged 5 to 18 years old) from 16 different classes in which the teacher had taught while symptomatic Of the 16 classes, 10 were interactive (teacher walking around class and speaking directly with students) and 6 were not interactive	- 120 students contacted, of which 21 (median age: 17 years) volunteered to participate: • 5 students (24%) had interactive contact (mean in-class time: 108 minutes) • 16 students (76%) had non-interactive contact (mean in-class time: 50 minutes) - out of the 5 students from interactive classes, one was seropositive (and was symptomatic) and 1 indeterminate (no symptoms). They were not in the classroom at the same period and they sat in different locations. The 3 other students tested negative, although 2 had reported limited symptoms - the 16 students from non-interactive classes all tested negative, although 7 of them (44%) reported symptoms
Danis and others (23) QCC rating: low	France 25 January to 16 February 2020	Epidemiological investigation of a cluster, including contact tracing of a paediatric case who visited 3 different schools while symptomatic	The paediatric case was a child aged 9 years old, diagnosed with COVID-19 and picornavirus and influenza A coinfections	<u>Results related to the paediatric case</u> - 86 school contacts identified: 61 at high/moderate risk, 25 at low risk. 55 were tested (RT-PCR) - none of them tested positive to SARS-CoV-2 - no additional cases were identified within the 14-day follow-up period of all the contacts

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
Fontanet and others (25) PREPRINT (v1; 26 May 2020) QCC rating: low	Crépy-en-Valois, France 30 March to 4 April 2020 Area "heavily affected" during early stages of COVID-19 pandemic	Retrospective cohort study Follow-up study to an initial epidemiological investigation (2 cases in this high school on 2 February 2020) Questionnaire (symptom and sociodemographic) and antibody detection (blood test, 3 different testing methods) Results adjusted for age and occupation (logistic regression)	Students, staff and household members from 1 high school 1,262 students, teachers and non-teacher staffs invited, of which 326 (37%) accepted and 345 parents and siblings Total participants: 661 Schools closed on 14 February	- infection attack rate (IAR) for antibody detection: • high school students: 38.3% (92 of 240) • teachers: 43.4% (23 of 53) • non-teaching staff: 59.3% (16 of 27) • parents: 11.4% (24 of 211) • siblings: 10.2% (13 of 127) - overall IAR: 25.9%. - the IAR was higher in the high school staff, teachers and pupils, than in parents and siblings ($p<0.001$)
Fontanet and others (24) PREPRINT (v2; 29 June 2020) QCC rating: low	Crépy-en-Valois, France 28 to 30 April 2020 Note: due to their design/timeline (school closed on 15 February) and outcome (seroprevalence),	Retrospective cohort study Follow-up study of (25), assessing seroprevalence across 6 primary schools Questionnaire (symptom and sociodemographic) and antibody detection	Primary school students (6 to 11 years old) from 6 primary schools, their parents and relatives, and staff 1,047 students and 51 teachers invited, of which 541 (51.5%) pupils and 46 (90.2%) teachers accepted.	- infection attack rate (IAR) for antibody detection: • primary school pupils: 8.8% (45 of 510) • teachers: 7.1% (3 of 42) • non-teaching staff: 3.6% (1 of 28) • parents: 11.9% (76 of 641) • relatives: 11.8% (14 of 119) - overall IAR: 10.4%, no difference by gender, age category or type of participant - prior to school closures, 3 pupils positive to SARS-CoV-2 had attended 3 separate schools with no secondary cases in the following 14 days

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
	these 2 studies do not really provide evidence on school transmission	(blood test, flow-cytometry-based assay)	28 non-teaching staff, 641 parents and 119 relatives also participated Total participants: 1,340 Schools closed on 14 February	- familial clustering observed: high proportion of antibodies among parents (61%; 36 of 59) and relatives (44%; 4 of 9) of infected pupils compared to non-infected pupils (6.9% for parents [p<0.0001] and 9.1% for relatives [p=0.002])
Heavey and others (26) QCC rating: medium	Ireland 1 March to 13 March 2020	Epidemiological investigation National database screened to identify positive cases who had attended the school setting Contact-tracing records and records from active surveillance were reviewed to identify cases of secondary transmission	Children younger than 18 years old and adults who had attended school settings Schools closed on 13 March	- 3 children and 3 adults with a history of school attendance tested COVID-19 positive. All cases but one were symptomatic. One paediatric case attended primary school, 2 attended secondary school - one adult was a teacher and 2 attended school for 2h educational sessions - For all these cases, the available epidemiological data suggest that they had not been infected within school settings - 924 child contacts and 101 adult contacts were identified within school settings, of which none were confirmed cases of COVID-19 (followed-up for 14 days, but only symptomatic testing)
Stein-Zamir and others (27)	Jerusalem, Israel May 2020	Outbreak investigation following identification of 2 cases on 26 to 27 May	1,190 students (12 to 18 years) and 162 staff members from a	- 1,161 students and 151 staff members tested: • grade 7 (13 years): 20.3% (40 of 197) • grade 8 (14 years): 17.3% (34 of 197)

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
QCC rating: high		2020, not epidemiologically linked In response to outbreak, school was closed, students/staff asked to self-isolate, and whole school community was tested (PCR, nasopharyngeal swabs)	regional public health school Schools closed on 13 March 2020, limited school reopening from 3 May, all classes reopened on 17 May IPC measures: daily health reports, hygiene, face masks, social distancing and minimal interaction between classes	• grade 9 (15 years): 32.6% (61 of 187) • grade 10 (16 years): 4.5% (9 of 200) • grade 11 (17 years): 3.1% (6 of 98) • grade 12 (18 years): 1.6% (3 of 87) • all students: 13.2% (153 of 1,161) • staff members: 16.6% (25 of 151) - peak rates in 4 classes: grade 9 (20 cases in one class; 13 cases in 2 other classes) and grade 7 (14 cases in one class). Of the cases in teachers, 4 taught all these 4 classes, 2 taught 3 of 4 classes and one taught 2 of 4 classes - overall, higher rates in junior grades (7 to 9) than in high grades (10 to 12) which are in 2 separate wings of the building - investigation: • crowded classes (35 to 38 students per class in class area of 39 to 49 metre squared); distancing not possible • extreme heatwave on 19 to 21 May: continuous air-conditioning in all classes and face masks not mandatory
Torres and others (28) QCC rating: high Possible risk of bias related to	Vitacura, Chile 4 to 19 May 2020 School year started on 4 March.	Cross sectional study, in response to an earlier outbreak (52 members of the school community positive for SARS-CoV-2 (RT-PCR), of which 17% were students, 35% staff and 52% parents)	Students and staff from a large community school: 2,616 students in 14 levels and 318 staff members (195 are teachers)	- outbreak investigation: index case was a staff member in the preschool and elementary school and had attended parent-teacher meetings on week of 4 March. - antibody positive rates: • students: 9.9% (95% CI 8.2% to 11.8%) ○ preschool (n=147): 12.3% ○ elementary (n=286): 10.8% ○ middle school (n=295): 11.9% ○ high school (n=281): 5.7% • staff: 16.6% (95% CI 12.1% to 21.9%)

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
outcome measures (self-administrated antibody test), but was identified and discussed by the authors.		To determine the overall seroprevalence, a randomised sample of students evenly distributed by classroom were invited; all staff invited Test: self-administrated IgG and IgM antibody test (finger-prick chromatographic-based), done 8 to 10 weeks after outbreak started. Quality check (verification of results) performed, duplicate opinion for any unclear results Multivariate logistic regression model to identify variables associated with antibody positivity	1,009 students and 235 staff members participated in the study Outbreak identified on 12 March, school closed on 13 March. Entire school community placed in quarantine	o teachers (n=165): 20.6% o support staff (n=70): 7.1% - students: positive results were associated with younger age (p=0.01), lower grade level (p=0.05), prior RT-PCR-confirmed COVID-19 (p=0.03), and history of contact with a confirmed case (p<0.001) - staff: positive rates were higher in teachers (p=0.01) and in those previously RT-PCR positive (p<0.001) - median % of antibody positive students per class: 8.3% (IQR 1.6% to 14.3%). In 7 classes, more than 25% positivity; 4 of these classes had a primary teacher who had tested positive (antibody and or RT-PCR) - students who were antibody positive had an average of 1.8 contacts with a confirmed RT-PCR COVID-19 case, while those who tested negative had 1.4 contacts (p=0.01). The probability that a student tested positive was associated with the number of contacts with a COVID-19 case (OR=1.4; p=0.05)
Yung and others (29)	Singapore February to March 2020	Epidemiological investigations of 3 potential SARS-CoV-2 outbreaks in educational	Preschool and secondary school	- secondary school: index case (12-year-old student) attended school on the day of symptoms onset. 8 students (mean age: 12.8 years) developed symptoms; all of them tested negative

Reference and QCC rating	Country and study period	Design and methods	Population and setting	Main results
QCC rating: medium		settings (2 preschools and one secondary school) All close contacts were quarantined and symptomatic testing was conducted. Analysis of contact tracing data		- preschool 1: index case (5-year-old student) attended school on the first day of symptoms. 34 preschool students developed symptoms (mean age: 4.9 years); all of them tested negative - preschool 2: index case was a staff member, resulting in 16 staff members being infected (and 11 cases from their own households). 77 children (about 73% of total) were tested, of which 8 were symptomatic and 69 did not have symptoms. All of them tested negative. The remaining 27% of students did not develop symptoms

Table 3. Modelling studies (question 2)

Reference	Model characteristics	Scenarios and outcome measures	Main findings
Asgary and others, 2021 (55) 'Simulating preventative testing of SARS-CoV-2 in schools: policy implications'	Objective: to analyse the outcomes and effectiveness of different testing strategies and scenarios in schools Settings: school in Ontario, Canada (model: 20 class of 25 students each) Study period: 60 days Model: agent-based model, using a modified SEIR model for disease transmission. Simulation starts with 3 asymptomatic infected children (out of 500 students) Model does not include testing accuracy considerations	Outcome • number of infected children at 60 days Intervention tested In each class, random number of students tested daily, self-isolation if positive results Scenarios Different options for testing or classroom isolation protocols for classes with a positive case	- without daily test, just over 60 infected students at the end of the study period. With only one daily test per class, this number would be just under 60. - 3 daily tests per class: 21 to 22 infected students - 5 daily tests per class: 16 to 17 infected students - Under the parameters of this model, increasing the number of tests to more than 5 (that is 20% of students) would not make a significant difference. - weekly testing can reduce the number of cases but the results suggest that it is not as effective as daily tests (except if comparing extreme scenarios, for example weekly testing of the whole class is more effective than one daily test per class). - waiting days for test results: fewer children would be infected if test results are provided on the same day (around 35) compared to providing results one day (around 41), 2 days (around 47) or 3 days (around 50) after testing - theoretical calculation performed to validate the model showed that testing 3 students a day would be sufficient to keep Reff less than 1 in school environment. With use of face masks and cohorting, 1.5 students/class/day would need to be tested to keep Reff less than 1
Aspinall and others, 2020 (56)	Objective: to estimate potential infection levels in primary schools,	Outcomes • prevalence in schools	- % of infected schools increases proportionally to the number of children and teachers attending schools (factor 3.6 between scenario 1 and scenario 3)

Reference	Model characteristics	Scenarios and outcome measures	Main findings
‘Quantifying threat from COVID-19 infection hazard in Primary Schools in England’ PREPRINT (v1; 11 August 2020)	depending on school attendance Settings: state-funded primary schools in England Study period: modelling for September 2020 Model: non-parametric Bayesian Belief Network (BBN) model, using prevalence data from ONS	• number of schools with 1 or more infected person on a given day (= “infected schools”) • transmission between different cohorts of people (for example children and adults) Intervention tested Different attendance levels, based on situation in June 2020 where Reception, Year 1 and Year 6 returned to school (and some from other years if key workers/vulnerable families) Scenarios • scenario 1: school attendance as in June 2020 (= reduced attendance, only some of Reception and Years 1 and 6) • scenario 2: attendance of all children in Reception and Years 1 and 6 • scenario 3: return of all primary school children in all years	- community prevalence appears as a major factor in infection hazard: for example a factor 4 increase in prevalence (compared to June 2020) would result in a 30% increase in infected school - infection hazard also proportional to school size - considering a full return to school and an average national prevalence of 1 in 1700 with spatial prevalence variations (based on data from June 2020), suggest that 82% of infected schools would be located in areas where prevalence is higher than the national average. The probability of having multiple infected people in a school increases with community prevalence - the estimate numbers from the model are lower than observed data, which could be due, in part, to the risk mitigation measure in place in schools
Bershteyn and others, 2020(57)	Objective: to determine which policies (infection control measures, all-remote instruction, in-	Outcome • secondary SARS-CoV-2 infections per infected teacher.	- remote instruction: with 50% of students in all-remote instruction, overall transmission reduction of up to 75%.

Reference	**Model characteristics**	**Scenarios and outcome measures**	**Main findings**
'Which policies most effectively reduce SARS-CoV-2 transmission in schools?' PREPRINT (v1; 27 November 2020)	person and remote alternative schedule, symptom screening, and testing) had the greatest impact on reducing the risk of in-school transmission <u>Settings</u>: public schools, New York City, US <u>Study period</u>: N/A <u>Model</u>: simulations based on SARS-CoV-2 secondary attack rate from real-world data (based on a non-systematic review of the literature). Hypothesis for simulations is that teachers act as a transmission bridge across rotating cohorts (= teacher index cases)	<u>Intervention tested</u> • all-remote instruction • alternative options for rota class schedules (in-person and remote instruction) • daily symptom screening (temperature check and qualitative self-assessment of symptoms), assuming 69% of index cases would develop symptoms on day 5 • testing 10% to 20% of students and staff weekly or monthly, with results available the day after	- <u>class scheduling</u>: smaller cohort and reduced instruction time reduced transmission risk. For example cohort of 9 attending 1 of 3 of days reduced transmission by about 30% (number estimated from graphical results) compared to cohort of 13 attending 1 of 2 of days - <u>daily symptom screening</u>: in the absence of testing, estimated to reduce transmission by 35% to 42% compared to no isolation - <u>universal weekly testing</u> (100%, with results the next day): first weekday most optimal day, last weekday the least. Universal testing on Monday without symptom screening would reduce transmission by 62% to 64% - the most effective strategies used a combination of daily symptom screening, 100% testing on the first weekday of each week and isolation of cases and could reduce transmission by 69% to 71% compared to no testing or symptom-based screening - <u>testing to identify school outbreaks</u> (assuming a school with 339 weekly in-person attendee): with, a 20% random testing strategy, the outbreak would have to grow to at least 4 positive cases to detect at least one positive case with greater than 50% probability, and to 11 positive cases with greater than 90% probability. With 10% random testing, it would be 7 and 22 cases for greater than 50% and greater than 90% probability
Bilinski and others, 2021 (58)	<u>Objective</u>: to compare the effects of varying school-	<u>Outcomes</u>	- <u>interventions:</u> Weekly testing had a bigger impact in reducing secondary transmission than teacher

Reference	Model characteristics	Scenarios and outcome measures	Main findings
'Passing the Test: A model-based analysis of safe school-reopening strategies' PREPRINT (v1; 29 January 2021)	based prevention strategies and community transmission levels on SARS-COV-2 transmission risk in schools <u>Settings</u>: average classroom in elementary and high schools in the US (638 students in elementary and 1,451 in high schools) <u>Study period</u>: 8 weeks (one quarter) <u>Model</u>: agent-based network, including interactions at home, school and between households. Assumed that elementary students are 50% as infectious, and high school students equally as infectious as adults. Daily community incidence values from 1 to 100 cases per 100,000.	• mean number of infections over 30 days after index case • % of scenario without transmission from the index case • % of scenario with more than 5 in-school transmission • % of infections among school population across a typical school quarter <u>Basic IPC (for example masking and distancing)</u> • low uptake (school implementing no or minimum infection control measures) • medium uptake (2 of 3 transmission risk compared to scenario 1) • high uptake (1 of 3 transmission risk compared to scenario 1) <u>Intervention tested</u> • isolation of symptomatic individuals (based on daily screening of symptoms) • quarantine of case contacts (symptomatic individual	vaccination or classroom quarantine. Symptomatic isolation had the smallest impact of the 4 measures - this pattern was the same in elementary school as in high schools, except the overall transmission was much higher in high schools - in general, the impact of the measures was greater for settings with low uptake of basic IPC measures - <u>scheduling or cohorting</u>: in all cases, alternative schedule resulted in the lowest level of transmission, followed by reduced class size, cohorting and then traditional 5-day schedule. The difference in impact between these measures was higher when there was low uptake of basic IPC measures than when there was high uptake - teacher vaccination had a small impact on overall transmission but had a substantial impact on transmission between teachers - <u>community transmission</u>: the difference in impact of these measures increased when community transmission increased • in elementary schools with medium uptake of basic IPC measures and a 5-day schedule, all strategies met a pre-defined threshold for "controlled transmission" if community incidence was below 25 cases per 100,000 per day In high schools with medium uptake and community incidence of 100 cases per 100,000 per day, only weekly testing met the threshold. Under high uptake, the threshold would be met for all strategies except symptomatic isolation

Reference	Model characteristics	Scenarios and outcome measures	Main findings
	Simulation starts with a single infection introduced into school.	isolated and tested, test results next day and all class quarantined for 10 days if positive) • staff vaccination (with an “infection-blocking vaccine” with 90% effectiveness, and 75% uptake) • weekly testing (90% test acceptance and 90% sensitivity, results available within 24h) <u>Scheduling/cohorting</u> • traditional 5-day in person schedule • cohorting (5-days in person with full class, but out-of-classroom contacts for example lunch and recess reduced by 50%) • reduced class sizes (5-day attendance but with half class size, and with reduced out-of-classroom contacts) • alternative schedules (classes divided into 2 cohorts, attending 2 days each)	

Reference	Model characteristics	Scenarios and outcome measures	Main findings
Burns and others, 2020 (59) 'Effectiveness of Isolation Policies in Schools: Evidence from a Mathematical Model of Influenza and COVID-19' PREPRINT (v2; 23 November 2020)	Objective: to examine the impact of several NPIs, focusing on a shortened school week and symptom-based isolation policies Settings: US schools (6 grades with 70 students each) Study period: N/A Model: modified SEIR model (validated for influenza outbreaks, and for one COVID-19 outbreak)	Outcomes • attack rate (proportion of the student population infected over the duration of the outbreak) • outbreak curve (daily prevalence of infected students) Intervention • symptom-based isolation • shortened in-person school-week	- for COVID-19, application of post-fever isolation policy was found to be less effective than that for flu and reduced the median attack rate by 10% (interquartile range: 5% to 17%) for a 2-day isolation policy (versus 70% for flu) and by 14% (5% to 26%) for 14 days - shortening the in-person school week significantly reduced the attack rate and duration of COVID-19 outbreaks: • 4-day: 57% (52% to 64%) reduction in attack rate, and 22% (12% to 26%) reduction in outbreak duration • 3-day: 81% (79% to 83%) reduction in attack rate, and 46% (33% to 52%) reduction in outbreak duration
Cohen and others, 2020 (60) 'Schools are not islands: Balancing COVID-19 risk and educational benefits using structural and temporal countermeasures'	Objective: to examine the impact of different school reopening scenarios on both transmission inside and outside of schools, and on the share of school days that would need to be spent learning at a distance	Outcomes • % of schools with one or more infected person on first day of school • % of in-person school days lost due to distanced learning, screening or quarantine • cumulative infection rate for students, staff and teachers	- on the first day of school, 5% to 42% of schools would have at least one person arrive at school with active COVID-19, depending on the incidence of COVID-19 in the community and school type - cumulative infection rates within 3 months for 20 to 110 cases per 100,000: • scenario 1: 9.5% to 25% teachers and staff; 6.4% to 17% students • scenario 2: 0.8% to 5.5% teachers and staff; 0.6% to 4.1% students

Reference	Model characteristics	Scenarios and outcome measures	Main findings
PREPRINT (v1; 10 September 2020)	Settings: US schools (elementary, middle and high schools) Study period: 3 months following school reopening (September to December 2020) Model: agent-based model. 3 different sizes of the epidemic in the 2 weeks prior to reopening considered: 20, 50 and 110 cases per 100,000 (and assuming R=0.9). Preschools and university assumed to be closed	• effective R over the first 3 months of school within the community Intervention tested • countermeasures (CM): NPI (face masks, distancing, hand washing), cohorting (students and teachers have minimal contact outside their class) and symptomatic screening (with 50% follow-up diagnostic testing and 50% follow-up contact tracing) • AB scheduling: class split into 2 groups, each group attending schools 2 days per week Scenarios • scenario 1: all in person, no CM • scenario 2: all in person with CM • scenario 3: all in person with CM and AB scheduling • scenario 4: elementary and middle schools in-person with CM, high school remote	• scenario 3: 0.6% to 4.3% teachers and staff; 0.4% to 4.1% students • scenario 4: 0.5% to 3.4% teachers and staff; 0.3% to 2.4% students • scenario 5: 0.3% to 2.1% teachers and staff; 0.2% to 1.2% students • scenario 6: 0.2% to 1.7% teachers and staff; 0.1% to 1.0% students

Reference	Model characteristics	Scenarios and outcome measures	Main findings
		• scenario 5: elementary schools in-person with CM, middle and high school remote • scenario 6: elementary schools in-person with CM and AB scheduling, middle and high school remote • scenario 7: all remote	
Gill and others, 2020 (61) 'Operating Schools in a Pandemic: Predicted Effects of Opening, Quarantining, and Closing Strategies' Published report, unclear whether it has been peer-reviewed	Objective: to simulate COVID-19 spread in schools under a range of different scenarios that vary based on community infection rate, grade level, operating strategy, local COVID-19 testing capacity, and the school's response to a confirmed infection. Settings: schools in Pennsylvania, US Study period: duration of 200 days (most of 2020 to 2021 school year) Model: agent-based model	Outcomes • relative total number of infections among students and staff • % of days in the school building for a typical student • estimated number of actual infections in the school based on recent detected infections Intervention tested Simulations explored the different approaches taken by different schools, including hybrid approaches compared to full 5-day attendance, different community infection rates, and different COVID-19 testing capacity (test results delivered in 2 days compared to one week or more)	- cumulative infection rates in elementary schools are likely to be consistently lower than in secondary schools employing the same operating strategies - within each scenario, the number of infections within schools increases as community incidence increases. However, community incidence rate has a much larger effect on infections within schools in scenarios with full time attendance than in scenarios with reduced attendance. Mitigation effects of reduced attendance are particularly large for community rates greater than 50 per 100,000 per week - measures such as use of face masks and eliminating mixing in common areas (for example cafeteria) can reduce infection spread within schools - AB scheduling (groups of students rotate between in-person and distance learning), would reduce the total number of infections in the school. Adding precautions (such as masks, no mixing of students outside classroom and 2 metre distancing between desks) to the scenario of AB scheduling would result in nearly 0 (average: 0.05) infections if an index case was attending school

Reference	Model characteristics	Scenarios and outcome measures	Main findings
		Scenarios • scenario 1: baseline scenario, as if no pandemic • scenario 2: daily attendance with precautions (mask, no mixing outside classroom, and so on) • scenario 3: scenario 2, but with block scheduling for middle and high schools (every other day) • scenario 4: scenario 2, but with same group of students kept together for middle and high schools • scenario 5: scenario 2, but with an A/B schedule (rotation daily) to allow for distancing and 60% reduction of contacts • scenario 6: scenario 5 but with weekly rota • scenario 7: classes divided into 5 groups, attending school one day per week each In all scenarios, it is assumed that 20% of students will voluntarily stay at home (based on real data)	- in full daily attendance scenario, temporary closure of school each time a case is detected would modestly reduce the total number of infections. However, implementing AB schedule from the start is far more effective in reducing infection spread than temporary closures - if the school is operating in AB scheduling, quarantine of close contacts of cases is likely to maintain school's infection rate low. Temporary closures reduce the number of in-person school days without demonstrable benefit in further reducing infections - in AB scheduling scenarios in communities with low or moderate infection rates, secondary schools students are likely to experience little disruption in the in-person school days. In contrast, students in schools operating full-time are more likely to be sent home for quarantine - with very low community rates (10 infections per 100,000 in the last 7 days) and with mitigation measures in place (such as mask wearing) most students are likely to be able to attend school nearly every day even in schools operating full-time - in schools operating full time without mitigation measures, delays in providing COVID-19 test results are likely to increase infections. However, in schools operating in AB scheduling, fast turnaround of test results had no measurable impact on infections as infections are likely to remain low independently of test result turnaround - in secondary schools with full-time attendance or in communities where infection rates are high, there may

Reference	Model characteristics	Scenarios and outcome measures	Main findings
			be already more than 5 infections in the school before the first case is detected
Kaiser and others, 2021 (62) 'Social network-based strategies for classroom size reduction can help limit outbreaks of SARS-CoV-2 in high schools. A simulation study in classrooms of four European countries.' PREPRINT (v2; 15 February 2021)	Objective: to investigate how classroom cohorting strategies may curb the spread of SARS-CoV-2 Settings: high schools (14 to 15-year-old students) in 4 European countries (England, Germany, the Netherlands and Sweden) Study period: Not applicable Model: agent-based modelling using real-world data from a longitudinal cohort (507 classrooms and 12,291 children from 4 different countries), including out-of-school interaction data. Simulations run for different transmission dynamics and different probabilities of out-of-school contacts.	Outcomes • COVID-19 spread to second cohort • % of students in quarantine • % of students infected Intervention • cohorting strategies that split full classrooms (about 20 to 40 students) into 2 cohorts of approximately equal size • in-person teaching: both cohort on the same day (in different classrooms or different schedules), or rota system between in-person and online teaching (every other week) Scenarios • baseline scenario: classroom not divided into cohort • scenario 1: random cohorting • scenario 2: gender-split cohorting • scenario 3: optimised cohorting (to minimise the number of out-	- compared to baseline scenario, random cohorting reduced COVID-19 transmission in classrooms by approximately 50%. Random cohorting using weekly rota-system also reduced transmission by 50% compared to same-day rota. Random cohorting is less effective when out-of-school contacts are frequent - scenarios 2 to 4 all outperform random cohorting. Optimised cohorting is the more effective scenario, followed by network chain cohorting, and then gender-split cohorting - higher transmission dynamics increase the differences between cohorting strategies - higher transmission dynamics result in more frequent infections of the second cohort, and so does more frequent out-of-school contacts - for all cohorting strategies, rota-systems with learning in alternating weeks contain outbreaks more effectively than same day in-person learning

Reference	Model characteristics	Scenarios and outcome measures	Main findings
		of-school contacts between cohorts) • scenario 4: network chain cohorting (first student names all their out-of-school contacts, and so on)	
Landeros and others, 2020 (63) 'An Examination of School Reopening Strategies during the SARS-CoV-2 Pandemic' PREPRINT (v1, 6 August 2020)	Objective: to explore the influences of reduced class density, transmission mitigation and viral detection on cumulative prevalence Settings: US Study period: 200 days duration (most of 2020 to 2021 school year) Model: SEIR model, considering a range of values for transmission across and within age classes	Outcomes • cumulative cases (%) in children and in adults • number of weeks before reaching the stopping rule (= schools close when 5% infection over a 2-week period is reached) Intervention tested and scenarios • reduced class density scenarios: full-time in-person, parallel cohort (half class in-person, half online) or rotating cohorts (weekly). • transmission mitigation: including but not limited to face masks, desk shields, hand washing, improved ventilation, surface cleaning, and outdoor instruction; combined impact of these measures was modelled	- effect of reducing density via cohorts: with strong adherence to mitigation policies, moving from full capacity to 2 cohorts would reduce R_0 by 50% - with full-capacity and no mitigation, schools would reach the stopping rule within a month. With 2 parallel cohorts, it would be reached in 8 to 10 weeks, and in 6 to 8 weeks with 2 rotating cohorts (range reflects differences in testing strategies) - testing strategy: when operating at full capacity, stopping rule will be reached at 12 weeks with a 100% sensitivity test, compared to 10 weeks with a 50% sensitivity test (4 weeks with no testing programme). With a parallel cohort strategy, this would go up to 18 to 22 weeks - mitigation transmission between children: with full attendance and a combined impact of 80% reduction, it would take 24 weeks to reach the stopping rule. With 20% reduction, 8 weeks - over 6 months, the effect on infection of full attendance combined with mitigation measures at 80% reduction is similar to the effect of 2 rotating cohorts without mitigation strategies. A combination of both interventions results in even fewer infections

Reference	Model characteristics	Scenarios and outcome measures	Main findings
		as 20%, 40%, 60% and 80% reduction in transmission rate • testing strategies: no monitoring programme; monitoring programme with perfectly sensitive test and no delay in reporting; monitoring program with rapid but less sensitive test	
McGee and others, 2021 (64) 'Model-driven mitigation measures for reopening schools during the COVID-19 pandemic' PREPRINT (v2, 6 February 2021)	Objective: to better understand the risks of reopening schools and to explore the effectiveness of different mitigation strategies Settings: primary and secondary schools (primary school model: 480 students, 24 teachers, 24 staff; secondary school: 800 students, 125 teachers, 75 staff) Study period: school semester (150 days)	Outcome • school outbreaks Intervention tested • cohorting (alternative day or week) • proactive testing with next day results (weekly or bi-weekly of teachers/staff alone, or of students as well) • quarantine protocols (whole class versus individuals) • vaccinating teachers and staff (with 90% efficacy in blocking symptomatic disease and 50% versus 100% reduction in transmission) Scenarios	- higher community prevalence increases probability of sizable outbreaks in both primary and secondary schools. But sizable outbreaks more likely in secondary than in primary schools due to higher susceptibility and more interconnected contact network - more transmissible strains (R=2.25) increase risk of major outbreaks. Aggressive control measures can mitigate some of the risk but are considerably less effective than with a less transmissible strain - cohorting (with R=1.5): alternative week performs better than alternative day. In primary schools, cohorting alone dramatically reduced outbreak risk. In secondary schools, cohorting is helpful but insufficient to keep outbreak risk low - combination of testing and cohorting can reduce outbreak risk in high schools when the baseline transmission is low. More aggressive testing can help reduce outbreak size, and so does more aggressive cohorting. Combination of both outperformed individual measures

Reference	Model characteristics	Scenarios and outcome measures	Main findings
	Model: stochastic, network-based models of COVID-19 transmission (SEIRS+), assuming that primary school children are 60% as susceptible as adults, and secondary school students the same as adults	• to account for community prevalence, different scenarios were modelled in which new cases were introduced at rates reflecting community rates (around community prevalence when R is between 1 and 2). Single introduction also considered • most simulations done with R=1.5, which assumes that basic in-school interventions such as mask wearing, physical distancing, and behavioural changes are implemented • for highly transmissible variants such as B117, simulations done with R=2.25	- isolation protocols: quarantine of the whole class can reduce outbreak risk and is more effective than isolating individuals - vaccination: vaccinating teachers with a transmission blocking vaccine reduces risk of outbreaks in children, especially when paired with cohorting - combination of vaccinating teacher and cohorting reduce the risk of outbreaks even at higher levels of transmission, such as with new strains (providing vaccines remain effective against these strains)
Panovska-Griffith and others, 2020 (65) 'Modelling the potential impact of mask use in schools and society on COVID-19 control in the UK'	Objective: to explore whether mandatory mask in secondary school alongside existing use in some community settings could reduce the risk of COVID-19 wave resurgence Settings: secondary schools in the UK	Outcome • cumulative infections Intervention tested • mask wearing in secondary schools (see scenario) and in the community • test and trace Scenarios	- with present test-trace-isolate (TTI) levels, mask wearing in secondary schools and community settings would not stop a second wave but can limit its size. More symptomatic testing and more testing and self-isolation of contacts is needed - with mandatory masks in secondary schools and in some community settings, and under present TTI levels, the following would be needed to prevent a second wave: • 68% or 46% of symptomatic cases tested, if the effective coverage of masks was 15% or 30%, respectively

Reference	Model characteristics	Scenarios and outcome measures	Main findings
PREPRINT (v2; 8 October 2020)	<u>Study period</u>: potential second wave of autumn/winter 2020 <u>Model</u>: Individual-based model (Covasim), calibrated with UK data up to end of August 2020	With and without mandatory masks, and with 2 different levels of masks' effective coverage, estimated as the product of mask efficacy (reduction in risk per-contact) and coverage (the proportion of contacts in which they are worn)	• this is compared to 76% and 57% with mandatory masks in community settings but not secondary schools
Phillips and others, 2020 (21) 'Model-based projections for COVID-19 outbreak size and student-days lost to closure in Ontario childcare centres and primary schools'	<u>Objective</u>: to project the impact of student-to-educator ratios and sibling grouping strategies on outbreaks of COVID-19 and on student-days lost to classroom closure <u>Settings</u>: hypothetical childcare centre and primary school (based on Canadian demographic data) <u>Study period</u>: not applicable <u>Model</u>: agent-based model	<u>Outcomes</u> • number of infections in schools, in households and in the community • student-days lost to classroom closure <u>Intervention tested</u> 2 cohorting strategies for primary schools: • reduced class size, student-educator ratio: 8 to 1, 15 to 1 and 30 to 1 (all in-person) • reduced class sizes with weekly rotations (in-person or online teaching): 8(A) to 1 and 15(A) to 1	- overall, bigger class size facilitates faster disease spread: each doubling of class size from 8 to 15 to 30 more than doubled the outbreak size and student-days lost, by factors 2 to 5 depending on the scenario - for a given class size, there was little effect of weekly rotations compared to no weekly rotations on student-days lost to classroom closure (shutdown of a classroom affects both cohorts) - weekly rotations resulted in better aggregate infection outcomes but had little effect on the effective reproductive ratio - based on the reading of results only presented as graphs, the number of infections in the community seemed minimal in all scenarios. Household infections increased with class size and with community transmission. For a given class size and community transmission level, household infections were slightly lower in weekly rotation scenario (although not significant)

Reference	Model characteristics	Scenarios and outcome measures	Main findings
		Scenarios • 8 to 1, 8(A) to 1, 15 to 1, 15(A) to 1 and 30 to 1 • simulations were run with low and high community transmission levels	
Saad and others, 2020 (66) 'COVID-19 Active Surveillance Simulation Case Study -Health and Economic Impacts of Active Surveillance in a School Environment" PREPRINT (v1; 3 November 2020)	Objective: to explore the efficacy of testing a random number of students daily for early detection of asymptomatic cases and for prevention of infection among students Settings: US school (500 people, where students and teachers interact daily) Study period: a school quarter (60-day duration) Model: Coronavirus Simulation Matlab (the Washington Post COVID-19 simulation)	Outcomes • infection rates • student health • economic impact Intervention • active Surveillance model (Random daily testing of X% of students and quarantine of sick students) Scenarios • scenario 1: normal behaviour with no mitigation practices (hypothesis: 99% transmission rate) • scenario 2: mitigation measures, including social distancing and mask wearing (hypothesis: transmission rate 30% with strict adherence, 60% with partial adherence)	- infection rate by the end of the 60 days • scenario 1: 97.6% • scenario 2 (strict adherence): 12.4% • scenario 2 (partial adherence): 86.4% • scenario 3 (5% students tested, partial adherence to IPC): 12.8% • scenario 3 (1% students tested, partial adherence to IPC): 74.4% - health and economic optimisation (considering testing costs, hospitalisation costs and income loss of parents): • partial adherence (60% transmission rate): 6% to 10% testing rate for optimal infection rate (10% or less) and minimal average costs (around 3,300$ per day) • no measures (99% transmission rate): 8% to 10% testing rate for optimal infection rate (10% or less) and minimal average costs (around 5,000$ per day)

Reference	Model characteristics	Scenarios and outcome measures	Main findings
		• scenario 3: active surveillance procedures where a % of students are randomly tested on a daily basis (hypothesis: 100% test accuracy and immediate test results)	
Tupper and others, 2020 (67) 'COVID-19's unfortunate events in schools: mitigating classroom clusters in the context of variable transmission' PREPRINT (v1; 22 October 2020)	Objective: to assess the impact of individual and environmental contributions to transmission rate and implications for cluster sizes and control measures Settings: elementary and high schools, Canada (structure based on British Columbia's schools) Study period: 50-day simulation (September 2020) Model: stochastic individual-based model, using local data on COVID-19 exposures or	Outcomes • total cluster size (number of student infected) • total disrupted (number of students isolated and/or tested) • asymptomatic student-days (when student is infectious but not asked to isolate) Classroom structure: 25 students (divided in groups of 5), 6h per day, Monday to Friday Scenarios when a student becomes symptomatic or tests positive • scenario 1 (baseline): symptomatic student quarantined, no further action • scenario 2: symptomatic student and their group quarantined	- none of the mitigation protocols modelled, initiated by a positive test in a symptomatic individual, are able to prevent large transmission clusters unless the transmission rate is low - among the measures modelled, only rapid universal monitoring (for example by regular, onsite, pooled testing) resulted in reduced cluster size. Onsite testing (2 hours) had a greater impact than testing at a centralised laboratory (2 days)

Reference	Model characteristics	Scenarios and outcome measures	Main findings
	clusters in educational settings	• scenario 3: as in scenario 2, but if 2 groups detected, outbreak is declared, and all students quarantined • scenario 4: all class quarantined <u>Testing framework</u> • testing of symptomatic students • pooled testing (regular testing, regardless of symptoms or contact)	
Zivelonghi and others, 2021 (68) 'Optimizing ventilation cycles to control airborne transmission risk of SARS-CoV2 in school classrooms' PREPRINT (v1; 1 February 2021)	<u>Objective</u>: to assess airborne transmission risk in classroom with ventilation <u>Settings</u>: typical high school classroom (dimensions: 8m x 7m x 3m) <u>Study period</u>: 5h day <u>Model</u>: infection risk model based on the Gammaitoni-Nucci model (to represent viral particles produced in	<u>Outcome</u> • cumulative risk curves <u>Intervention tested</u> • periodic windows opening • mechanical ventilation <u>Scenarios</u> • scenario 1: one positive student remained for 5h in the same classroom • scenario 2: one positive teacher remained for 2h in the same classroom (taking into	<u>Scenario 1</u> - shorter but more frequent breaks (=window opening) performs better in terms of risks - natural ventilation alone can reduce the risk by 50% at the end of a lecture - surgical masks, if worn by all subjects, can result in an additional 30 to 45% risk reduction - frequent window opening (10min per hour) at full aperture combined with mask wearing can achieve 0 infections after 5 hours - risk of airborne transmission is also reduced if number of students in the classroom is reduced <u>Scenario 2</u> - risk curves increase more quickly than for scenario 1 and some viral charge remains even once the teacher has left the room

Reference	Model characteristics	Scenarios and outcome measures	Main findings
	the class and then diluted in the whole environment)	account higher emission rate due to speaking activity) In both cases, a range of emission rates were considered, based on published data for COVID-19. Face mask use was also considered (worn 50% or 100% of the time)	- for a class of 30 wearing masks half the time, the one-infection threshold via airborne transmission was reached in one hour or less in scenario 2 while it was reached in 2.4h to 4.5h in scenario 1 (range of values to take into account range of possible emission rates) In both scenarios, mechanic ventilation (HVAC system, active only during breaks) alone was not enough to reduce risk below 1-contagion threshold

Table 4. Experimental and observational studies (question 2)

Reference	Study design	Methods	Main findings
Curtius and others, 2021 (69) QCC rating: low High risk of confounding: the 2 rooms had different orientations (window on busy road versus quiet area); aerosol concentrations higher at baseline in the reference room; more	Study type: mixed (experimental and modelling) Objective: to evaluate if the use of mobile air purifiers in classrooms can reduce the aerosol load fast, efficiently and homogeneously. Participants: one classroom (L 8.2m, W 6.2m, H 3.7m) and one reference classroom of similar	Outcomes • experimental: aerosol concentration • modelling: concentration of virus exhaled and inhaled Intervention 3 or 4 mobile air purifiers with HEPA filters (regular household model; 99.97% filtration efficiency for particles 0.1 to 0.3µm) placed in one classroom. Air exchange rate of 5.5 to 5.7 per hour	Experimental results (after 35 min) - aerosol concentration: • HEPA filters: 95% reduction • reference: 30% reduction (due to diffusion in the room and inhalation by people) - number concentration large particles (0.3 to 10µm): • HEPA filters: exponential decrease (same as for aerosol) • reference: almost constant - homogeneous reduction in particle concentration with respect to all particle sizes in classroom with HEPA filers Calculation results

Reference	Study design	Methods	Main findings
classes held in the reference room than in the room with filters. Unclear risk of information bias for both exposure and outcome.	dimensions, where single (45min) and double (90min) lessons are held Settings: schools, Germany Study period: 14 to 18 September 2020	No HEPA filters in the reference classroom Modelling Based on the experimental data on the efficiency of HEPA filters in the classroom, calculations of RNA-containing aerosol and inhaled dose were made, based on assumptions about SARS-CoV-2 virus (infectious dose, concentration of virus and volume of particles released when speaking and breathing, and so on) for a 2h class without ventilation versus with air purifiers	- with one highly infective person: • HEPA filters: steady state of 0.006 virus-RNA containing aerosol/l reached after around 20 min • reference: 0.069 virus-RNA containing aerosol per litre after 2 hours - virus inhaled by a susceptible person in the room during 2h: • HEPA filter: 3.3 virus-RNA containing aerosol • Reference: 21 virus-RNA containing aerosol - difference increase with time for both outcomes - 3 out of 6 teachers felt that the noise emitted by the HEPA filters was strongly disturbing (one) and 2 somewhat disturbing (2); none of the students (26) were disturbed
Sparks and others, 2021 (70) QCC rating: medium High risk of selection bias (of the teachers who acted as expert, and of loss to follow up - 7 out of 34)	Study type: mixed method (interviews and questionnaires to collect quantitative and qualitative data) Objective: to quantify primary school contact patterns and how contact rates changed upon re-opening with risk mitigation measures in place	Outcome • mean number of contacts/day (contact = conversation or interaction at a spacing of one metre or less for 5 minutes or more) Methodology - structured expert judgement used to assess contact rates and patterns in children at school (through interviews and	- number of daily contacts within school prior to lockdown, and % reduction of contact after reopening: • younger children (Reception and Year 1): 15 contacts per day [range 8.35], reduced by 53% • older children (Year 6): 18 contacts per day [range 5.55], reduced by 62% • teaching staff: 25 contacts [range 4.55], reduced by 60% • non classroom staff: 11 contacts [range 2.27], reduced by 64% • contacts between teaching and non-teaching staff reduced by 80%

Reference	Study design	Methods	Main findings
	<u>Population</u>: 34 teachers (only 27 completed all questionnaires) from primary schools of different sizes and settings (urban/rural) and from different quintiles (with slight bias towards higher-achieving catchments). However, all but one from state schools <u>Settings</u>: primary schools, England <u>Study period</u>: June to July 2020	questionnaires) before lockdown, and after reopening - the calculated effect, based on all expert responses (weighted by a calibration score), represent the group's collective judgment - the questionnaires also included questions related to IPC measures in place - data on number of schools, students, teachers and staff were retrieved from national database	- risk mitigation survey suggests that governmental guidelines were followed, including bubble size (90% respondent: less than 15 per bubble), physical distancing with visual indicators (76%), staggered break times and start times (50%), ongoing cleaning throughout the day (more than 70%) To note that study was conducted during a period of low school attendance, unclear if the results would still apply for full attendance

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