Public Health England

Protecting and improving the nation's health

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

A rapid review

Contents

Main messages

1. This review included 9 studies: 3 epidemiological and 6 modelling studies (including 5 preprints) (search up to 18 June 2020).

2. There is limited and weak evidence from the 3 epidemiological studies that the transmission of COVID-19 within school settings is low.

3. There is weak evidence from 6 modelling studies that the re-opening of schools at a reduced capacity, particularly for younger children, may not be associated with a second epidemic wave.

4. The evidence base should be routinely monitored to capture new studies on transmission and interventions as they emerge.

Background

School closures were implemented globally to slow the spread of COVID-19, with an estimated 91% or 1.5 billion of students worldwide affected (1). In England, as part of post-COVID-19 recovery, a phased return began from 1 June 2020 for some reception, year 1 and year 6 primary school pupils, and from 15 June the introduction of some face to face contact time with teachers within school for years 10 and 12 in secondary schools. This has proceeded with a number of in-school interventions in place to enable social distancing such as reduced or staggered timetabling, and cohorting, as well as more frequent cleaning, hand and respiratory hygiene and measures to contain the spread if someone develops symptoms (2).

Evidence surrounding the role of children in the transmission of COVID-19 is mixed. A systematic review conducted by the UK Chief Medical Office (search up to 9 March 2020) identified mainly low-quality evidence from Asia that reported conflicting results, with some studies suggesting that children were less affected by COVID-19 than adults and other studies showing similar rates (3). This review also reported that data on clinical outcomes in children were scarce and suggested that children may mainly be asymptomatic or mildly infected (3). A recent systematic review (preprint, search up to 16 May 2020) identified low and medium quality evidence, including evidence from Europe: studies from Iceland, the Netherlands, Spain and Italy reported a lower prevalence of COVID-19 amongst children and young people while studies from Stockholm, England, Switzerland and Germany showed no difference in prevalence between adults and children (4). The authors of the review concluded that there was weak evidence that children and young people played a lesser role in transmission of COVID-19 at a population level and a meta-analyses of contact tracing studies suggested that children and young people had lower susceptibility to SARS-CoV-2, with a 56% lower odds of being an infected contact (4).

Globally, a variety of approaches have been adopted in relation to the re-opening of schools: for instance, schools have remained open in Sweden over the course of the pandemic, while in Spain schools will remain closed until September 2020 (see Annexe A for an overview). In the UK, schools were closed until the end of May 2020, except to approximately 244,000 children of critical workers and vulnerable children and have since commenced a partial re-opening with 659,000 children in attendance on 4 June 2020 (5). Surveillance reports for England during lockdown (Public Health England [PHE], 13 April 2020 to 1 June 2020, weeks 16 to 22) indicate a number of possible school-based outbreaks notified to PHE (n=28), of which 16 outbreaks were confirmed as SARS-CoV-2 positive (6).

Decisions around both the initial closures and the re-opening of schools within England have been informed by evidence and advice from the Scientific Advisory Group for Emergencies (SAGE). A list of relevant papers considered by SAGE is provided in Annexe B. It is currently anticipated that schools in England will re-open in full from September 2020 (7), and there is an ongoing need to understand how to do this safely.

It is recognised that there are other potential benefits and harms for children that need to be considered regarding school closures. For instance, reports from the National Foundation for Educational Research show that a third of pupils were not engaged with their lessons, and that pupils in the most disadvantaged schools were the least likely to be engaged with remote learning (8). The focus of this review is on the transmission of COVID-19, but where studies reported any wider impacts (including harms), these will also be reported on.

Objective

The purpose of this rapid review was to identify and assess direct evidence on the transmission of COVID-19 within school settings, and on the effectiveness of school-based interventions in reducing transmission.

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

Review questions

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

Summary of methods

A literature search was undertaken for primary and secondary evidence published (or available as preprint) between 1 January 2020 and 8 June 2020. The search was updated up to the 18 June 2020. See Annexe C for details of the methodology, a protocol is available in Annexe E.

Evidence

The initial search returned 754 records; after removal of duplicates, 394 records, plus 10 studies identified by reference-checking, were screened by title and abstract according to prospectively specified inclusion criteria. Of these, 105 full text articles were assessed for eligibility and 8 were included in this review. The search was updated up to 18 June, where 16 full text articles were assessed, and one modelling study was found to meet the inclusion criteria. A PRISMA diagram describing the literature search process is reported in Figure C.1.

In total, 9 papers were included. Of these, 3 were epidemiological studies (relevant to question 1), and 6 were modelling studies (relevant to question 2). Five of the modelling studies were preprints so have not been peer-reviewed. Full details of the studies can be found in Annexe D.

Question 1: transmission of COVID-19 within school settings

Evidence from epidemiological studies (Table D.1)
Three epidemiological studies which reported on transmission within school settings were included (9 to 11). Two of these studies were published in peer-reviewed journals (10,11) and one was a report published on a national organisation website (9).

The national report is an investigation from the Australian National Centre for Immunisation Research and Surveillance (NCIRS) of all cases of COVID-19 in New South Wales (NSW) schools. A total of 18 cases (9 children and 9 staff) were identified, with a cumulative 863 close contacts, out of which 2 secondary cases (one in high school and one in primary school) were found to have tested positive for SARS-CoV-2 (9). One limitation of this study is that only one third of the 863 close contacts were tested.

An investigation from Ireland conducted in March 2020 prior to the COVID-19 schools lockdown, screened COVID-19 notifications to identify children (<18 years old) and adults who attended school settings and found no evidence of secondary transmission of COVID-19 from children attending school (10). Despite the small number of primary cases identified in schools (3 children and 3 adults), the strength of this study is that is included al known cases with school attendance in Ireland.

A study from France investigated a primary case and its 11 secondary cases, of which one was a 9-year-old child. The child attended 3 schools whilst being symptomatic and 86 close contacts within these schools were identified. Of these, 54 were considered as possible cases and none of them tested positive to SARS-CoV-2. The authors concluded that the secondary paediatric case most likely did not transmit the virus (11).

Two of these studies specifically examined whether child-to-teacher transmission had occurred. In the Australian investigation, which identified128 staff as close contacts, it was found that no teacher or staff member contracted COVID-19 from any of the initial school cases (9). Similarly, in the study from Ireland, none of the 101 adults identified as contacts within school settings tested positive (10).

These 3 epidemiological studies consistently reported a lack of confirmed transmission of COVID-19 by children within school settings. However, these studies are subject to a number of limitations, such as small numbers of cases included within each study, and that not all contacts of cases were tested. It is therefore unclear whether any asymptomatic secondary cases were missed, and the level of transmission might have been underestimated. In addition, different methodologies were used so the results cannot be compared directly. For example, the method for identification of cases varied across studies, with some using contact tracing of a single case and their contacts, whilst others began by screening records of COVID-19 notifications and contact tracing records. Finally, the risk of transmission within schools might have been reduced by other measures, including reduced school attendance: in the Australian study, parents were encouraged to keep their children at home; the Irish study was conducted on a small period (13 days) as the schools then closed; in the French study, the 3 schools of interest had been closed for 1 to 2 weeks once the case was known.

Schools-based surveillance studies could help build further knowledge regarding children and COVID-19 transmission within school settings. For instance, the PHE COVID-19 Surveillance in Children attending preschool, primary and secondary schools (SKID) study will test up to 20,000 pupils and teachers within 100 schools (12). Alongside this, recent publication (preprint) of a French primary school based cohort study suggests that there was no evidence of onward transmission in children within school settings (13). However, this study was published after the search for this review was concluded, and was therefore not included.

Main finding: overall, evidence consistently suggests that transmission of COVID-19 within school settings may be low, however this is based on a small number of studies and the evidence is considered to be weak. Further research and analysis is needed.

Question 2: effectiveness of interventions within school settings on transmission of COVID-19

Evidence from modelling studies (Table D.2)

Six modelling studies examined the potential impact of the closure of schools, or the partial or full re-opening on population transmission (R_0) (14 to 19). All of these studies were preprint, except one (19). None of these studies addressed the impact of specific interventions within school settings explicitly, though some did incorporate social distancing measures as a parameter in their model for returned school cohorts. Social contact matrices (indication of the number of contacts per day within different groups) were included within most models. All studies had referred to the use of either national or regional population datasets to calibrate model development (UK, England, France, Australia and South Korea) and had also conducted sensitivity analyses.

Three modelling studies (all preprints) reported on the impact of re-opening schools on the population transmission of COVID-19 (14 to 16). One study examined eight scenarios for the re-opening of primary and secondary schools in England from 1 June 2020, calibrated to the

UK population data (14). The study reported that the partial re-opening of primary schools was unlikely to increase the R_0. A greater risk was associated with the re-opening of secondary schools, with regional variation. A regional analysis, which assumed transmission levels associated with strict lockdown, predicted regional variation in the impact of schools re-opening and in some regions it was predicted that the R_0 would increase to above 1. The authors noted that any impacts from the relaxation of other lockdown measures were yet to be quantified, but their modelling points to a need to consider the underlying changes in R_0 from the relaxation of other population interventions, which are expected to result in an increased level of community infection, rather than solely the re-opening of schools.

A French study (preprint) estimated that re-opening both primary and secondary schools in full and at the same time would generate the largest increase in cases compared to other 'phased re-opening' scenarios (15). The model explored the impact of children returning to school on the population of the region of Île-de-France. It assumed that older children would have a greater number of social contacts and hence a greater potential for transmission of the virus. The study predicted the re-opening of secondary schools would result in larger increases in COVID-19 cases than the re-opening of pre-schools and primary schools alone, and that a second wave of COVID-19 could be averted if the maximum school attendance was limited to 50% for all ages. This study required at least 50% case isolation from large scale trace and testing, alongside moderate social distancing for any schools re-opening scenario. The model estimated that even partial schools reopening would be unable to avert a second wave, if trace isolation was at only 25% (15).

The importance of trace and testing was also highlighted in a UK modelling study (preprint) which estimated that to keep the R_0 below 1 and avert an epidemic rebound, a phased return of UK schools from June 2020 would require testing 51% of symptomatic infections at community level, and tracing 40% of their contacts, along with the isolation of symptomatic and diagnosed cases.(16)

A modelling study (preprint) from Australia assessed the impact of lifting different policy restrictions separately on population level COVID-19 transmission (18). From the 6 policy changes modelled, which included opening of bars and removing working from home, the re-opening of all schools was expected to have the fifth lowest impact on population-level COVID-19 incidence; with only the allowing of small social gatherings of less than 10 people having less impact. The model assumed schools consisted of separate class cohorts, with no interaction between individuals from other cohorts (18). Another study (preprint) from Australia also suggested that re-opening schools (whilst maintaining social distancing, and with class groups of 20 pupils) without lifting other lockdown restrictions would have little impact on the effective reproductive number R_{eff}. However, re-opening schools while lifting other measures such as home lockdown was associated with an increase of R_{eff} (17). It should be noted that both studies are modelled on an Australia specific population and R_0 value, and that, as at the time of writing (June 2020) Australia had very low transmission rates, applicability of these results to the UK population is unclear.

A modelling study from the early stages of the pandemic from South Korea, estimated that any school re-opening would lead to additional cases and that school closure was an essential intervention to prevent or mitigate the COVID-19 epidemic (19). This model however was based on early data from the start of the pandemic and assumed a homogenous level of susceptibility and transmission across all age groups up to 19 years, which does not reflect the subsequent discourse on transmission rates for COVID-19 in pre-adolescent children (19). Part of the limitations of modelling studies is that they are usually run in controlled environments that may not accurately reflect the behaviours that we observe in real life, and that assumptions have to be made when evidence or data are lacking. Specific limitations of the included modelling studies are included within the supplementary material (Table D.2).

Main finding: evidence on the effectiveness of school-based interventions is currently limited to modelling studies which considered the population impact of school closures or re-opening. The modelling studies calibrated with UK and EU data predict the re-opening of schools at reduced capacity, particularly for younger children, may not increase the R_0 greater than 1. However, this is based on 6 studies of which 5 were preprints so the evidence is considered to be weak.

Limitations

This review is based on a literature search of databases and it is possible that some additional grey literature has been missed.

The evidence identified for question 1 was based on 3 epidemiological studies, which included small numbers of index cases and were partially confounded by school closing and/or lower student attendance than usual. For question 2, only modelling studies were identified. Five out of the 6 modelling studies were preprints which have not been peer-reviewed. Overall, the body of evidence identified for this review is considered weak.

None of the identified studies reported on subgroups such as gender, ethnicity and socio-economic status or potential harms. The focus of this review was on the transmission of COVID-19 within school settings and as the risk of harms related to school closures was not included in the search strategy, a new search would be required to examine this evidence fully.

Conclusions

There is consistent evidence that the transmission of COVID-19 within schools may be low, however the available evidence is limited and weak. More research is needed to understand this more fully.

Weak evidence from 6 modelling studies, of which 5 were preprints, suggests that the re-opening of schools at reduced capacity, particularly for younger children, might not be associated with an epidemic rebound.

Following widespread closures, schools have begun to re-open in England and around the world. It will be essential to closely monitor the transmission of COVID-19 as schools begin to re-open. Further research is needed both on the role of schools in the transmission of COVID-19 and the effectiveness of school-based interventions to minimise transmission.

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.

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

References

1. UNESCO. 'Education: From disruption to recovery'. 2020
2. Department for Education. 'Coronavirus (COVID-19): implementing protective measures in education and childcare settings. Updated June 1 2020'. 2020
3. Mehta N and others. 'SARS-CoV-2 (COVID-19): What do we know about children? A systematic review'. Clinical Infectious Diseases 2020: volume 71, issue 9
4. Viner RM and others. 'Susceptibility to and transmission of COVID-19 amongst children and adolescents compared with adults: a systematic review and meta-analysis'. MedRxiv (pre-print) 2020
5. Department for Education. 'Attendance in education and early years settings during the coronavirus (COVID-19) outbreak – summary of returns to 4 June'. 2020
6. Public Health England. 'National COVID-19 surveillance reports'. 2020
7. House of Commons. 'Debate (22 June 2020) vol 677 [HCWS304]'. 2020
8. National Foundation for Educational Research. 'New report looks at pupil engagement in remote learning during the Covid-19 pandemic'. 2020
9. National Centre for Immunisation Research and Surveillance (NCIRS). 'COVID-19 in schools – the experience in NSW (26 April 2020)'. 2020
10. Heavey L and others. 'No evidence of secondary transmission of COVID-19 from children attending school in Ireland, 2020'. Euro Surveillance: Bulletin Europeen sur les Maladies Transmissibles = European Communicable Disease Bulletin 2020: volume 25, issue 21, pages 05
11. Danis K and others. 'Cluster of coronavirus disease 2019 (Covid-19) in the French Alps, 2020'. Clinical Infectious Diseases 2020: volume 11, pages 11
12. Public Health England. 'Study launched to monitor prevalence of COVID-19 in schools'. 2020
13. Fontanet A and others. 'SARS-CoV-2 infection in primary schools in northern France: A retrospective cohort study in an area of high transmission'. MedRxiv (preprint) 2020
14. Keeling MJ and others. 'The impact of school reopening on the spread of COVID-19 in England'. MedRxiv (preprint) 2020
15. Di Domenico L and others. 'Expected impact of reopening schools after lockdown on COVID-19 epidemic in Île-de-France'. MedRxiv (preprint) 2020
16. Panovska-Griffiths J and others. 'Determining the optimal strategy for reopening schools, work and society in the UK: balancing earlier opening and the impact of test and trace strategies with the risk of occurrence of a secondary COVID-19 pandemic wave'. MedRxiv (preprint) 2020
17. McBryde ES and others. 'Stepping out of lockdown should start with school re-openings while maintaining distancing measures. Insights from mixing matrices and mathematical models'. MedRxiv (preprint) 2020
18. Scott N and others. 'Modelling the impact of reducing control measures on the COVID-19 pandemic in a low transmission setting'. MedRxiv (preprint) 2020
19. Kim S and others. 'School Opening Delay Effect on Transmission Dynamics of Coronavirus Disease 2019 in Korea: Based on Mathematical Modeling and Simulation Study'. Journal of Korean Medical Science 2020: volume 35, issue 13, pages e143
20. Viner RM and others. 'School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review'. Lancet Child Adolesc Health 2020: volume 4, issue 5, pages 397 to 404

Annexe A. Global approaches to school re-opening at June 2020

Table A.1. Approaches to school re-opening
Adapted from Vancouver Coastal Health, COVID-19 Research & Knowledge Translation Unit, Rapid Response Report 20 May 2020

Country	School re-opening approach
Austria	Most pupils returned to school on May 18 with staggered attendance, Monday to Wednesday and Thursday to Friday, students split into two groups, each attending lessons during half of the week. Pupils in their final year went back to school on 4 May.
Australia	NSW has indicated that schools would re-open for one day a week for all students starting 11 May.
China	Older students started to return to school in mid-April Wuhan re-opened high schools on 6 May (BBC, 2020).
Denmark	Daycare re-openings began on 15 April Phase 2 of re-opening from 18 May and includes primary school and youth education programs.
Finland	Restrictions on education gradually lifted in Finland from 14 May 2020.
France	Nursery and elementary schools opened 11 May. Resumed for all students 22 June with one metre distancing. Students in lycées (last 3 years of high school) excepted and continue home schooling.
Germany	Schools and child care regulated by states and opening at different times: list here. In Berlin, all pupils expected to receive face-to-face classes in their schools by May 29.
Greece	High schools to resume from 11 May, followed possibly by pre-schools and primary schools on 1 June, if epidemic conditions remain favourable.
Iceland	Schools re-opened 4 May 2020 (Government of Iceland, 2020b).
Italy	Schools remain closed for rest of school year (until September 2020). Child care remains closed (Povoledo, 2020) .
Ireland	Schools remain closed until September 2020 (O'Brien, 2020). As of 18 May, childcare for essential healthcare workers, and schools/colleges for teachers can start to re-open. Overview of Re-opening Phases.

Netherlands	Primary schools re-open 11 May. Secondary schools re-open 2 June. Vocational secondary schools re-open 15 June, but only for exams and for vulnerable students.
New Zealand	Alert level 3: Schools open for children who could not stay home. Alert level 2: 18 May, all early learning services, including play centres and playgroups, opened for onsite learning.
Norway	Kindergarten re-opened on 20 April. Primary schools opened 27 April (up to 4th grade). All schools allowed to open from 11 May 2020.
Singapore	Singapore schools to open in phases from 2 June Kindergarten children may return from 2 June. Nursery children could return from 8 June. Infant care and playgroup children can return 10 June.
South Korea	Planned re-opening in phases starting with high school seniors on 13 May. However, re-opening delayed a week due to new surge in cases. (Lee and others, 2020; Gong, 2020).
Spain	Schools remain closed until September, 2020 (Nasman and others, 2020).
Sweden	Schools and preschools have remained open over the course of the pandemic.
Switzerland	All compulsory schools (up to age 16) allowed to re-open starting 11 May 2020, but individual cantons make final decision (Leybold-Johnson, 2020).
Taiwan	Schools have remained open in Taiwan since the initial outbreak in Wuhan; schools opened on 25 February 2020 after extending winter break by 10 days (Wiley, 2020). Introduced NPIs including face masks, daily temperature testing, cohorting, regular handwashing, barriers at lunchtime.
United Kingdom	Schools and nurseries closed to all pupils except children of key workers and vulnerable children during March 2020 to May 2020. England: From 1 June, some primary schools opened, and some secondary school pupils returned from 15 June. Plans for schools to resume in full, from September 2020. Wales: From 29 June, cohort return of primary and secondary pupils.

	Scotland: All schools plan to return in full from 11 August with no physical distancing between pupils if SARS-CoV-2 continues to be suppressed. Northern Ireland: secondary school years 7, 12 and 14 from 24 August with one metre distancing.
United States	Re-opening of schools decided by individual states and districts. Most remain closed. Montana has allowed schools to be open as of 7 May 2020, but few districts choose to do so (Nagel, 2020). Re-opening childcare decided by individual states. Most states remain open with guidelines in place, some are open only for essential workers. Rhode Island is the only state with blanket closure, with a plan to re-open 1 June 2020 (Child Care Aware of America, 2020).

Annexe B. Documents of interest published by SAGE on schools and COVID-19

Table B.1. List of documents on schools and COVID-19 discussed at SAGE meetings (Source)

Meeting date	Title
Meeting 38 21 May 2020	GOS: Risk of COVID-19 amongst parents and grandparents of primary school children, 21 May 2020 (Paper prepared by the Government Office for Science)
Meeting 37 19 May 2020	Quick findings on age distributions of grandparents and parents of primary school aged children, 18 May 2020 (Paper prepared by the Office for National Statistics)
Meeting 31 1 May 2020	Technical briefing to Dutch Parliament: role of children in the COVID-19 outbreak (22 April 2020)
	Transmission and susceptibility in children
	Interdisciplinary Task and Finish Group on the Role of Children in Transmission: Modelling and behavioural science responses to scenarios for relaxing school closures (1 May 2020)
Meeting 30 30 April 2020	Susceptibility and Transmission in Children - updates from the last few weeks - 29-Apr-20
	Interdisciplinary Task and Finish Group on the Role of Children in Transmission: Modelling and behavioural science responses to scenarios for relaxing school closures (30 April 2020)
Meeting 26 16 April 2020	The role of children in transmission (16 April)
Meeting 23 7 April 2020	UNCOVER Review: What is the evidence for transmission of COVID-19 by children [or in schools]? (1 April 2020)
Meeting 17 18 March 2020	SPI-B: note on school closures (17 March 2020)
	SPI-M-O: Consensus view on the impact of school closures on Covid-19 (17 March 2020)
	Impact of school closures, 18 March 2020 (Paper prepared by the University of Warwick)
	Timing of the introduction of school closure for COVID-19 epidemic suppression, 18 March 2020 (Paper prepared by the MRC Centre for Global Infectious Disease Analysis (MRC GIDA), Imperial College)

	The impact of adding school closure to other social distance measures, 17 March 2020 (Paper prepared by the London School of Hygiene & Tropical Medicine)
Meeting 14 10 March 2020	PHE: SARS-CoV-2, SARS-CoV-1 and MERS-CoV: What do we know about children? 9 March 2020 (Paper prepared by Public Health England and the Chief Medical Officer)
	DHSC: SARS-CoV-2, SARS-Cov-1 and MERS-CoV: Epidemiology and clinical characteristics in children, 10 March 2020 (Paper prepared by the Department of Health and Social Care)
Meeting 13 5 March 2020	Timing & local triggering of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demands, 5 March 2020 (paper prepared by Imperial College)
Meeting 12 03 March 2020	Adoption and impact of non-pharmaceutical interventions for COVID-19 (paper prepared by Imperial College and the London School of Hygiene & Tropical Medicine (LSHTM))
	Summary indicative effects of non-pharmaceutical interventions (NPIs) to reduce COVID-19 transmission & mortality, 2 March 2020 (paper prepared by Imperial College)
Meeting 11 27 February 2020	Potential effect of non-pharmaceutical interventions (NPIs) on a Covid-19 epidemic in the UK 26 February 2020
Meeting 10 25 February 2020	Potential effect of non-pharmaceutical interventions on a COVID-19 epidemic (paper prepared by Imperial College)
Meeting 09 20 February 2020	SPI-M-O: Consensus view on the impact of mass school closures 19 February 2020
	Potential effect of school closure on a UK COVID-19 epidemic: annex to SPI-M-O consensus view, 20 February 2020 (paper prepared by Imperial College)
Meeting 06 11 February 2020	SPI-M-O: Consensus view on the impact of mass school closures on 2019 Novel Coronavirus (2019-nCoV) 10 February 2020
Meeting 04 04 February 2020	SPI-M-O's statement on the impact of possible interventions to delay the spread of a UK outbreak of 2019-nCov [includes closure of schools] 03 February 2020

Annexe C. Methods

We conducted a rapid evidence review following an accelerated process. The research questions, search strategy, eligibility criteria and review process were agreed prospectively by the evidence team and summarised in a review protocol, available in Annexe E. The review was attempting to find all the literature on COVID-19 transmission within schools.

Review questions

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

Sources of evidence:

1. Ovid Medline, Ovid Embase, medRxiv, WHO Covid database and Google scholar.
2. We supplemented database searches with reference-checking of relevant papers during the initial search. This was not repeated during the updated search.

Search strategy

The initial evidence search covered the period 1 January 2020 to 8 June 2020, and was repeated for the period 8 to 18 June 2020. Search terms covered main aspects of the research questions and the Ovid Medline search strategy is provided below. Article eligibility criteria are summarised in Table C.1.

Screening process

Reference lists were extracted using Endnote. Screening of titles and abstracts was performed independently by two reviewers and supported by Rayyan software. Studies on which the reviewers disagreed were included for full text assessment. Full text screening was performed independently by 2 reviewers.

Data extraction and evidence synthesis

Main results from included papers were extracted and reported by one reviewer, which was checked by a second reviewer.

Bias assessment

Due to the rapid nature of the work, a validated risk of bias tool was not used to assess study quality. An accelerated quality assurance process was used when reviewing studies and major sources of bias were noted (mainly population, selection, exposure and outcome).

Strength of evidence

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

Table C.1. Eligibility criteria for evidence search

	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	• non-humans studies • 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 disease	Other diseases, including Influenza
Intervention or exposure	• impact of schools re-opening in countries such as UK • impact of limited school closures in countries such as Iceland or Sweden • impact of other school social distancing measures • impact of infection prevention and control measures	
Outcomes	• SARS-CoV-2 infection rate in children and staff • transmission of COVID-19 within school settings • COVID-19 outbreaks in schools	
Language	English, French, Spanish, Italian	All other languages
Date of publication	1 January 2020 to 18 June 2020	
Study design	• systematic and rapid reviews	• guidelines

	Included	Excluded
	• experimental or observational studies • modelling studies • if relevant, data from UK surveillance reports might be included.	• opinion pieces
Publication type	Published and preprint	

Search strategy for Ovid Medline

1. school*.tw,kw.
2. (primary adj2 educat*).tw,kw.
3. (secondary adj2 educat*).tw,kw.
4. (pre-school* or preschool*).tw,kw.
5. sixth form*.tw,kw.
6. (post16 or post-16).tw,kw.
7. teacher*.tw,kw.
8. teaching staff.tw,kw.
9. teaching assistant*.tw,kw.
10. early years practitioner*.tw,kw.
11. educat* setting*.tw,kw.
12. educat* workforce.tw,kw.
13. reception.tw,kw.
14. (privat* adj educat*).tw,kw.
15. (state adj2 educat*).tw,kw.
16. (mainstream adj2 educat*).tw,kw.
17. (pupil or pupils).tw,kw.
18. kindergarten*.tw,kw.
19. (pre-kindergarten* or prekindergarten*).tw,kw.
20. Schools/
21. Schools, Nursery/
22. School Teachers/
23. Nurses, Community Health/
24. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23
25. exp coronavirus/
26. exp Coronavirus Infections/
27. ((corona* or corono*) adj1 (virus* or viral* or virinae*)).ti,ab,kw.
28. (coronavirus* or coronovirus* or coronavirinae* or CoV or HCoV*).ti,ab,kw.
29. (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.

30. (respiratory* adj2 (symptom* or disease* or illness* or condition*) adj10 (Wuhan* or Hubei* or China* or Chinese* or Huanan*)).ti,ab,kw.
31. ((seafood market* or food market* or pneumonia*) adj10 (Wuhan* or Hubei* or China* or Chinese* or Huanan*)).ti,ab,kw.
32. ((outbreak* or wildlife* or pandemic* or epidemic*) adj1 (Wuhan* or Hubei or China* or Chinese* or Huanan*)).ti,ab,kw.
33. or/25-32
34. 24 and 33
35. limit 34 to yr="2020"

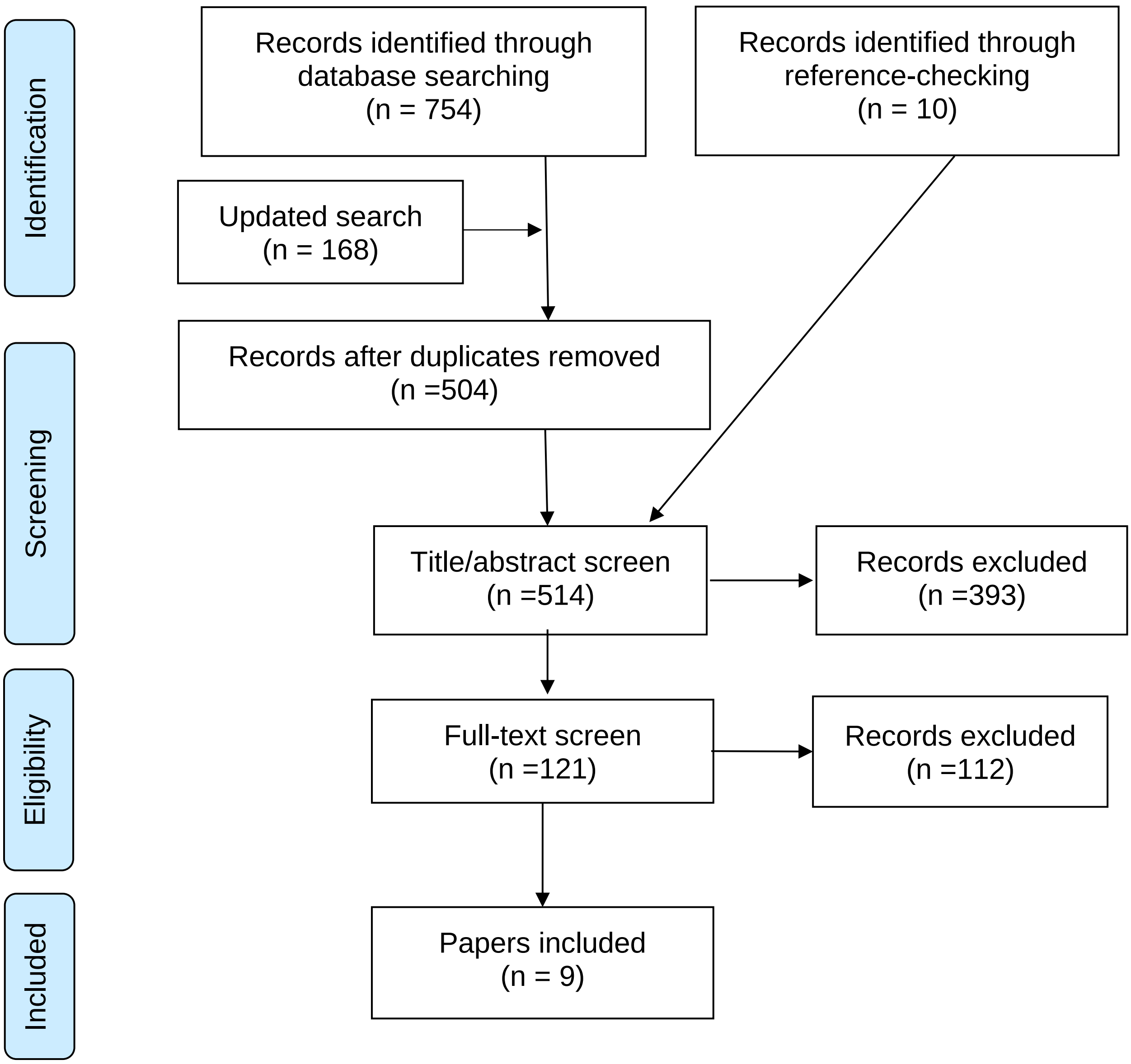

Figure C.1. PRISMA diagram

Figure C.1. PRISMA diagram alt text

A PRISMA diagram showing the flow of studies through this review.

There were n = 754 records identified via database searching and a further n = 168 records identified from the updated search, resulting in n = 504 records after duplicates were removed. An additional n = 10 records were identified from reference checking, resulting in n = 514 records screened on title and abstract.

From these, n = 393 records were excluded. This left n = 121 records screened on full text, of which n = 112 were excluded, leaving n = 9 papers that were included in the review.

Annexe D: Data extraction

Table D.1. Epidemiological studies

Acronyms used: NCIRS = National Centre for Immunisation Research and Surveillance, NSW = New South Wales, RT-PCR = reverse transcriptase polymerase chain reaction

Reference	Study description	Methods	Findings	Comments
National Centre for Immunisation Research and Surveillance (NCIRS) (2020) (9) 'COVID-19 in schools – the experience in NSW'	Objective To understand the transmission of SARS-CoV-2 in schools and childcare centres in New South Wales (NSW), Australia. Setting 15 schools in NSW (10 high schools and 5 primary schools) Timing From March to 21 April 2020 Description of cases 18 individuals (9 students and 9 staff) from 15 NSW schools were confirmed as COVID-19 cases	Investigation conducted by the National Centre for Immunisation Research and Surveillance (NCIRS), with the support of the NSW Ministry of Health and NSW Department of Education. Selection COVID-19 notifications were screened to identify children and adults who had attended the school setting. Contact-tracing records were reviewed to identify cases of secondary transmission. A 'close contact' was defined as a person who has been in face to face contact for at least 15 minutes or in the same room for 2 hours with a case. Once the close contacts are identified, they are required to isolate themselves at home for 2 weeks and if they become unwell, go to the doctor or a fever clinic to get a nose or throat swab to test for COVID-19. Diagnosis For staff and students that agreed to participate: a) symptom questionnaire b) test swab for COVID-19 5 to 10 days after the last contact with the case c) blood sample taken to detect antibodies	18 COVID-19 cases (9 students and 9 staff) were identified between 5 March 2020 and 3 April 2020. 863 people were identified as close contacts in 15 schools. 12 of the initial cases (8 students and 4 staff) were from 10 high schools; with a total of 695 close contacts identified (598 students and 97 staff). Of these contacts, 235 were tested for SARS-CoV-2 via nose/throat swabs (all negative), and 75 had blood testing after about one month, of which one student had antibodies detected. 6 of the initial cases (1 student and 5 staff) were from 5 primary schools, with a total of 168 close contacts identified (137 students and 31 staff). Of these, 53 had nose or throat swabs taken, and 21 underwent blood testing. The same student tested positive for both (no other positive case). Conclusions This detailed investigation found only 2 secondary cases, both in children. One secondary case (in the child in a high school) was presumed to have been infected following close contact with 2 student cases. The other secondary case was presumed to have been infected by a staff member (teacher) who was a case. Investigation found no evidence of children infecting teachers.	Author identified limitations Findings are preliminary, with a future more detailed paper to follow. Notes from the review team Small number of cases (n=2) Only symptomatic primary and only a third of the secondary cases were tested. Potential confounding factor: from 23 March 2020, although schools remained open, parents were encouraged to keep their children at home for online learning, and face-to-face school attendance decreased significantly. This may have impacted the results of this investigation. Furthermore, school holidays commenced in NSW on Friday 10 April for 2 weeks. Unclear applicability because of the differences in relation to population size and density, COVID-19 incidence, R value and natural course of the virus.
Danis and others (2020) (11) 'Cluster of coronavirus disease	Objective To conduct an investigation of a confirmed case to identify secondary cases and interrupt transmission. Setting France	Selection Contact tracing of a paediatric secondary case. Diagnosis Positive RT-PCR	In addition to the index case, 11 secondary cases were identified: 5 in France, 5 in England and 1 in Spain (overall attack rate: 75%). One of the secondary cases was a child aged 9 years old which was diagnosed with COVID-19 and picornavirus influenza A coinfections. This	Author identified limitations Asymptomatic cases might have been missed. Viral load was only tested 8 days after onset of symptoms. Out of 172 contacts, only 73 were tested.

Reference	Study description	Methods	Findings	Comments
2019 (Covid-19) in the French Alps, February 2020’	Timing From 25 January to 16 February 2020 Description of cases Englishman (index case) stayed in the same chalet with 10 English tourists and a family of 5 French residents		child visited 3 different schools while symptomatic. A total of 172 individuals were identified as close contacts, of which 86 were school contacts from the infected child. The 86 school contacts were contacted and 54 were identified as possible cases. 55 contacts (including the 54 possible cases) were tested and none of them tested positive. In total (including the school contacts) 73 were tested, of which; 1 case was tested COVID-19 positive (tertiary case; not school related). No additional cases were identified within the 14-day follow-up period of all the contacts. Conclusions Secondary case most likely did not transmit COVID-19 within school settings.	Other viruses (picornavirus and influenza) were in circulation at the time of this outbreak and it possible that the lack of transmission of COVID-19 might be related the co-circulation of respiratory viruses. Notes from the review team Small number of paediatric cases (n=1) Potential confounding factor: the 3 schools had been closed (2 for 2 weeks, one for one week) as a preventive measure. Study has potential applicability to an England context as the secondary case attended schools in a comparable country (that is, France).
Heavey and others (2020) (10) ‘No evidence of secondary transmission of COVID-19 from children attending school in Ireland, 2020’	Objective To examine the evidence of paediatric transmission in school setting in the Republic of Ireland. Setting Ireland Timing From 1 March to 13 March 2020 Description of cases The first Irish case of COVID-19 was in a school-going child who had recently returned from Northern Italy.	Selection COVID-19 notifications to Public Health Departments were screened to identify children, under the age of 18 years, and adults who had attended the school setting. Contact-tracing records and records from active surveillance were reviewed to identify cases of secondary transmission. Diagnosis Not reported	3 children and 3 adults with a history of school attendance were 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 a 2 hour 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. Conclusions: No evidence of secondary transmission of COVID-19 from children attending school in Ireland. This investigation included all known cases with school attendance in the Republic of Ireland.	Author identified limitations Small number of cases: 3 children and 3 adults. Not all age ranges are represented, as children are older than 10 years Only symptomatic contacts were tested so asymptomatic secondary cases were not captured Prior to school closure on 12 March, when a case was identified within a school, either all children and staff within the school or all children and staff involved with an individual case were excluded. This limited the potential for further transmission within the school setting once a case was identified. Notes from the review team Unclear applicability because of the differences in relation to population size and density, COVID-19 incidence, R value and natural course of the virus.

Table D.2. Modelling studies

Acronyms used: SEIR = susceptible, exposed, infected, recovered

Reference	Model characteristics	Scenarios and outcome measures	Findings	Comments
Di Domenico, L and others, 13 April 2020 (15) PREPRINT 'Expected impact of re-opening schools after lockdown on COVID-19 epidemic in Île-de-France'	Overview Modelling of partial, progressive, and full school re-opening scenarios in Île-de-France, with moderate social distancing and large-scale tracing, testing, and isolation. Also tested hypotheses on children's transmissibility distinguishing between younger children (pre-school and primary school age) and adolescents (middle and high school age). Model Stochastic discrete age-structured epidemic model. Model calibration data 1. Hospital admission data pre-lockdown, and ICU admission data during the lockdown phase. 2. Population inputs: demographic and age profile data from region of Île-de-France. 3. Contact matrices from 2012 (for population mixing). Model parameters 1. 4 age classes: 0 to 11 years, 11 to 19 years, 19 to 65 years, and 65 years and older. 2. Children's susceptibility assumed same level as adults. 3. Viral load assumed similar across all age classes and for asymptomatic and symptomatic cases. 4. Contact settings: household, school, workplace, transport, leisure, other. 5. Transmission: divided into susceptible, exposed, infectious, hospitalized, in ICU, recovered, and deceased. 6. Infectious: split to 2 phases: i) prodromic occurring before the end of the incubation period, ii) phase where individuals are either asymptomatic or develop symptoms (including different degrees of severity)	Baseline model All scenarios are compared to the situation where schools remain closed. Model scenarios Set 1: re-opening of pre-schools and primary schools only: • progressive (100%): 25% students return school first week after lockdown lifted, 50% on the second, 75% on the third, 100% fourth week till summer holidays • progressive (50%): 25% students return to school first week post lockdown lifted, 50% from second week till summer holidays • prompt (50%): partial re-opening with 50% attendance from May 11 • prompt (100%): full re-opening with 100% attendance from May 11 Set 2: 100% pre-school and primary schools start May 11, with middle and high schools 4 weeks after (8 June) through progressive or prompt protocols at full or partial attendance (that is, as before, but for adolescents and starting on June 8). Set 3: all schools reopen on 11 May, through progressive or prompt protocols at full or partial attendance. Outcomes 1. Number of clinical cases at 5 July 2020 2. ICU beds demand at 1 August (factoring delay in disease progression).	Re-opening only pre-schools and primary schools on 11 May (set 1) would result in the increase of ICU occupation by 72%. Re-opening all schools on 11 May (set 3) would increase ICU occupation by 138%. Re-opening all schools on 11 May (set 3) but limiting maximum school attendance to 50% for both younger children and adolescents, could avert a second wave. No substantial difference for epidemic risk between progressive and prompt re-opening of pre-schools and primary schools. Re-opening pre and primary schools would require large-scale trace and testing and moderate social distancing. No level of school reopening was deemed safe if trace isolation efficiency is reduced to 25%. Full attendance in middle and high schools is not recommended. Although viral load similar across different age groups and for asymptomatic and symptomatic cases, risk of transmission shown to vary with the severity of symptoms.	Author identified limitations Widespread use of masks not factored in the model. Caution advised for interpretation of model for cases over the summer as earlier spring holiday contact data used as a proxy, and limited information on control measures and protocols for summer months. Authors highlight they did not analyse impact of reactive school closures as a means to slow virus propagation. Notes from the review team Authors used parameter that children under 10 years had a lower incidence of COVID-19 (based on data from Italy) than adolescents and adults; and that those less than 10 years tended to be either asymptomatic or to have limited symptoms. Based on data observed in case reports on high school students (Oise cluster) and the role of asymptomatic infection, authors adopted parameter for adolescents have the same reduction in transmissibility in absence of symptoms as adults at $r\%$ = 0.55. Model does not use the generally accepted protocol of using Erlang distributed waiting times for the exposed and infected compartments. The observation that primary schools are unlikely to cause a second wave is likely to still stand, however less confidence should be placed on any conclusions about the timing and magnitude of any changes relative to baseline.

Reference	Model characteristics	Scenarios and outcome measures	Findings	Comments
	7. Younger children: 4 different values for reduction in transmissibility compared to adolescents and adults: r% = 0.1, 0.25, 0.33, 0.55 Quality Model assumptions were calibrated, and sensitivity analysis conducted, for example on assumption that the reproductive number in lockdown is 10% lower or higher than the that estimated on current data.	Results presentation Median curves are displayed with associated 95% probability ranges.		
Keeling, MJ. and others 05.06.2020 (14) PREPRINT 'The impact of school re-opening on the spread of COVID-19 in England'	Overview Modelled strategies for re-opening primary and secondary schools in England from 1 June. Model Deterministic, age-structured compartmental SARS-CoV-2 SEIR disease states transmission model. Model simulation modifies a previous dynamic transmission model for SARS-CoV-2 based on a stratified population according to current disease status. Model calibration Inputs to the model (including hospital admissions and ICU cases and proportions going through each disease state) were drawn from the COVID-19 Hospitalisation in England Surveillance System data set. Assumptions for transmission figures were informed by use of age-dependent mixing matrices. Model parameters Age stratification of 0 and 19 years old into single year cohorts, with the remainder of the population stratified into 5-year age brackets (20 to 24 years, 25 to 29 years and so on). Quality Limited reference to quality factors, with no detail of any sensitivity analysis.	Baseline model All scenarios are compared to the situation where schools remain closed. Model scenarios 1. Reception (year 0), year 1 and year 6 (full class sizes) 2. Reception, year 1 and year 6 (half class sizes) 3. All primary schools 4. Reception, years 1, 6, 10 and 12 (full class sizes) 5. reception, years 1, 6, 10 and 12 (half class sizes) 6. Primary schools plus year groups 10 and 12 7. All secondary schools 8. All schools. Modelled in 4 different regions in England (London, North East and Yorkshire, East of England, the Midlands) To reflect lockdown impact/social distancing authors scaled mixing matrices associated with schools, work and other activities while increasing the within household transmission matrix Outcomes measured 1. Clinical case impact (the number of symptomatic cases, deaths and intensive care unit admissions)	Proposes that re-opening schools with half class sizes (across age groups) or focussing just on re-opening to younger children is unlikely to push R_0 above 1, although regional variation is anticipated. Re-opening secondary schools would result in larger increases in COVID-19 case burden than only re-opening primary schools. Full re-opening of both primary and secondary schools estimated to generate the largest increase and could push R_0 above 1 some regions (Midlands and East of England). The impact of less social-distancing amongst the rest of the population is viewed as having a larger effect on the R0 than re-opening schools. This exacerbates the opportunity for re-opening schools. The return of all age groups to school at full capacity (whilst maintaining restrictions in place for other age-groups) in London, North East England and Yorkshire was expected to not increase the R_0 above 1. For the East of England and the Midlands this action was	Author identified limitations England context only; UK devolved administrations employ different school system/term dates, which may affect outcome of re-opening schools on specific dates. Model does not reflect full context, for example, if school returns enable parent return to work, increasing their risk of infection. Potential side effects not fully captured in a model, for example, parents interacting at school gates, teachers' exposure while travelling to school or effects of school re-opening on children mixing outside of school. Notes from the review team Authors tested different hypotheses on children's transmissibility. Parameters used to distinguish between younger children (pre-school and primary school age) and adolescents (middle and high school age). The model assumes that older children will have a greater number of social contacts and in turn a greater potential for transmission.

Reference	Model characteristics	Scenarios and outcome measures	Findings	Comments
		2. Change in R_0 per region	predicted (with 95% certainty) to increase the R_0 over 1.	
Kim and others (2020) (19) Published April 2020 Journal of Korean Medical Science 'School Opening Delay Effect on Transmission Dynamics of Coronavirus Disease 2019 in Korea: Based on Mathematical Modelling and Simulation Study'	Overview South Korean modelling study investigating effect of school opening delay on the COVID-19 epidemics Model Age-structured SEIR model including with isolation and behaviour-changed susceptible individuals. Model calibration The daily cumulative confirmed data retrieved from the laboratory confirmed data reported by the Korea Centers for Disease Control and Prevention from 16 February to 22 March was used. Model parameters 1. Two age groups: children (aged up to 19) and adults (aged over 19). 2. Isolation and behaviour-changed susceptible individuals are additionally considered. 3. Incubation period 4.1 days; symptom onset to confirmation and isolation was 4 days (confirmation to recovery is 14 days). Quality Performance of sensitivity analysis was not reported.	Baseline model Assumed that the general susceptible group is transferred to the behaviour-changed susceptible group which is less likely to transmit the disease due to social distancing and personal hygiene enhancement. Child-to-child, child-to-adult and adult-to-child transmission rates were considered to be the same. Model scenarios 1. Transmission rate increased 10-fold after schools open 2. Transmission rate increased 30-fold after schools open 3. School opening delay 1 from 2 March to 9 March 4. School opening delay 2 from 9 March to 23 March 5. School opening delay 3 from 23 March to 6 April Outcomes Expected number of paediatric cases with COVID-19.	After schools are re-opened additional 60 cases are expected to occur from 2 to 9 March and approximately additional 100 children cases are expected from 9 March to 23 March. After 23 March, the number of expected cases for children is 28.4 for 7 days and 33.6 for 14 days. Simulation results showed that the government could reduce at least 200 cases and 900 cases assuming 10-fold and 30-fold increased transmission rates, respectively. The extended school closure from 23 March 2020 for two more weeks could reduce the magnitude of cases and speed up the end of epidemic.	Author identified limitations Transmission rate to children from adults and that to adults from children was considered the same. Parameters related to behaviour changes were assumed. The model assumed only the transmission rate among children would increase It was assumed that all behaviour-changed susceptible individuals are keeping their transmission reduction efforts (for example, wear masks and enhance personal hygiene). Notes from the review team Children were assumed as a homogenous group for 0 to 19 years; and the study estimated a 10-fold increase in cases per school day. The students in South Korea are spending more time in school than the students in any other country, so results might not be applicable to the UK context. There are some significant technical issues with the development and implementation of this model that need to be considered. All compartments in the model have exponentially distributed waiting times, which is not representative of the gamma distributions usually observed. Parameter estimations are out of step with the generally accepted incubation period which is now around 4.8 days, not the 4.1 days used in this model. Most current models are using incubation period of around 5 days The time from confirmation to recovery is estimated form just 16 patients. It would be more useful to use symptom onset to recovery, as this better reflects genuine transitions within the model.
McBryde and others 19.05.2020 (17) PREPRINT 'Stepping out	Overview Australian modelling study Contact rates weighted initially according to the relative susceptibility and infectiousness of different age groups, before multiplying through by the mean.	Baseline model All scenarios compared to the current lockdown restrictions (R_0 at baseline was 2.49). Model scenarios 1. Current conditions continued 2. Return to school	Re-opening of schools (whilst the rest of population is in lockdown) is estimated to reduce R_{eff} from 0.8 to 0.78. This is because increase in school contact is estimated to be offset by decrease in home contact.	Author identified limitations Considerable uncertainty in their estimates. Limited detail on data from China that was used. Study is modelled on an Australian population, R_0 value and disease outbreak course. Notes from the review team

Reference	Model characteristics	Scenarios and outcome measures	Findings	Comments
of lockdown should start with school re-openings while maintaining distancing measures. Insights from mixing matrices and mathematical models'	Model Development of applied contact matrices referred to as 'next generation'. Limited detail of methods and parameters used. Model calibration 1. Modelling using national age-specific contact rates 2. Commonwealth and Google data used to adjust to Australian location-specific mixing and micro-distancing behaviour. 3. Transmission and susceptibility data from China used. Parameters Age-specific contact rates used (from a contact matrix study by Prem and others), weighted to susceptibility and infectiousness of different age groups (using Chinese data) and multiplied by mean transmission rate per contact over the lifetime of infection. Quality Sensitivity and uncertainty analysis is presented.	3. Return to school and cease home lockdown, but with micro-distancing 4. Return to school and work, and cease home lockdown, but with improved micro-distancing 5. Return to pre-COVID-19 activity levels Outcomes measured Incidence of SARS-CoV-2	Changes in out-of-home contacts estimated to have greater impact. Exiting home lockdown modelled to lead to R=0.86. Returning to work estimated to lead to R=0.94, provided strenuous levels of micro/social-distancing remain. Removing micro-distancing and returning to contact rates pre-COVID-19 is estimated to return R to 2.49.	Social-distancing is viewed as critically important to maintain R <1. Although the role of micro-distancing remains highly uncertain, reopening workplaces and ceasing lockdown while sustaining strict distancing may allow suppression of COVID-19. The model is built around an idea of a 'micro-distancing' factor, which takes the value of R_{eff} estimated in the next gen matrices and scales it to the observed value of 0.8. There could be issues here as Australia has very low transmission rates, making R difficult to estimate. Local heterogeneity in the R value might cause clusters of infection to occur in the model. Assumes that susceptibility and transmissibility are equal between individuals of the same age group. The susceptibility of age groups is inferred from age stratified infection rates in China, leading to very low susceptibility in children, a value which directly influences the contact matrix generation. Sensitivity of this value is assessed, with increasing younger susceptibility resulting in a downscaling of the 'micro-distancing' value to achieve the same R value. Assumes schools reopening can occur in isolation which is unlikely.
Panovska-Griffiths, J. and others 01.06.2020 (16) PREPRINT 'Determining the optimal strategy for re-opening schools, work and society in the UK: balancing earlier	Overview Individual-based model to predict the impact of a range of school re-opening strategies with a society-wide relaxation of lockdown measures. Study examines individuals' contact networks and UK data against. Presence of different non-pharmaceutical interventions. Model Covasim, a stochastic agent-based model designed specifically for COVID-19 epidemic analysis. Population of 100,000 agents used and seeded with 4,500 cases from 21 January 2020. Model calibration	Baseline model 1. All schools would reopen to all students on 1 June 2020 2. All schools would reopen to all students on 1 September 2020. Assumption across all scenarios of increase in school, workplace and community transmission probabilities to account for a) increased social mixing with re-opening of schools and b) relaxation of social distancing restrictions on work, leisure and community. Model Scenarios	For UK schools to have a phased reopen from June 2020, prevention of a second wave would require testing 51% of symptomatic infections, tracing 40% of their contacts, and isolation of symptomatic and diagnosed cases. Without testing and tracing at levels outlined above, re-opening of schools together with gradual relaxing of the lockdown measures are likely to induce a secondary pandemic wave. When infectiousness of less than 20 year olds was varied from 100% to 50% of older	Author identified limitations Some parameters used are from a variety of sources across different settings. Caution is advised regarding assumptions on proportion of infections that are symptomatic, as varying evidence on this. Assumption that school and workplace contacts can be traced in one day, and community contacts can be traced in two days and that those who test positive will immediately isolate for 14 days may be slightly optimistic in UK. Notes from the review team First study to quantify the amount of testing and tracing required to prevent a second wave of COVID-19 in the UK under different re-opening scenarios.

Reference	Model characteristics	Scenarios and outcome measures	Findings	Comments
opening and the impact of test and trace strategies with the risk of occurrence of a secondary COVID-19 pandemic wave'	Calibrated to the UK epidemic data inbuilt into Covasim model including population age structures and household sizes. No. seeded infectious individuals was varied during calibration and final number chosen to reflect epidemic trend to date. <u>Model parameters</u> 1. Number of new COVID-19 infections, cumulative cases, recoveries and deaths. 2. Temporal distribution/ timeseries of the R number. 3. Transmission states: susceptible, exposed, infected, recovered or dead. Transmission path: susceptible individuals come into contact with infectious individuals; daily probability for transmission. 4. Contact networks stratified as household, school, work and community layers. 5. Infected and infectious: i) asymptomatic or ii) symptomatic groups: pre-symptomatic (before viral shedding has begun) and with mild, severe or critical symptoms. 6. Time: estimated the number of new infections and cumulative cases over time until 31 May 2021. <u>Quality</u> 1. Tailored COVID-19 model used with defaults for progressing through the states based on evidence to 10 May 2020 on probabilities associated with onward transmission and disease progression, duration of disease by acuity, and effects of interventions. 2. Sensitivity analysis conducted with different levels of infectiousness of children and young adults under 20 years old compared to older ages. 3. Figure for number of seeded individuals in model was also consistent with undetected community transmission as well as possible multiple importation events.	1. Reception, year one and year six in English primary schools would return, followed in July by other years of primary school. After that, secondary school students would return, starting with those in year 10 and year 12 in July followed by other secondary school students the following September. 2. Reception, year one and year six of primary schools would return on 1 July 2020, followed by all other primary and secondary school students on 1 September 2020 <u>Outcomes</u> Estimate number of new infections Cumulative cases and deaths R_{eff}	ages, model predictions remained unchanged	Model includes assumption that probability of developing clinical symptoms rises from 20% in under 10 years to over 70% in older adults. The use of a one-day tracing and testing turnover rate, if turnover times are longer than this then the testing/tracing rates required could be significantly higher. Estimates for numbers of new infections, cumulative cases and death under different TI and TTI regimes. Sensitivity analysis on transmissibility of less than 20 year olds is useful, but it would be helpful to see this age bracket further broken down. The model is used to make predictions on the outcome of interventions put in place in September, based on data up to June. This long prediction period leads to wide uncertainties in the prediction for September. It would be difficult to draw any firm conclusions about school reopening in September from this prediction.
Scott, N. and others 12.06.2020 (18)	<u>Overview</u> Victoria (Australia). Modelled strategies for relaxing policies relating non-pharmaceutical interventions including school re-opening	<u>Baseline model</u> A baseline scenario was run between 1 March and 30 April, including with the policy changes	Opening schools was not predicted to lead to major population-level epidemic rebound, however this	<u>Author identified limitations</u> Classroom are modelled as disjoint network structures, with no interactions between individuals from different classrooms.

Reference	Model characteristics	Scenarios and outcome measures	Findings	Comments
PREPRINT 'Modelling the impact of reducing control measures on the COVID-19 pandemic in a low transmission setting'	Model An agent-based model, Covasim, was calibrated to the local COVID-19 epidemiological and policy environment Contact networks were modelled to capture transmission risks in households, schools and workplaces, and a variety of community spaces (for example, public transport, parks, bars, cafes/restaurants) and activities (for example, community or professional sports, large events). Model calibration 1. The epidemiological data were obtained from the Victorian Department of Health Disease specific parameters were based on global published estimates. 2. Parameters for contact networks and the effect of policy changes were obtained from a combination of the literature and a modified Delphi process 3. A reasonable model fit was obtained that included the initial increase in cases observed followed by the subsequent decline in cases following the introduction of specific policy changes. We estimate that by 30 April, approximately 2000 people had been infected with COVID-19, of which approximately 1,600 (80%) had been diagnosed. The undiagnosed proportion primarily includes asymptomatic cases. Model parameters 1. Epidemiological data: the daily number of tests conducted, new diagnoses and new severe cases, critical cases and deaths 2. Disease specific parameters: duration of incubation, infectious and symptomatic periods, and age-specific risks associated with disease severity and outcomes 3. Households were generated in the model through sampling of age distributed population data for Victoria. Quality Sensitivity analysis conducted, and calibration of parameters took place.	that had occurred over that period, and the parameter for the overall probability of transmission per contact was calibrated such that the model projections fit the data on number of diagnoses and deaths. Model scenarios 1. Lifting of different policy restrictions modelled: opening pubs/bars; allowing large events; opening cafes and restaurants; allowing community sports; allowing small social gatherings; opening entertainment venues (for example, cinemas); removing work from home directives (greater public transport use and more work interactions); and opening schools. 2. Contact tracing: modelled population-level coverage required for contact tracing app to mitigate risks of relaxing different policies. 3. Physical distancing policies (including outdoor pub and bar service) modelled to estimate how effective interventions need to be to mitigate the risks with opening these venues. 4. Patron records at venues: modelled with the ability to contact trace 40% to 80% of contacts from a venue. Outcomes measured Number of new cases	conclusion is based on some input parameters for which there is limited evidence. The least risk comes from policy changes that facilitate smaller numbers of contacts, or repeated contacts with the same people (for example, schools). Authors recommended caution when releasing policy interventions, as some changes took more than two months to then reflect in the population level COVID-19 incidence. Opening of pubs/bars and removing work from home directions were policies found to have the greatest risk.	Values used for relative transmissibility in 0 to 9 year olds and 10 to 19 year olds were selected somewhat arbitrarily, and there is no sensitivity analysis to assess the impact of these values. The model accounted only for age, household structure and participation in different contact networks and does not account for demographic and health characteristics such as socioeconomic status, comorbidities and risk factors and so cannot account for differences in transmission risks, testing, quarantine adherence or disease outcomes for different population subgroups. The model does not include a geospatial component and so cannot capture geographic clustering of infections or concentration of interventions, including differential tracing app uptake in urban versus rural settings or among people attending particular events or settings, or concentrated testing in response to a localised outbreak. This means that projections may be overestimating outbreak sizes as geographic clustering may slow epidemic spread. Data reported on disease parameters such as duration of asymptomatic and infectious periods, as well as age-specific estimates of susceptibility, transmissibility and disease severity and are likely to be influenced by differences in surveillance systems in the countries they are being reported from. Used Delphi methods to obtain data on contact networks. Notes from the review team A graph in the pre-print paper estimated that if schools re-opened on 15 May, it would result in around new 7,000 cases by early September 2020. This work looks at a region with very low levels of community transmission, and the findings cannot be reasonably applied to areas of moderate or high transmission. Age distribution in generated population does not accurately capture observed distributions for younger aged groups (0 to 20 years) - could lead to underestimations of school transmission rates. Some of the parameters obtained by the Delphi method have quite wide distributions. However, the particularly problematic parameters do not pertain to school interventions.

Reference	Model characteristics	Scenarios and outcome measures	Findings	Comments
				The author notes specific concerns with modelling of schools within the model and points out that more work should be done to create a suitable model to properly assess school reopening. In the case of opening bars and restaurants – the intervention found to have the greatest impact on transmission rates – it is found that at least 30% uptake of tracking and tracing apps is required, despite the current uptake in Australia sitting at 24%.

Annexe E: Protocol

Schools and COVID-19: rapid review protocol

To assess the evidence on schools and COVID-19, 2 review questions have been defined:

1. on the risk of transmission of COVID-19 and the second on the effectiveness of social distancing infection prevention and control and other interventions within school settings, for which primary and secondary evidence will be considered

2. insights from two recent rapid systematic reviews (3,20) of the evidence on the susceptibility to and transmission of SARS-CoV-2 between school-aged children, and between children and teachers will be explored during the analysis and considerations for this current rapid review.

Review question 1
What is the risk of transmission of COVID-19 within school settings and preschool settings that are attached to a school?

Review question 2
What is the effectiveness of social distancing, infection prevention and control and other interventions within school settings on the transmission of COVID-19?

Table D.1 Inclusion and exclusion criteria for research questions 1 and 2

	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	• non-humans studies • 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 disease	Other diseases, including Influenza
Intervention / exposure	• impact of schools re-opening in countries such as UK	

	Included	Excluded
	• impact of limited school closures in countries such as Iceland or Sweden • impact of other school social distancing measures • impact of infection prevention and control measures	
Outcomes	• SARS-CoV-2 infection rate in children and staff • transmission of SARS-CoV-2 within school settings • COVID-19 outbreaks in schools	
Language	English, French, Spanish, Italian	All other languages
Date of publication	1 January 2020 to present	
Study design	• systematic and rapid reviews • experimental or observational studies • modelling studies • if relevant, data from UK surveillance reports might be included.	• guidelines • opinion pieces
Publication type	Published and pre-print	

Sources of evidence

Medline, Embase, medRxiv preprints, WHO COVID-19 Research Database.

Search terms

Search terms include terms for schools and school settings, teachers and other staff, combined with Cov-19 terms.

Search strategy for Ovid Medline

1. school*.tw,kw.
2. (primary adj2 educat*).tw,kw.
3. (secondary adj2 educat*).tw,kw.
4. (pre-school* or preschool*).tw,kw.
5. sixth form*.tw,kw.
6. (post16 or post-16).tw,kw.
7. teacher*.tw,kw.
8. teaching staff.tw,kw.

9. teaching assistant*.tw,kw.
10. early years practitioner*.tw,kw.
11. educat* setting*.tw,kw.
12. educat* workforce.tw,kw.
13. reception.tw,kw.
14. (privat* adj educat*).tw,kw.
15. (state adj2 educat*).tw,kw.
16. (mainstream adj2 educat*).tw,kw.
17. (pupil or pupils).tw,kw.
18. kindergarten*.tw,kw.
19. (pre-kindergarten* or prekindergarten*).tw,kw.
20. Schools/
21. Schools, Nursery/
22. School Teachers/
23. Nurses, Community Health/
24. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23
25. exp coronavirus/
26. exp Coronavirus Infections/
27. ((corona* or corono*) adj1 (virus* or viral* or virinae*)).ti,ab,kw.
28. (coronavirus* or coronovirus* or coronavirinae* or CoV or HCoV*).ti,ab,kw.
29. (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.
30. (respiratory* adj2 (symptom* or disease* or illness* or condition*) adj10 (Wuhan* or Hubei* or China* or Chinese* or Huanan*)).ti,ab,kw.
31. ((seafood market* or food market* or pneumonia*) adj10 (Wuhan* or Hubei* or China* or Chinese* or Huanan*)).ti,ab,kw.
32. ((outbreak* or wildlife* or pandemic* or epidemic*) adj1 (Wuhan* or Hubei or China* or Chinese* or Huanan*)).ti,ab,kw.
33. or/25-32
34. 24 and 33
35. limit 34 to yr="2020"

Note: Student* removed as it picked up medical, nursing, university, graduate student.

Screening

Depending on number of hits, screening on title and abstract will be undertaken in duplicate by 2 reviewers for at least 10% of the eligible studies (up to 100% depending on resources). Disagreement will be resolved by discussion.

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

Data extraction

Summary information for each study will be extracted and reported in tabular form. This will be undertaken by one reviewer.

Risk of bias assessment

The risk of bias for each included review will be assessed by one reviewer using AMSTAR 2. Due to the rapid nature of the work, validated tools will not be used for primary studies; however, papers will be evaluated based on study design and main source of bias (mainly population, selection, exposure and outcome).

Synthesis

A narrative synthesis will be provided.

Areas for consideration

International learning: The WHO Collaborating Centre for Public Health Nursing and Midwifery has initiated an international call for practical examples of learning related to schools and interventions to reduce COVID-19 transmission. Insights from this call if available, may be drawn from by the rapid review team for context and discussion.

Susceptibility and severity of SARS-CoV-2 in children: insights from two recent rapid systematic reviews will be drawn from as part of the considerations, including if available, any learning regarding differential impact and severity of COVID-19 between different age groups of children.

If the evidence includes insights on the impact on population transmission and the R value arising or in conjunction with schools reopening, this may be explored in the considerations.

Unintended impact on children health and wellbeing or educational attainment from not attending school during COVID-19 related school closures.

Inequalities: Where evidence is identified, factors relating to inequalities will be considered during the analysis, for example in relation to state or privately-funded school settings and COVID-19 transmission.

About Public Health England

Public Health England exists to protect and improve the nation's health and wellbeing, and reduce health inequalities. We do this through world-leading science, knowledge and intelligence, advocacy, partnerships and the delivery of specialist public health services. We are an executive agency of the Department of Health and Social Care, and a distinct delivery organisation with operational autonomy. We provide government, local government, the NHS, Parliament, industry and the public with evidence-based professional, scientific and delivery expertise and support.

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