WAUNAKEE COMMUNITY SCHOOL DISTRICT
BOARD OF EDUCATION MEDICAL ADVISORY AD HOC COMMITTEE
Tuesday, March 2, 2021
6:00 PM

Waunakee Community School District
905 Bethel Circle
Waunakee, WI 53597

Members of the public may attend Board of Education meetings in-person, subject to space limitations, as well as guidelines and orders that are in place for indoor gatherings.
You will be required to abide by guidelines and/or orders required for indoor public locations in Dane County and Wisconsin. If in-person attendance is unexpectedly high at a Board meeting, adhering to social distancing guidelines may not be possible in the limited space available in the District Office.
A recording of the meeting will be posted on the District webpage within 24 hours of the meeting time.

AGENDA

I. **CALL TO ORDER**
II. **ROLL CALL**
III. **APPROVAL OF MINUTES**
IV. **APPROVE AGENDA**
V. **REVIEW PROGRESS OF GUIDING PRINCIPLES AND DASHBOARD DATA FOR SCHOOL REOPENING**
A. Internal Processes
B. Internal Data
C. Community Wide Data
VI. **VACCINE UPDATES**
A. Staff Vaccine Timeline and Plan
We will provide an update on the vaccination plan for our staff at the meeting on Tuesday. We are working directly with SSM/Dean on our vaccination program, and pending final availability of the vaccine, plans are moving forward. Our vaccination clinic is scheduled for Tuesday, March 2nd for all staff, with a second dose scheduled for Friday, March 26th.
B. Vaccine for Children
We are seeking information from the Committee on any new updates that might be available regarding vaccinations for children.
VII. **FURTHER REOPENING OF SCHOOLS** **4**

The purpose of this agenda item is to solicit feedback from the Committee on further reopening plans.
At the meeting on Tuesday, the District will provide a data and vaccination update for your

review and information. Further reopening of schools to more students requires both significant planning and logistics, and a lead time to ensure that it is done well. These plans would be considered for implementation if latitude by Public Health Madison Dane County were provided regarding the social distancing requirements.
Per PHMDC Order #13 -- School Districts are required to follow "6ft social distancing to the greatest extent possible". PHMDC has continued to define this standards as follows:
Answer: When we say, '6ft distancing to the greatest extent possible', we are recognizing that students and staff may pass each other briefly or there may be certain circumstances where it is necessary to be closer than 6ft (such as a staff member working with a student or a student getting up from their seat to use the restroom). 6ft distancing to the greatest extent possible does not mean placing desks or students 3ft apart.
If the definition or requirement to follow this standard is loosened by PHMDC, then there are opportunities for us to further return students to school. Given that a proportion of our students have chosen to remain in remote learning (about 30%) we could have more students in-person each day.
The following articles may be of help and interest for this discussion:

The American Academy of Pediatrics posted this article about Covid-19 Guidance for Safe Schools --
https://services.aap.org/en/pages/2019-novel-coronavirus-covid-19-infections/clinical-guidance/covid-19-planning-considerations-return-to-in-person-education-in-schools/
The Wood County Wisconsin Study of 17 School Districts addresses degree of spread of COVID in schools.
https://www.cdc.gov/mmwr/volumes/70/wr/mm7004e3.htm

Attached please find:
European CDC Report on Schools: COVID-19 in Children and the Role of Schools First Update
" Physical distancing measures should aim at decreasing the number of individuals and contacts in tight or closed spaces whilst ensuring schooling can take place. The selection of measures should consider the current knowledge of disease transmission in different age groups, and the feasibility and appropriateness of the measures for the age group, including the need to ensure learning and psychosocial development."

Physical Distancing, Face Masks, and Eye Protection
"Transmission of viruses was lower with physical distancing of 1 m or more, compared with a distance of less than 1 m (n=10 736, pooled adjusted odds ratio [aOR] 0·18, 95% CI 0·09 to 0·38; risk difference [RD] -10·2%, 95% CI -11·5 to -7·5; moderate certainty); protection was increased as distance was lengthened (change in relative risk [RR] 2·02 per m; pinteraction=0·041; moderate certainty)."

Mayo Clinic Research Confirms the Critical Role of Masks-Chart
https://newsnetwork.mayoclinic.org/discussion/mayo-clinic-research-confirms-critical-role-of-masks-in-preventing-covid-19-infection/#
"I think we had some knowledge about the importance of masks and there's been a number of studies that have showed masks are effective in blocking viruses, but what's really important here is just how effective masking is when done by both parties," says Dr. Berbari."

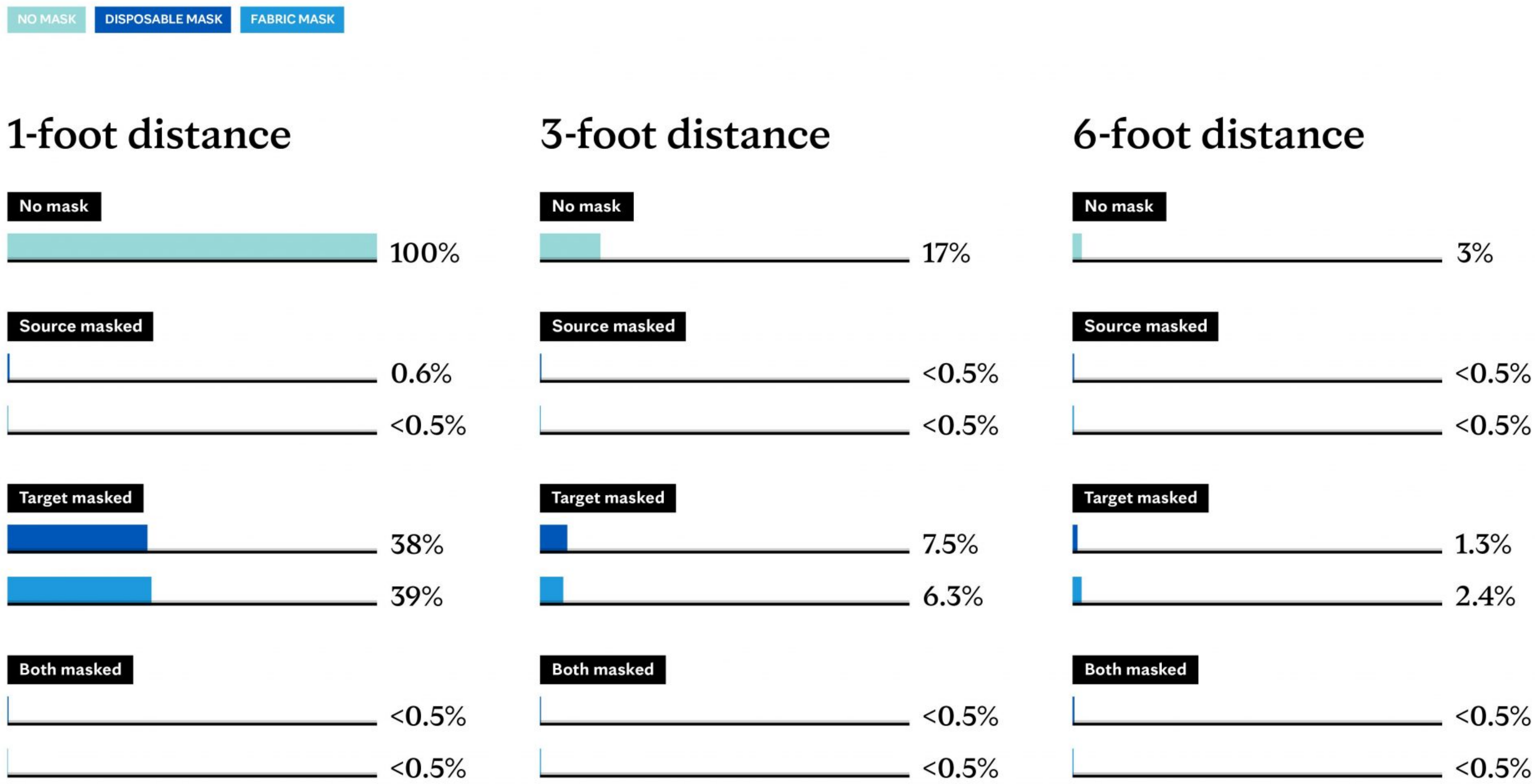
The District has thoroughly addressed concerns about operating schools during the pandemic and has valued the input and guidance of this Committee to assist with the daily protocols and practices. The one area that limits our ability to further return more students to school is pertaining to the area of "social / physical distancing" .
Given our local data, district practices, and the guidance that exists within the literature, if PHMDC provided latitude to move forward with less than 6ft social distancing where necessary, what are the thoughts on the committee regarding reopening further under these provisions?

VIII. **FUTURE MEETINGS**

IX. **ADJOURN**

"Any person who has a qualifying disability as defined by the Americans with Disabilities Act who requires assistance with access or materials should contact the Waunakee Community School District Office at 849-2000, 905 Bethel Circle Drive Waunakee, WI 53597, at least twenty-four hours prior to the commencement of the meeting so that necessary arrangements can be made to accommodate the request."

Exposure Risk Based on Masking and Distance



Source = person with active COVID-19

Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis

*Derek K Chu, Elie A Akl, Stephanie Duda, Karla Solo, Sally Yaacoub, Holger J Schünemann, on behalf of the COVID-19 Systematic Urgent Review Group Effort (SURGE) study authors**

Summary

Background Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) causes COVID-19 and is spread person-to-person through close contact. We aimed to investigate the effects of physical distance, face masks, and eye protection on virus transmission in health-care and non-health-care (eg, community) settings.

Methods We did a systematic review and meta-analysis to investigate the optimum distance for avoiding person-to-person virus transmission and to assess the use of face masks and eye protection to prevent transmission of viruses. We obtained data for SARS-CoV-2 and the betacoronaviruses that cause severe acute respiratory syndrome, and Middle East respiratory syndrome from 21 standard WHO-specific and COVID-19-specific sources. We searched these data sources from database inception to May 3, 2020, with no restriction by language, for comparative studies and for contextual factors of acceptability, feasibility, resource use, and equity. We screened records, extracted data, and assessed risk of bias in duplicate. We did frequentist and Bayesian meta-analyses and random-effects meta-regressions. We rated the certainty of evidence according to Cochrane methods and the GRADE approach. This study is registered with PROSPERO, CRD42020177047.

Findings Our search identified 172 observational studies across 16 countries and six continents, with no randomised controlled trials and 44 relevant comparative studies in health-care and non-health-care settings (n=25 697 patients). Transmission of viruses was lower with physical distancing of 1 m or more, compared with a distance of less than 1 m (n=10 736, pooled adjusted odds ratio [aOR] 0·18, 95% CI 0·09 to 0·38; risk difference [RD] –10·2%, 95% CI –11·5 to –7·5; moderate certainty); protection was increased as distance was lengthened (change in relative risk [RR] 2·02 per m; $p_{interaction}$=0·041; moderate certainty). Face mask use could result in a large reduction in risk of infection (n=2647; aOR 0·15, 95% CI 0·07 to 0·34, RD –14·3%, –15·9 to –10·7; low certainty), with stronger associations with N95 or similar respirators compared with disposable surgical masks or similar (eg, reusable 12–16-layer cotton masks; $p_{interaction}$=0·090; posterior probability >95%, low certainty). Eye protection also was associated with less infection (n=3713; aOR 0·22, 95% CI 0·12 to 0·39, RD –10·6%, 95% CI –12·5 to –7·7; low certainty). Unadjusted studies and subgroup and sensitivity analyses showed similar findings.

Interpretation The findings of this systematic review and meta-analysis support physical distancing of 1 m or more and provide quantitative estimates for models and contact tracing to inform policy. Optimum use of face masks, respirators, and eye protection in public and health-care settings should be informed by these findings and contextual factors. Robust randomised trials are needed to better inform the evidence for these interventions, but this systematic appraisal of currently best available evidence might inform interim guidance.

Funding World Health Organization.

Lancet 2020; 395: 1973–87

Published Online June 1, 2020 https://doi.org/10.1016/S0140-6736(20)31142-9

See Comment page 1950

*Study authors are listed in the appendix and at the end of the Article

Department of Health Research Methods, Evidence and Impact (D K Chu MD, S Duda MSc, K Solo MSc, Prof E A Akl MD, Prof H J Schünemann MD), **and Department of Medicine** (D K Chu, Prof H J Schünemann), **McMaster University, Hamilton, ON, Canada; The Research Institute of St Joe's Hamilton, Hamilton, ON, Canada** (D K Chu); **Department of Internal Medicine** (Prof E A Akl), **and Clinical Research Institute** (Prof E A Akl, S Yaacoub MPH), **American University of Beirut, Beirut, Lebanon; and Michael G DeGroote Cochrane Canada and GRADE Centres, Hamilton, ON, Canada** (Prof H J Schünemann)

Correspondence to: Prof Holger J Schünemann, Michael G DeGroote Cochrane Canada and McMaster GRADE Centres, McMaster University, Hamilton, ON L8N 3Z5, Canada **schuneh@mcmaster.ca**

See Online for appendix

Introduction

As of May 28, 2020, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has infected more than 5·85 million individuals worldwide and caused more than 359 000 deaths.[1] Emergency lockdowns have been initiated in countries across the globe, and the effect on health, wellbeing, business, and other aspects of daily life are felt throughout societies and by individuals. With no effective pharmacological interventions or vaccine available in the imminent future, reducing the rate of infection (ie, flattening the curve) is a priority, and prevention of infection is the best approach to achieve this aim.

SARS-CoV-2 spreads person-to-person through close contact and causes COVID-19. It has not been solved if

Research in context

Evidence before this study

We searched 21 databases and resources from inception to May 3, 2020, with no restriction by language, for studies of any design evaluating physical distancing, face masks, and eye protection to prevent transmission of the viruses that cause COVID-19 and related diseases (eg, severe acute respiratory syndrome [SARS] and Middle East respiratory syndrome [MERS]) between infected individuals and people close to them (eg, household members, caregivers, and health-care workers). Previous related meta-analyses have focused on randomised trials and reported imprecise data for common respiratory viruses such as seasonal influenza, rather than the pandemic and epidemic betacoronaviruses causative of COVID-19 (severe acute respiratory syndrome coronavirus 2 [SARS-CoV-2]), SARS (SARS-CoV), or MERS (MERS-CoV). Other meta-analyses have focused on interventions in the health-care setting and have not included non-health-care (eg, community) settings. Our search did not retrieve any systematic review of information on physical distancing, face masks, or eye protection to prevent transmission of SARS-CoV-2, SARS-CoV, and MERS-CoV.

Added value of this study

We did a systematic review of 172 observational studies in health-care and non-health-care settings across 16 countries and six continents; 44 comparative studies were included in a meta-analysis, including 25 697 patients with COVID-19, SARS, or MERS. Our findings are, to the best of our knowledge, the first to rapidly synthesise all direct information on COVID-19 and, therefore, provide the best available evidence to inform optimum use of three common and simple interventions to help reduce the rate of infection and inform non-pharmaceutical interventions, including pandemic mitigation in non-health-care settings. Physical distancing of 1 m or more was associated with a much lower risk of infection, as was use of face masks (including N95 respirators or similar and surgical or similar masks [eg, 12–16-layer cotton or gauze masks]) and eye protection (eg, goggles or face shields). Added benefits are likely with even larger physical distances (eg, 2 m or more based on modelling) and might be present with N95 or similar respirators versus medical masks or similar. Across 24 studies in health-care and non-health-care settings of contextual factors to consider when formulating recommendations, most stakeholders found these personal protection strategies acceptable, feasible, and reassuring but noted harms and contextual challenges, including frequent discomfort and facial skin breakdown, high resource use linked with the potential to decrease equity, increased difficulty communicating clearly, and perceived reduced empathy of care providers by those they were caring for.

Implications of all the available evidence

In view of inconsistent guidelines by various organisations based on limited information, our findings provide some clarification and have implications for multiple stakeholders. The risk for infection is highly dependent on distance to the individual infected and the type of face mask and eye protection worn. From a policy and public health perspective, current policies of at least 1 m physical distancing seem to be strongly associated with a large protective effect, and distances of 2 m could be more effective. These data could also facilitate harmonisation of the definition of exposed (eg, within 2 m), which has implications for contact tracing. The quantitative estimates provided here should inform disease-modelling studies, which are important for planning pandemic response efforts. Policy makers around the world should strive to promptly and adequately address equity implications for groups with currently limited access to face masks and eye protection. For health-care workers and administrators, our findings suggest that N95 respirators might be more strongly associated with protection from viral transmission than surgical masks. Both N95 and surgical masks have a stronger association with protection compared with single-layer masks. Eye protection might also add substantial protection. For the general public, evidence shows that physical distancing of more than 1 m is highly effective and that face masks are associated with protection, even in non-health-care settings, with either disposable surgical masks or reusable 12–16-layer cotton ones, although much of this evidence was on mask use within households and among contacts of cases. Eye protection is typically underconsidered and can be effective in community settings. However, no intervention, even when properly used, was associated with complete protection from infection. Other basic measures (eg, hand hygiene) are still needed in addition to physical distancing and use of face masks and eye protection.

SARS-CoV-2 might spread through aerosols from respiratory droplets; so far, air sampling has found virus RNA in some studies[2–4] but not in others.[5–8] However, finding RNA virus is not necessarily indicative of replication-competent and infection-competent (viable) virus that could be transmissible. The distance from a patient that the virus is infective, and the optimum person-to-person physical distance, is uncertain. For the currently foreseeable future (ie, until a safe and effective vaccine or treatment becomes available), COVID-19 prevention will continue to rely on non-pharmaceutical interventions, including pandemic mitigation in community settings.[9] Thus, quantitative assessment of physical distancing is relevant to inform safe interaction and care of patients with SARS-CoV-2 in both health-care and non-health-care settings. The definition of close contact or potentially exposed helps to risk stratify, contact trace, and develop guidance documents, but these definitions differ around the globe.

To contain widespread infection and to reduce morbidity and mortality among health-care workers and others in contact with potentially infected people, jurisdictions have issued conflicting advice about physical or social distancing. Use of face masks with or

6

without eye protection to achieve additional protection is debated in the mainstream media and by public health authorities, in particular the use of face masks for the general population;[10] moreover, optimum use of face masks in health-care settings, which have been used for decades for infection prevention, is facing challenges amid personal protective equipment (PPE) shortages.[11]

Any recommendations about social or physical distancing, and the use of face masks, should be based on the best available evidence. Evidence has been reviewed for other respiratory viral infections, mainly seasonal influenza,[12,13] but no comprehensive review is available of information on SARS-CoV-2 or related betacoronaviruses that have caused epidemics, such as severe acute respiratory syndrome (SARS) or Middle East respiratory syndrome (MERS). We, therefore, systematically reviewed the effect of physical distance, face masks, and eye protection on transmission of SARS-CoV-2, SARS-CoV, and MERS-CoV.

Methods

Search strategy and selection criteria

To inform WHO guidance documents, on March 25, 2020, we did a rapid systematic review.[14] We created a large international collaborative and we used Cochrane methods[15] and the GRADE approach.[16] We prospectively submitted the systematic review protocol for registration on PROSPERO (CRD42020177047; appendix pp 23–29). We have followed PRISMA[17] and MOOSE[18] reporting guidelines (appendix pp 30–33).

From database inception to May 3, 2020, we searched for studies of any design and in any setting that included patients with WHO-defined confirmed or probable COVID-19, SARS, or MERS, and people in close contact with them, comparing distances between people and COVID-19 infected patients of 1 m or larger with smaller distances, with or without a face mask on the patient, or with or without a face mask, eye protection, or both on the exposed individual. The aim of our systematic review was for quantitative assessment to ascertain the physical distance associated with reduced risk of acquiring infection when caring for an individual infected with SARS-CoV-2, SARS-CoV, or MERS-CoV. Our definition of face masks included surgical masks and N95 respirators, among others; eye protection included visors, faceshields, and goggles, among others.

We searched (up to March 26, 2020) MEDLINE (using the Ovid platform), PubMed, Embase, CINAHL (using the Ovid platform), the Cochrane Library, COVID-19 Open Research Dataset Challenge, COVID-19 Research Database (WHO), Epistemonikos (for relevant systematic reviews addressing MERS and SARS, and its COVID-19 Living Overview of the Evidence platform), EPPI Centre living systematic map of the evidence, ClinicalTrials.gov, WHO International Clinical Trials Registry Platform, relevant documents on the websites of governmental and other relevant organisations, reference lists of included papers, and relevant systematic reviews.[19,20] We handsearched (up to May 3, 2020) preprint servers (bioRxiv, medRxiv, and Social Science Research Network First Look) and coronavirus resource centres of *The Lancet*, *JAMA*, and *N Engl J Med* (appendix pp 3–5). We did not limit our search by language. We initially could not obtain three full texts for evaluation, but we obtained them through interlibrary loan or contacting a study author. We did not restrict our search to any quantitative cutoff for distance.

Data collection

We screened titles and abstracts, reviewed full texts, extracted data, and assessed risk of bias by two authors and independently, using standardised prepiloted forms (Covidence; Veritas Health Innovation, Melbourne, VIC, Australia), and we cross-checked screening results using artificial intelligence (Evidence Prime, Hamilton, ON, Canada). We resolved disagreements by consensus. We extracted data for study identifier, study design, setting, population characteristics, intervention and comparator characteristics, quantitative outcomes, source of funding

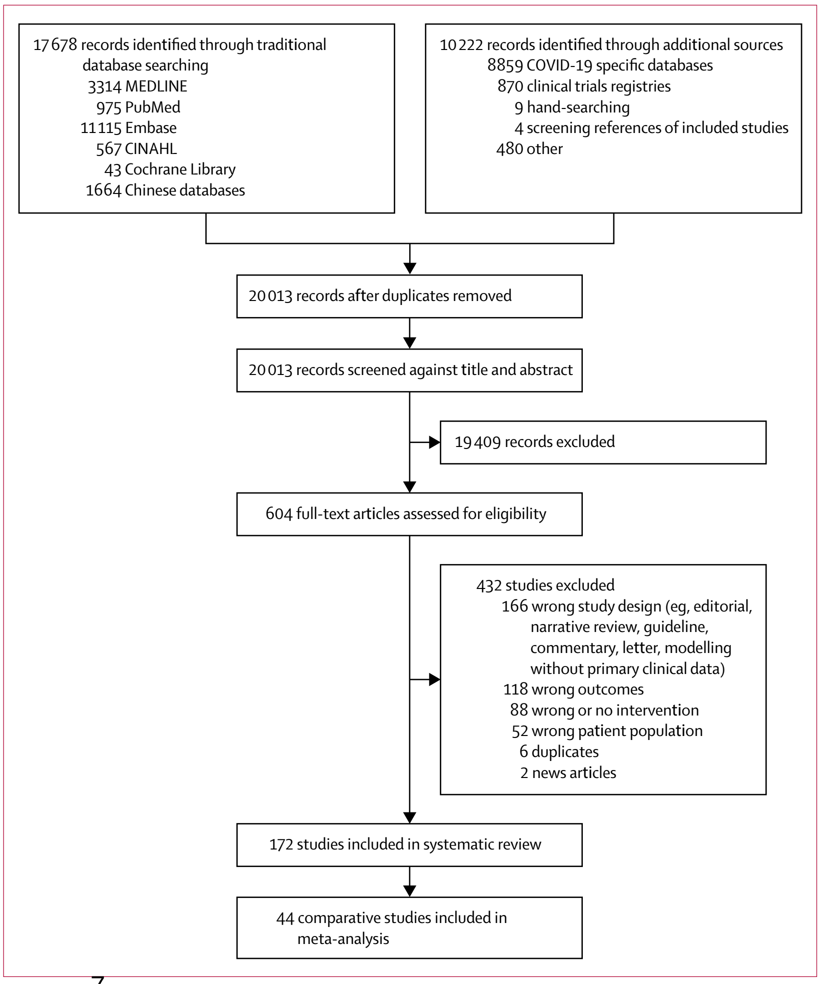


Figure 1: **Study selection**

	Population size (n)	Country	Setting	Disease caused by virus	Case definition (WHO)	Adjusted estimates	Risk of bias*
Alraddadi et al (2016)[34]	283	Saudi Arabia	Health care	MERS	Confirmed	Yes	********
Arwady et al (2016)[35]	79	Saudi Arabia	Non-health care (household and family contacts)	MERS	Confirmed	No	******
Bai et al (2020)[36]	118	China	Health care	COVID-19	Confirmed	No	*****
Burke et al (2020)[37]	338	USA	Health care and non-health care (including household and community)	COVID-19	Confirmed	No	****
Caputo et al (2006)[38]	33	Canada	Health care	SARS	Confirmed	No	*****
Chen et al (2009)[39]	758	China	Health care	SARS	Confirmed	Yes	*******
Cheng et al (2020)[40]	226	China	Non-health care (household and family contacts)	COVID-19	Confirmed	No	******
Ha et al (2004)[42]	117	Vietnam	Health care	SARS	Confirmed	No	**
Hall et al (2014)[43]	48	Saudi Arabia	Health care	MERS	Confirmed	No	***
Heinzerling et al (2020)[44]	37	USA	Health care	COVID-19	Confirmed	No	****
Ho et al (2004)[45]	372	Taiwan	Health care	SARS	Confirmed	No	********
Ki et al (2019)[47]	446	South Korea	Health care	MERS	Confirmed	No	******
Kim et al (2016)[48]	9	South Korea	Health care	MERS	Confirmed	No	*****
Kim et al (2016)[49]	1169	South Korea	Health care	MERS	Confirmed	No	******
Lau et al (2004)[50]	2270	China	Non-health care (households)	SARS	Probable	Yes	******
Liu et al (2009)[51]	477	China	Health care	SARS	Confirmed	Yes	*****
Liu et al (2020)[52]	20	China	Non-health care (close contacts)	COVID-19	Confirmed	No	*******
Loeb et al (2004)[53]	43	Canada	Health care	SARS	Confirmed	No	**
Ma et al (2004)[54]	426	China	Health care	SARS	Confirmed	Yes	*********
Nishiura et al (2005)[55]	115	Vietnam	Health care	SARS	Confirmed	Yes	********
Nishiyama et al (2008)[56]	146	Vietnam	Health care	SARS	Confirmed	Yes	******
Olsen et al (2003)[57]	304	China	Non-health care (airplane)	SARS	Confirmed	No	******
Park et al (2004)[58]	110	USA	Health care	SARS	Confirmed	No	**********
Park et al (2016)[59]	80	South Korea	Health care	MERS	Confirmed and probable	No	***
Peck et al (2004)[60]	26	USA	Health care	SARS	Confirmed	No	*********
Pei et al (2006)[61]	443	China	Health care	SARS	Confirmed	No	********
Rea et al (2007)[62]	8662	Canada	Non-health care (community contacts)	SARS	Probable	No	****
Reuss et al (2014)[63]	81	Germany	Health care	MERS	Confirmed	No	*****
Reynolds et al (2006)[64]	153	Vietnam	Health care	SARS	Confirmed	No	***
Ryu et al (2019)[65]	34	South Korea	Health care	MERS	Confirmed	No	******
Scales et al (2003)[66]	69	Canada	Health care	SARS	Probable	No	**
Seto et al (2003)[67]	254	China	Health care	SARS	Confirmed	Yes	********
Teleman et al (2004)[68]	86	Singapore	Health care	SARS	Confirmed	Yes	********
Tuan et al (2007)[69]	212	Vietnam	Non-health care (household and community contacts)	SARS	Confirmed	Yes	******
Van Kerkhove et al (2019)[46]	828	Saudi Arabia	Non-health care (dormitory)	MERS	Confirmed	Yes	********
Wang et al (2020)[41]	493	China	Health care	COVID-19	Confirmed	Yes	****

(Table 1 continues on next page)

	n	Country	Setting	Disease caused by virus	Case definition (WHO)	Adjusted estimates	Risk of bias*
(Continued from previous page)							
Wang et al (2020)[70]	5442	China	Health care	COVID-19	Confirmed	No	*****
Wiboonchutikul et al (2016)[71]	38	Thailand	Health care	MERS	Confirmed	No	*****
Wilder-Smith et al (2005)[72]	80	Singapore	Health care	SARS	Confirmed	No	********
Wong et al (2004)[73]	66	China	Health care	SARS	Confirmed	No	*****
Wu et al (2004)[74]	375	China	Non-health care (community)	SARS	Confirmed	Yes	********
Yin et al (2004)[75]	257	China	Health care	SARS	Confirmed	Yes	******
Yu et al (2005)[76]	74	China	Health care	SARS	Confirmed	No	*******
Yu et al (2007)[77]	124 wards	China	Health care	SARS	Confirmed	Yes	*******

Across studies, mean age was 30–60 years. SARS=severe acute respiratory syndrome. MERS=Middle East respiratory syndrome. *The Newcastle-Ottawa Scale was used for the risk of bias assessment, with more stars equalling lower risk.

Table 1: **Characteristics of included comparative studies**

and reported conflicts of interests, ethics approval, study limitations, and other important comments.

Outcomes

Outcomes of interest were risk of transmission (ie, WHO-defined confirmed or probable COVID-19, SARS, or MERS) to people in health-care or non-health-care settings by those infected; hospitalisation; intensive care unit admission; death; time to recovery; adverse effects of interventions; and contextual factors such as acceptability, feasibility, effect on equity, and resource considerations related to the interventions of interest. However, data were only available to analyse intervention effects for transmission and contextual factors. Consistent with WHO, studies generally defined confirmed cases with laboratory confirmation (with or without symptoms) and probable cases with clinical evidence of the respective infection (ie, suspected to be infected) but for whom confirmatory testing either had not yet been done for any reason or was inconclusive.

Data analysis

Our search did not identify any randomised trials of COVID-19, SARS, or MERS. We did a meta-analysis of associations by pooling risk ratios (RRs) or adjusted odds ratios (aORs) depending on availability of these data from observational studies, using DerSimonian and Laird random-effects models. We adjusted for variables including age, sex, and severity of source case; these variables were not the same across studies. Because between-study heterogeneity can be misleadingly large when quantified by I^2 during meta-analysis of observational studies,[21,22] we used GRADE guidance to assess between-study heterogeneity.[21] Throughout, we present RRs as unadjusted estimates and aORs as adjusted estimates.

We used the Newcastle-Ottawa scale to rate risk of bias for comparative non-randomised studies corresponding to every study's design (cohort or case-control).[23,24] We planned to use the Cochrane Risk of Bias tool 2.0 for randomised trials,[25] but our search did not identify any eligible randomised trials. We synthesised data in both narrative and tabular formats. We graded the certainty of evidence using the GRADE approach. We used the GRADEpro app to rate evidence and present it in GRADE evidence profiles and summary of findings tables[26,27] using standardised terms.[28,29]

For more on the **GRADEpro app** see https://www.gradepro.org

We analysed data for subgroup effects by virus type, intervention (different distances or face mask types), and setting (health care *vs* non-health care). Among the studies assessing physical distancing measures to prevent viral transmission, the intervention varied (eg, direct physical contact [0 m], 1 m, or 2 m). We, therefore, analysed the effect of distance on the size of the associations by random-effects univariate meta-regressions, using restricted maximum likelihood, and we present mean effects and 95% CIs. We calculated tests for interaction using a minimum of 10 000 Monte Carlo random permutations to avoid spurious findings.[30] We formally assessed the credibility of potential effect-modifiers using GRADE guidance.[21] We did two sensitivity analyses to test the robustness of our findings. First, we used Bayesian meta-analyses to reinterpret the included studies considering priors derived from the effect point estimate and variance from a meta-analysis of ten randomised trials evaluating face mask use versus no face mask use to prevent influenza-like illness in health-care workers.[31] Second, we used Bayesian meta-analyses to reinterpret the efficacy of N95 respirators versus medical masks on preventing influenza-like illness after seasonal viral (mostly influenza) infection.[13] For these sensitivity analyses, we used hybrid Metropolis-Hastings and Gibbs sampling, a 10 000 sample burn-in, 40 000 Markov chain Monte Carlo samples, and we tested non-informative and sceptical priors (eg, four time variance)[32,33] to inform

	Country	Respirator (0=no)	Distance (m)	Events, further distance (n/N)	Events, shorter distance (n/N)	RR (95% CI)	% weight (random)
MERS							
Van Kerkhove et al (2019)[46]	Saudi Arabia	0	0	8/774	11/54	0·05 (0·02–0·12)	5·5
Arwady et al (2016)[35]	Saudi Arabia	0	1	1/10	8/20	0·25 (0·04–1·73)	2·6
Ki et al (2019)[47]	South Korea	1	2	2/29	4/42	0·72 (0·14–3·70)	3·2
Park et al (2016)[59]	South Korea	0	2	0/3	5/25	0·59 (0·04–8·77)	1·6
Hall et al (2014)[43]	Saudi Arabia	1	1	0/5	0/43	(Not calculable)	0
Wiboonchutikul et al (2019)[71]	Thailand	1	1	0/16	0/22	(Not calculable)	0
Reuss et al (2014)[63]	Germany	1	2	0/12	0/69	(Not calculable)	0
Ryu et al (2019)[65]	South Korea	1	2	0/7	0/27	(Not calculable)	0
Random, subtotal (I^2=75%)				**11/856**	**28/302**	**0·23 (0·04–1·20)**	**12·9**
SARS							
Scales et al (2003)[66]	Canada	0	0	1/12	6/19	0·35 (0·05–2·57)	2·6
Ma et al (2004)[54]	China	1	0*	4/149	43/294	0·18 (0·07–0·50)	5·0
Nishiyama et al (2008)[56]	Vietnam	0	0	1/12	26/73	0·23 (0·03–1·57)	2·7
Tuan et al (2007)[69]	Vietnam	0	0	3/123	6/57	0·23 (0·06–0·89)	3·9
Rea et al (2007)[62]	Canada	0	1	18/3493	41/647	0·08 (0·05–0·14)	6·6
Chen et al (2009)[39]	China	0	1*	28/314	63/445	0·63 (0·41–0·96)	6·9
Lau et al (2004)[50]	China	0	1	39/965	136/1124	0·33 (0·24–0·47)	7·1
Liu et al (2009)[51]	China	0	0	14/133	39/341	0·92 (0·52–1·64)	6·5
Pei et al (2006)[61]	China	0	1	8/61	139/382	0·36 (0·19–0·70)	6·2
Wong et al (2004)[73]	China	0	1	0/4	3/3	0·11 (0·01–1·63)	1·7
Teleman et al (2004)[68]	Singapore	1	1	4/9	32/77	1·07 (0·49–2·33)	5·8
Reynolds et al (2006)[64]	Vietnam	0	1	5/38	17/29	0·22 (0·09–0·54)	5·5
Olsen et al (2003)[57]	China	0	1·5	9/84	11/35	0·34 (0·16–0·75)	5·8
Wong et al (2004)[73]	China	0	2	0/4	4/8	0·20 (0·01–3·00)	1·6
Loeb et al (2004)[53]	Canada	1	2*	0/11	8/40	0·20 (0·01–3·24)	1·6
Yu et al (2005)[76]	China	1	2	17/54	13/20	0·48 (0·29–0·81)	6·6
Peck et al (2004)[60]	USA	1	1	0/3	0/38	(Not calculable)	0
Random, subtotal (I^2=75%)				**151/5469**	**587/3632**	**0·35 (0·23–0·52)**	**76·1**
COVID-19							
Bai et al (2020)[36]	China	1	0	0/76	12/42	0·02 (0·001–0·37)	1·5
Burke et al (2020)[37]	USA	0	0	0/13	2/2	0·04 (0·003–0·68)	1·6
Liu et al (2020)[52]	China	0	1	0/17	2/3	0·04 (0·003–0·76)	1·5
Cheng et al (2020)[40]	Taiwan	0	1*	5/47	7/36	0·55 (0·19–1·58)	4·8
Heinzerling et al (2020)[44]	USA	0	1·8	0/4	3/33	0·97 (0·06–16·14)	1·5
Burke et al (2020)[37]	USA	1	0	0/50	0/76	(Not calculable)	0
Burke et al (2020)[37]	USA	0	2	0/41	0/37	(Not calculable)	0
Random, subtotal (I^2=59%)				**5/248**	**26/229**	**0·15 (0·03–0·73)**	**10·9**
Unadjusted estimates, overall (I^2=73%)				**167/6573**	**641/4163**	**0·30 (0·20–0·44)**	**100·0**
Adjusted estimates, overall (1 MERS, 8 SARS)						**aOR 0·18 (0·09–0·38)**	
						aRR 0·20 (0·10–0·41)	

Interaction by type of virus p=0·49

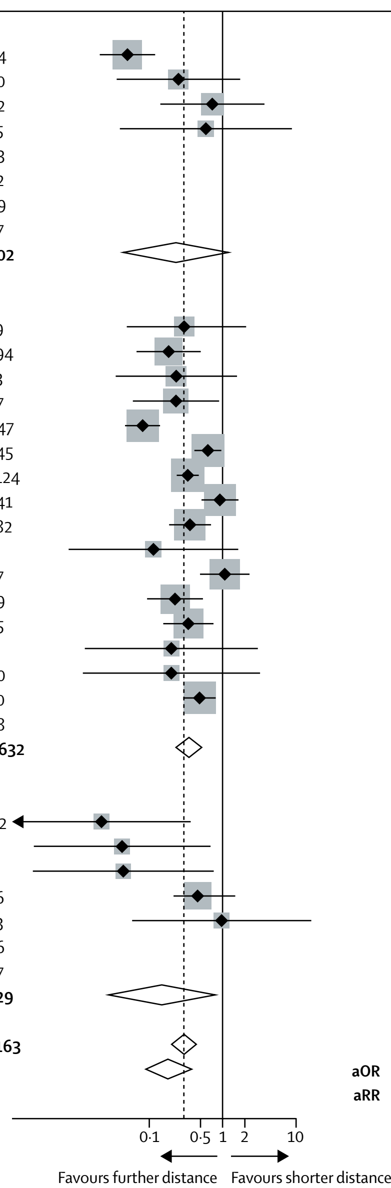


Figure 2: **Forest plot showing the association of COVID-19, SARS, or MERS exposure proximity with infection**
SARS=severe acute respiratory syndrome. MERS=Middle East respiratory syndrome. RR=relative risk. aOR=adjusted odds ratio. aRR=adjusted relative risk. *Estimated values; sensitivity analyses excluding these values did not meaningfully alter findings.

mean estimates of effect, 95% credibility intervals (CrIs), and posterior distributions. We used non-informative hyperpriors to estimate statistical heterogeneity. Model convergence was confirmed in all cases with good mixing in visual inspection of trace plots, autocorrelation plots, histograms, and kernel density estimates in all scenarios. Parameters were blocked, leading to acceptance of approximately 50% and efficiency greater than 1% in all cases (typically about 40%). We did analyses using Stata version 14.3.

Role of the funding source

The funder contributed to defining the scope of the review but otherwise had no role in study design and data collection. Data were interpreted and the report drafted and submitted without funder input, but according to contractual agreement, the funder provided review at the time of final publication. The corresponding author had full access to all data in the study and had final responsibility for the decision to submit for publication.

	Studies and participants	Relative effect (95% CI)	Anticipated absolute effect (95% CI), eg, chance of viral infection or transmission		Difference (95% CI)	Certainty*	What happens (standardised GRADE terminology)[29]
			Comparison group	Intervention group			
Physical distance ≥1 m *vs* <1 m	Nine adjusted studies (n=7782); 29 unadjusted studies (n=10 736)	aOR 0·18 (0·09 to 0·38); unadjusted RR 0·30 (95% CI 0·20 to 0·44)	Shorter distance, 12·8%	Further distance, 2·6% (1·3 to 5·3)	–10·2% (–11·5 to –7·5)	Moderate†	A physical distance of more than 1 m probably results in a large reduction in virus infection; for every 1 m further away in distancing, the relative effect might increase 2·02 times
Face mask *vs* no face mask	Ten adjusted studies (n=2647); 29 unadjusted studies (n=10 170)	aOR 0·15 (0·07 to 0·34); unadjusted RR 0·34 (95% CI 0·26 to 0·45)	No face mask, 17·4%	Face mask, 3·1% (1·5 to 6·7)	–14·3% (–15·9 to –10·7)	Low‡	Medical or surgical face masks might result in a large reduction in virus infection; N95 respirators might be associated with a larger reduction in risk compared with surgical or similar masks§
Eye protection (faceshield, goggles) *vs* no eye protection	13 unadjusted studies (n=3713)	Unadjusted RR 0·34 (0·22 to 0·52)¶	No eye protection, 16·0%	Eye protection, 5·5% (3·6 to 8·5)	–10·6% (–12·5 to –7·7)	Low‖	Eye protection might result in a large reduction in virus infection

Table based on GRADE approach.[26–29] Population comprised people possibly exposed to individuals infected with SARS-CoV-2, SARS-CoV, or MERS-CoV. Setting was any health-care or non-health-care setting. Outcomes were infection (laboratory-confirmed or probable) and contextual factors. Risk (95% CI) in intervention group is based on assumed risk in comparison group and relative effect (95% CI) of the intervention. All studies were non-randomised and evaluated using the Newcastle-Ottawa Scale; some studies had a higher risk of bias than did others but no important difference was noted in sensitivity analyses excluding studies at higher risk of bias; we did not further rate down for risk of bias. Although there was a high I^2 value (which can be exaggerated in non-randomised studies)[21] and no overlapping CIs, point estimates generally exceeded the thresholds for large effects and we did not rate down for inconsistency. We did not rate down for indirectness for the association between distance and infection because SARS-CoV-2, SARS-CoV, and MERS-CoV all belong to the same family and have each caused epidemics with sufficient similarity; there was also no convincing statistical evidence of effect-modification across viruses; some studies also used bundled interventions but the studies include only those that provide adjusted estimates. aOR=adjusted odds ratio. RR=relative risk. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. SARS-CoV=severe acute respiratory syndrome coronavirus. MERS-CoV=Middle East respiratory syndrome coronavirus. *GRADE category of evidence; high certainty (we are very confident that the true effect lies close to that of the estimate of the effect); moderate certainty (we are moderately confident in the effect estimate; the true effect is probably close to the estimate, but it is possibly substantially different); low certainty (our confidence in the effect estimate is limited; the true effect could be substantially different from the estimate of the effect); very low certainty (we have very little confidence in the effect estimate; the true effect is likely to be substantially different from the estimate of effect). †The effect is very large considering the thresholds set by GRADE, particularly at plausible levels of baseline risk, which also mitigated concerns about risk of bias; data also suggest a dose–response gradient, with associations increasing from smaller distances to 2 m and beyond, by meta-regression; we did not rate up for this domain alone but it further supports the decision to rate up in combination with the large effects. ‡The effect was very large, and the certainty of evidence could be rated up, but we made a conservative decision not to because of some inconsistency and risk of bias; hence, although the effect is qualitatively highly certain, the precise quantitative effect is low certainty. §In a subgroup analysis comparing N95 respirators with surgical or similar masks (eg, 12–16-layer cotton), the association was more pronounced in the N95 group (aOR 0·04, 95% CI 0·004–0·30) compared with other masks (0·33, 0·17–0·61; $p_{interaction}$=0·090); there was also support for effect-modification by formal analysis of subgroup credibility. ¶Two studies[54,75] provided adjusted estimates with n=295 in the eye protection group and n=406 in the group not wearing eye protection; results were similar to the unadjusted estimate (aOR 0·22, 95% CI 0·12–0·39). ‖The effect is large considering the thresholds set by GRADE assuming that ORs translate into similar magnitudes of RR estimates; this mitigates concerns about risk of bias, but we conservatively decided not to rate up for large or very large effects.

Table 2: **GRADE summary of findings**

Results

We identified 172 studies for our systematic review from 16 countries across six continents (figure 1; appendix pp 6–14, 41–47). Studies were all observational in nature; no randomised trials were identified of any interventions that directly addressed the included study populations. Of the 172 studies, 66 focused on how far a virus can travel by comparing the association of different distances on virus transmission to people (appendix pp 42–44). Of these 66 studies, five were mechanistic, assessing viral RNA, virions, or both cultured from the environment of an infected patient (appendix p 45).

44 studies were comparative[34–77] and fulfilled criteria for our meta-analysis (n=25 697; figure 1; table 1). We used these studies rather than case series and qualitative studies (appendix pp 41–47) to inform estimates of effect. 30 studies[34,37,41–45,47–51,53–56,58–61,64–70,72,74,75] focused on the association between use of various types of face masks and respirators by health-care workers, patients, or both with virus transmission. 13 studies[34,37–39,47,49,51,54,58,60,61,65,75] addressed the association of eye protection with virus transmission.

Some direct evidence was available for COVID-19 (64 studies, of which seven were comparative in design),[36,37,40,41,44,52,70] but most studies reported on SARS (n=55) or MERS (n=25; appendix pp 6–12). Of the 44 comparative studies, 40 included WHO-defined confirmed cases, one included both confirmed and probable cases, and the remaining three studies included probable cases. There was no effect-modification by case-definition (distance $p_{interaction}$=0·41; mask $p_{interaction}$=0·46; all cases for eye protection were confirmed). Most studies reported on bundled interventions, including different components of PPE and distancing, which was usually addressed by statistical adjustment. The included studies all occurred during recurrent or novel outbreak settings of COVID-19, SARS, or MERS.

Risk of bias was generally low-to-moderate after considering the observational designs (table 1), but both within studies and across studies the overall findings were similar between adjusted and unadjusted estimates. We did not detect strong evidence of publication bias in the body of evidence for any intervention (appendix pp 15–18). As we did not use case series data to inform estimates of effect of each intervention, we did not systematically rate risk of bias of these data. Therefore, we report further only those studies with comparative data.

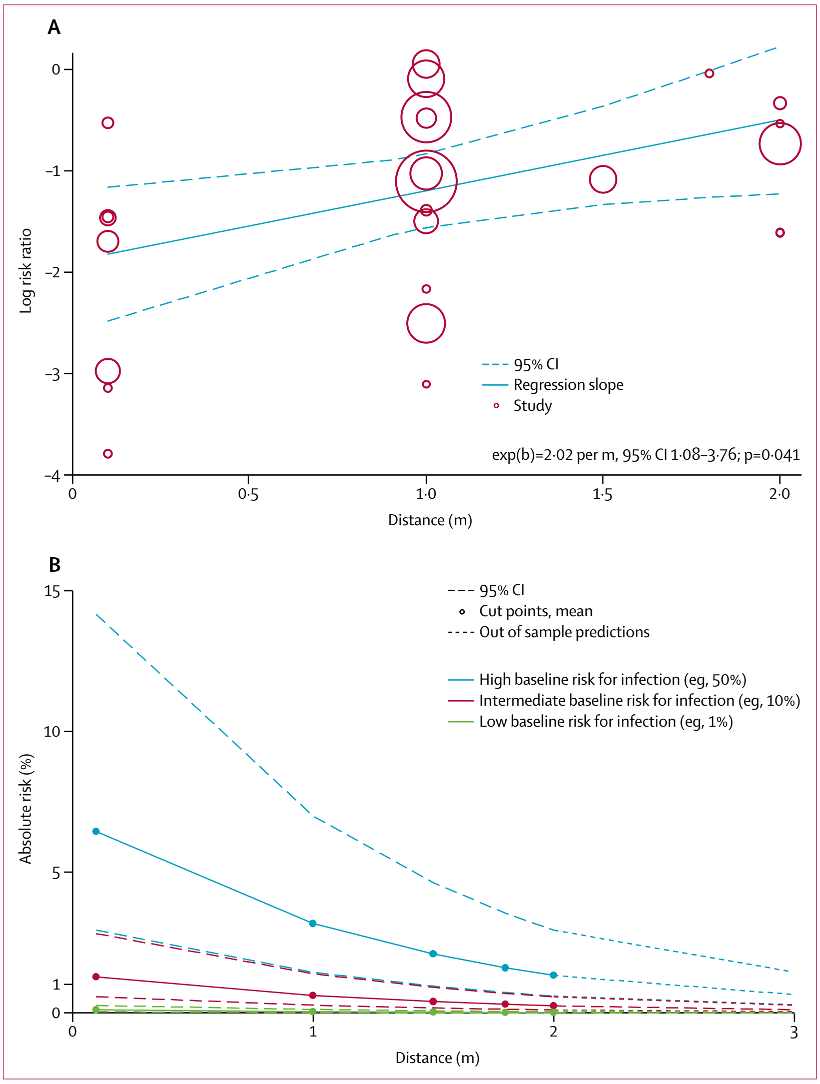


Figure 3: **Change in relative risk with increasing distance and absolute risk with increasing distance**
Meta-regression of change in relative risk with increasing distance from an infected individual (A). Absolute risk of transmission from an individual infected with SARS-CoV-2, SARS-CoV, or MERS-CoV with varying baseline risk and increasing distance (B). SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. SARS-CoV=severe acute respiratory syndrome coronavirus. MERS-CoV=Middle East respiratory syndrome coronavirus.

Across 29 unadjusted and nine adjusted studies,[35–37,39,40,43,44,46,47,50–54,56,57,59–66,68,69,71,73,76] a strong association was found of proximity of the exposed individual with the risk of infection (unadjusted n=10 736, RR 0·30, 95% CI 0·20 to 0·44; adjusted n=7782, aOR 0·18, 95% CI 0·09 to 0·38; absolute risk [AR] 12·8% with shorter distance *vs* 2·6% with further distance, risk difference [RD] –10·2%, 95% CI –11·5 to –7·5; moderate certainty; figure 2; table 2; appendix p 16). Although there were six studies on COVID-19, the association was seen irrespective of causative virus ($p_{interaction}$=0·49), health-care setting versus non-health-care setting ($p_{interaction}$=0·14), and by type of face mask ($p_{interaction}$=0·95; appendix pp 17, 19). However, different studies used different distances for the intervention. By meta-regression, the strength of association was larger with increasing distance (2·02 change in RR per m, 95% CI 1·08 to 3·76; $p_{interaction}$=0·041; moderate credibility subgroup effect; figure 3A; table 2). AR values with increasing distance given different degrees of baseline risk are shown in figure 3B, with potential values at 3 m also shown.

Across 29 unadjusted studies and ten adjusted studies,[34,37,41–45,47–51,53–56,58–61,64–70,72,74,75] the use of both N95 or similar respirators or face masks (eg, disposable surgical masks or similar reusable 12–16-layer cotton masks) by those exposed to infected individuals was associated with a large reduction in risk of infection (unadjusted n=10 170, RR 0·34, 95% CI 0·26 to 0·45; adjusted studies n=2647, aOR 0·15, 95% CI 0·07 to 0·34; AR 3·1% with face mask *vs* 17·4% with no face mask, RD –14·3%, 95% CI –15·9 to –10·7; low certainty; figure 4; table 2; appendix pp 16, 18) with stronger associations in health-care settings (RR 0·30, 95% CI 0·22 to 0·41) compared with non-health-care settings (RR 0·56, 95% CI 0·40 to 0·79; $p_{interaction}$=0·049; low-to-moderate credibility for subgroup effect; figure 4; appendix p 19). When differential N95 or similar respirator use, which was more frequent in health-care settings than in non-health-care settings, was adjusted for the possibility that face masks were less effective in non-health-care settings, the subgroup effect was slightly less credible ($p_{interaction}$=0·11, adjusted for differential respirator use; figure 4). Indeed, the association with protection from infection was more pronounced with N95 or similar respirators (aOR 0·04, 95% CI 0·004 to 0·30) compared with other masks (aOR 0·33, 95% CI 0·17 to 0·61; $p_{interaction}$=0·090; moderate credibility subgroup effect; figure 5). The interaction was also seen when additionally adjusting for three studies that clearly reported aerosol-generating procedures ($p_{interaction}$=0·048; figure 5). Supportive evidence for this interaction was also seen in within-study comparisons (eg, N95 had a stronger protective association compared with surgical masks or 12–16-layer cotton masks); both N95 and surgical masks also had a stronger association with protection versus single-layer masks.[38,39,51,53,54,61,66,67,75]

We did a sensitivity analysis to test the robustness of our findings and to integrate all available information on face mask treatment effects for protection from COVID-19. We reconsidered our findings using random-effects Bayesian meta-analysis. Although non-informative priors showed similar results to frequentist approaches (aOR 0·16, 95% CrI 0·04–0·40), even using informative priors from the most recent meta-analysis on the effectiveness of masks versus no masks to prevent influenza-like illness (RR 0·93, 95% CI 0·83–1·05)[31] yielded a significant association with protection from COVID-19 (aOR 0·40, 95% CrI 0·16–0·97; posterior probability for RR <1, 98%). Minimally informing (25% influence with or without four-fold smaller mean effect size) the most recent and rigorous meta-analysis of the effectiveness of N95

	Country	Respirator (0=no)	Infection	Events, face mask (n/N)	Events, no face mask (n/N)	RR (95% CI)	% weight (random)
Health-care setting							
Scales et al (2003)[66]	Canada	0	SARS	3/16	4/15	0·70 (0·19–2·63)	3·2
Liu et al (2009)[51]	China	0	SARS	8/123	43/354	0·54 (0·26–1·11)	6·7
Pei et al (2006)[61]	China	0	SARS	11/98	61/115	0·21 (0·12–0·38)	7·9
Yin et al (2004)[75]	China	0	SARS	46/202	31/55	0·40 (0·29–0·57)	10·3
Park et al (2016)[59]	South Korea	0	MERS	3/24	2/4	0·25 (0·06–1·06)	2·8
Kim et al (2016)[48]	South Korea	0	MERS	0/7	1/2	0·13 (0·01–2·30)	0·8
Heinzerling et al (2020)[44]	USA	0	COVID-19	0/31	3/6	0·03 (0·002–0·54)	0·9
Nishiura et al (2005)[55]	Vietnam	0	SARS	8/43	17/72	0·79 (0·37–1·67)	6·5
Nishiyama et al (2008)[56]	Vietnam	0	SARS	17/61	14/18	0·36 (0·22–0·58)	9·0
Reynolds et al (2006)[64]	Vietnam	0	SARS	8/42	14/25	0·34 (0·17–0·69)	6·7
Loeb et al (2004)[53]	Canada	1	SARS	3/23	5/9	0·23 (0·07–0·78)	3·6
Wang et al (2020)[41]	China	1	COVID-19	0/278	10/215	0·04 (0·002–0·63)	0·9
Seto et al (2003)[67]	China	1	SARS	0/51	13/203	0·15 (0·01–2·40)	0·9
Wang et al (2020)[70]	China	1	COVID-19	1/1286	119/4036	0·03 (0·004–0·19)	1·7
Alraddadi et al (2016)[34]	Saudi Arabia	1	MERS	6/116	12/101	0·44 (0·17–1·12)	5·0
Ho et al (2004)[45]	Singapore	1	SARS	2/62	2/10	0·16 (0·03–1·02)	1·9
Teleman et al (2004)[68]	Singapore	1	SARS	3/26	33/60	0·21 (0·07–0·62)	4·2
Wilder-Smith et al (2005)[72]	Singapore	1	SARS	6/27	39/71	0·40 (0·19–0·84)	6·5
Ki et al (2019)[47]	South Korea	1	MERS	0/218	6/230	0·08 (0·005–1·43)	0·8
Kim et al (2016)[49]	South Korea	1	MERS	1/444	16/308	0·04 (0·01–0·33)	1·6
Hall et al (2014)[43]	Saudi Arabia	1	MERS	0/42	0/6	(Not calculable)	0
Ryu et al (2019)[65]	South Korea	1	MERS	0/24	0/10	(Not calculable)	0
Park et al (2004)[58]	USA	1	SARS	0/60	0/45	(Not calculable)	0
Peck et al (2004)[60]	USA	1	SARS	0/13	0/19	(Not calculable)	0
Burke et al (2020)[37]	USA	1	COVID-19	0/64	0/13	(Not calculable)	0
Ha et al (2004)[42]	Vietnam	1	SARS	0/61	0/1	(Not calculable)	0
Random subtotal (I^2=50%)				**126/3442**	**445/6003**	**0·30 (0·22–0·41)**	**81·9**
Non-health-care setting							
Lau et al (2004)[50]	China	0	SARS	12/89	25/98	0·53 (0·28–0·99)	7·5
Wu et al (2004)[74]	China	0	SARS	25/146	69/229	0·57 (0·38–0·85)	9·7
Tuan et al (2007)[69]	Vietnam	0	SARS	0/9	7/154	1·03 (0·06–16·83)	0·9
Random subtotal (I^2=0%)				**37/244**	**101/481**	**0·56 (0·40–0·79)**	**18·1**
Unadjusted estimates, overall (I^2=48%)				**163/3686**	**546/6484**	**0·34 (0·26–0·45)**	**100·0**
Adjusted estimates, overall (1 COVID-19, 1 MERS, 8 SARS)						**aOR 0·15 (0·07–0·34)**	
						aRR 0·18 (0·08–0·38)	

Interaction by setting, p=0·049; adjusted for N95 and distance, p=0·11

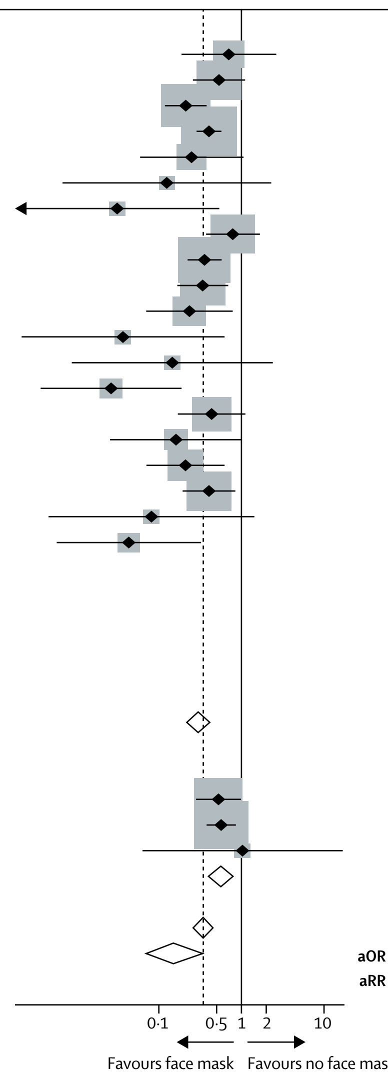


Figure 4: **Forest plot showing unadjusted estimates for the association of face mask use with viral infection causing COVID-19, SARS, or MERS**
SARS=severe acute respiratory syndrome. MERS=Middle East respiratory syndrome. RR=relative risk. aOR=adjusted odds ratio. aRR=adjusted relative risk.

respirators versus medical masks in randomised trials (OR 0·76, 95% CI 0·54–1·06)[13] with the effect-modification seen in this meta-analysis on COVID-19 (ratio of aORs 0·14, 95% CI 0·02–1·05) continued to support a stronger association of protection from COVID-19, SARS, or MERS with N95 or similar respirators versus other face masks (posterior probability for RR <1, 100% and 95%, respectively).

In 13 unadjusted studies and two adjusted studies,[34,37-39,47,49,51,54,58,60,61,65,75] eye protection was associated with lower risk of infection (unadjusted n=3713, RR 0·34, 95% CI 0·22 to 0·52; AR 5·5% with eye protection *vs* 16·0% with no eye protection, RD –10·6%, 95% CI –12·5 to –7·7; adjusted n=701, aOR 0·22, 95% CI 0·12 to 0·39; low certainty; figure 6; table 2; appendix pp 16–17).

Across 24 studies in health-care and non-health-care settings during the current pandemic of COVID-19, previous epidemics of SARS and MERS, or in general use, looking at contextual factors to consider in recommendations, most stakeholders found physical distancing and use of face masks and eye protection acceptable, feasible, and reassuring (appendix pp 20–22). However, challenges included frequent discomfort, high resource use linked with potentially decreased equity, less clear communication, and perceived reduced empathy of care providers by those they were caring for.

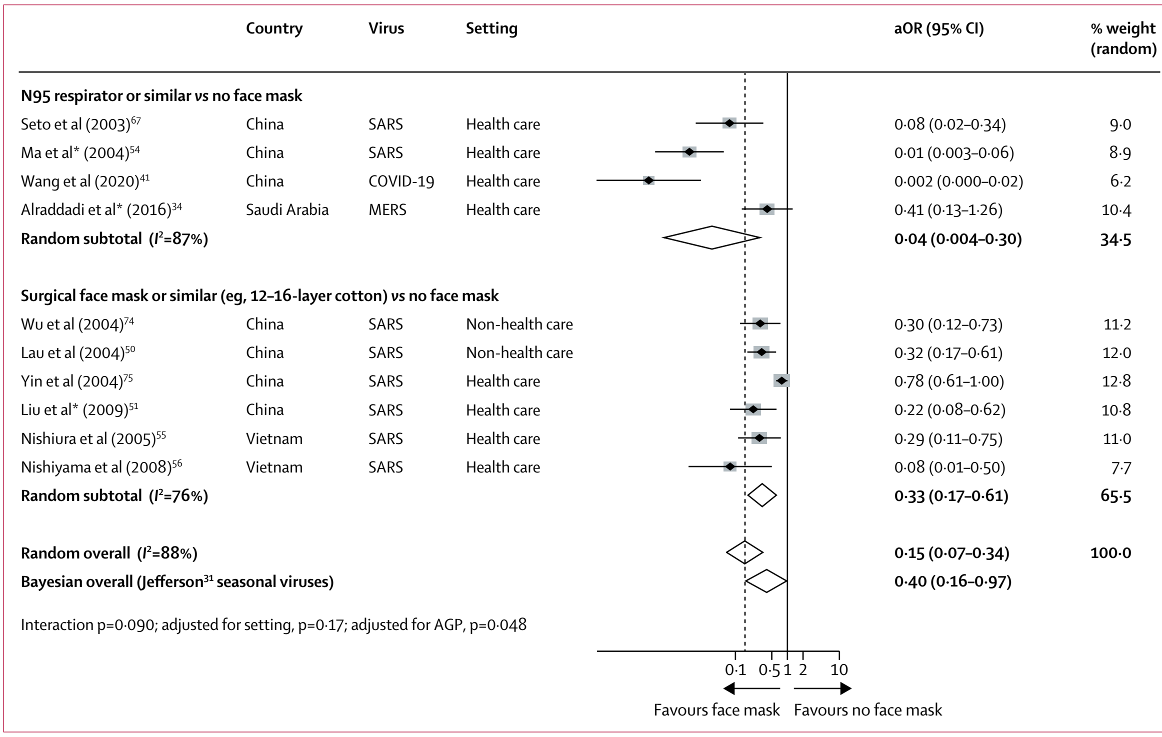


Figure 5: **Forest plot showing adjusted estimates for the association of face mask use with viral infection causing COVID-19, SARS, or MERS**
SARS=severe acute respiratory syndrome. MERS=Middle East respiratory syndrome. RR=relative risk. aOR=adjusted odds ratio. AGP=aerosol-generating procedures. *Studies clearly reporting AGP.

Discussion

The findings of this systematic review of 172 studies (44 comparative studies; n=25 697 patients) on COVID-19, SARS, and MERS provide the best available evidence that current policies of at least 1 m physical distancing are associated with a large reduction in infection, and distances of 2 m might be more effective. These data also suggest that wearing face masks protects people (both health-care workers and the general public) against infection by these coronaviruses, and that eye protection could confer additional benefit. However, none of these interventions afforded complete protection from infection, and their optimum role might need risk assessment and several contextual considerations. No randomised trials were identified for these interventions in COVID-19, SARS, or MERS.

Previous reviews are limited in that they either have not provided any evidence from COVID-19 or did not use direct evidence from other related emerging epidemic betacoronaviruses (eg, SARS and MERS) to inform the effects of interventions to curtail the current COVID-19 pandemic.[13,19,31,78] Previous data from randomised trials are mainly for common respiratory viruses such as seasonal influenza, with a systematic review concluding low certainty of evidence for extrapolating these findings to COVID-19.[13] Further, previous syntheses of available randomised controlled trials have not accounted for cluster effects in analyses, leading to substantial imprecision in treatment effect estimates. In between-study and within-study comparisons, we noted a larger effect of N95 or similar respirators compared with other masks. This finding is inconsistent with conclusions of a review of four randomised trials,[13] in which low certainty of evidence for no larger effect was suggested. However, in that review, the CIs were wide so a meaningful protective effect could not be excluded. We harmonised these findings with Bayesian approaches, using indirect data from randomised trials to inform posterior estimates. Despite this step, our findings continued to support the ideas not only that masks in general are associated with a large reduction in risk of infection from SARS-CoV-2, SARS-CoV, and MERS-CoV but also that N95 or similar respirators might be associated with a larger degree of protection from viral infection than disposable medical masks or reusable multilayer (12–16-layer) cotton masks. Nevertheless, in view of the limitations of these data, we did not rate the certainty of effect as high.[21] Our findings accord with those of a cluster randomised trial showing a potential benefit of continuous N95 respirator use over medical masks against seasonal viral infections.[79] Further high-quality research, including randomised trials of the optimum physical distance and the effectiveness of different types of masks in the general population and for health-care workers' protection, is urgently needed. Two trials are registered to better inform the optimum use of face masks for COVID-19 (NCT04296643 [n=576] and

	Country	Respirator (0=no)	Events, eye protection (n/N)	Events, no eye protection (n/N)	RR (95% CI)	% weight (random)
MERS						
Alraddadi et al (2016)[34]	Saudi Arabia	1	1/47	17/165	0·21 (0·03–1·51)	4·0
Ki et al (2019)[47]	South Korea	1	0/9	6/64	0·50 (0·03–8·21)	2·2
Kim et al (2016)[49]	South Korea	1	0/443	2/294	0·13 (0·01–2·76)	1·8
Ryu et al (2019)[65]	South Korea	1	0/24	0/10	(Not calculable)	0
Random subtotal (I^2=0%)			**1/523**	**25/533**	**0·24 (0·06–0·99)**	**8·0**
SARS						
Chen et al (2009)[39]	China	0	1/45	90/703	0·17 (0·02–1·22)	4·2
Liu et al (2009)[51]	China	0	17/221	34/256	0·58 (0·33–1·01)	21·2
Pei et al (2006)[61]	China	0	24/120	123/323	0·53 (0·36–0·77)	26·0
Yin et al (2004)[75]	China	0	10/120	67/137	0·17 (0·09–0·32)	19·4
Caputo et al (2006)[38]	Canada	1	2/46	4/32	0·35 (0·07–1·79)	5·6
Ma et al (2004)[54]	China	1	7/175	40/269	0·27 (0·12–0·59)	15·6
Park et al (2004)[58]	USA	1	0/30	0/72	(Not calculable)	0
Peck et al (2004)[60]	USA	1	0/13	0/19	(Not calculable)	0
Random subtotal (I^2=62%)			**61/770**	**358/1811**	**0·34 (0·21–0·56)**	**92·0**
COVID-19						
Burke et al (2020)[37]	USA	1	0/42	0/34	(Not calculable)	0
Random subtotal			**0/42**	**0/34**	**(Not calculable)**	**0**
Random overall (I^2=43%)			**62/1335**	**383/2378**	**0·34 (0·22–0·52)**	**100·0**
Adjusted estimates, overall (2 studies, Yin[75] and Ma[54])					**aOR 0·22 (0·12–0·39)**	
					aRR 0·25 (0·14–0·43)	
Interaction by virus, p=0·75						

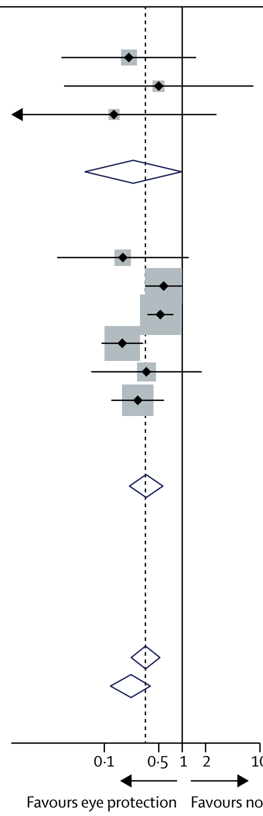


***Figure 6:* Forest plot showing the association of eye protection with risk of COVID-19, SARS, or MERS transmission**
Forest plot shows unadjusted estimates. SARS=severe acute respiratory syndrome. MERS=Middle East respiratory syndrome. RR=relative risk. aOR=adjusted odds ratio. aRR=adjusted relative risk.

NCT04337541 [n=6000]). Until such data are available, our findings represent the current best estimates to inform face mask use to reduce infection from COVID-19. We recognise that there are strong, perhaps opposing, sentiments about policy making during outbreaks. In one viewpoint, the 2007 SARS Commission report stated:

> "...recognize, as an aspect of health worker safety, the precautionary principle that reasonable action to reduce risk, such as the use of a fitted N95 respirator, need not await scientific certainty".[80]

> "...if we do not learn from SARS and we do not make the government fix the problems that remain, we will pay a terrible price in the next pandemic".[81]

A counter viewpoint is that the scientific uncertainty and contextual considerations require a more nuanced approach. Although challenging, policy makers must carefully consider these two viewpoints along with our findings.

We found evidence of moderate certainty that current policies of at least 1 m physical distancing are probably associated with a large reduction in infection, and that distances of 2 m might be more effective, as implemented in some countries. We also provide estimates for 3 m. The main benefit of physical distancing measures is to prevent onward transmission and, thereby, reduce the adverse outcomes of SARS-CoV-2 infection. Hence, the results of our current review support the implementation of a policy of physical distancing of at least 1 m and, if feasible, 2 m or more. Our findings also provide robust estimates to inform models and contact tracing used to plan and strategise for pandemic response efforts at multiple levels.

The use of face masks was protective for both health-care workers and people in the community exposed to infection, with both the frequentist and Bayesian analyses lending support to face mask use irrespective of setting. Our unadjusted analyses might, at first impression, suggest use of face masks in the community setting to be less effective than in the health-care setting, but after accounting for differential N95 respirator use between health-care and non-health-care settings, we did not detect any striking differences in effectiveness of

15

face mask use between settings. The credibility of effect-modification across settings was, therefore, low. Wearing face masks was also acceptable and feasible. Policy makers at all levels should, therefore, strive to address equity implications for groups with currently limited access to face masks and eye protection. One concern is that face mask use en masse could divert supplies from people at highest risk for infection.[10] Health-care workers are increasingly being asked to ration and reuse PPE,[82,83] leading to calls for government-directed repurposing of manufacturing capacity to overcome mask shortages[84] and finding solutions for mask use by the general public.[84] In this respect, some of the masks studied in our review were reusable 12–16-layer cotton or gauze masks.[51,54,61,75] At the moment, although there is consensus that SARS-CoV-2 mainly spreads through large droplets and contact, debate continues about the role of aerosol,[2–8,85,86] but our meta-analysis provides evidence (albeit of low certainty) that respirators might have a stronger protective effect than surgical masks. Biological plausibility would be supported by data for aerosolised SARS-CoV-2[5–8] and preclinical data showing seasonal coronavirus RNA detection in fine aerosols during tidal breathing,[87] albeit, RNA detection does not necessarily imply replication and infection-competent virus. Nevertheless, our findings suggest it plausible that even in the absence of aerosolisation, respirators might be simply more effective than masks at preventing infection. At present, there is no data to support viable virus in the air outside of aerosol generating procedures from available hospital studies. Other factors such as super-spreading events, the subtype of health-care setting (eg, emergency room, intensive care unit, medical wards, dialysis centre), if aerosolising procedures are done, and environmental factors such as ventilation, might all affect the degree of protection afforded by personal protection strategies, but we did not identify robust data to inform these aspects.

Strengths of our review include adherence to full systematic review methods, which included artificial intelligence-supported dual screening of titles and abstracts, full-text evaluation, assessment of risk of bias, and no limitation by language. We included patients infected with SARS-CoV-2, SARS-CoV, or MERS-CoV and searched relevant data up to May 3, 2020. We followed the GRADE approach[16] to rate the certainty of evidence. Finally, we identified and appraise a large body of published work from China, from which much evidence emerged before the pandemic spread to other global regions.

The primary limitation of our study is that all studies were non-randomised, not always fully adjusted, and might suffer from recall and measurement bias (eg, direct contact in some studies might not be measuring near distance). However, unadjusted, adjusted, frequentist, and Bayesian meta-analyses all supported the main findings, and large or very large effects were recorded. Nevertheless, we are cautious not to be overly certain in the precise quantitative estimates of effects, although the qualitative effect and direction is probably of high certainty. Many studies did not provide information on precise distances, and direct contact was equated to 0 m distance; none of the eligible studies quantitatively evaluated whether distances of more than 2 m were more effective, although our meta-regression provides potential predictions for estimates of risk. Few studies assessed the effect of interventions in non-health-care settings, and they primarily evaluated mask use in households or contacts of cases, although beneficial associations were seen across settings. Furthermore, most evidence was from studies that reported on SARS and MERS (n=6674 patients with COVID-19, of 25 697 total), but data from these previous epidemics provide the most direct information for COVID-19 currently. We did not specifically assess the effect of duration of exposure on risk for transmission, although whether or not this variable was judged a risk factor considerably varied across studies, from any duration to a minimum of 1 h. Because of inconsistent reporting, information is limited about whether aerosol-generating procedures were in place in studies using respirators, and whether masks worn by infected patients might alter the effectiveness of each intervention, although the stronger association with N95 or similar respirators over other masks persisted when adjusting for studies reporting aerosol-generating medical procedures. These factors might account for some of the residual statistical heterogeneity seen for some outcomes, albeit I^2 is commonly inflated in meta-analyses of observational data,[21,22] and nevertheless the effects seen were large and probably clinically important in all adjusted studies.

Our comprehensive systematic review provides the best available information on three simple and common interventions to combat the immediate threat of COVID-19, while new evidence on pharmacological treatments, vaccines, and other personal protective strategies is being generated. Physical distancing of at least 1 m is strongly associated with protection, but distances of up to 2 m might be more effective. Although direct evidence is limited, the optimum use of face masks, in particular N95 or similar respirators in health-care settings and 12–16-layer cotton or surgical masks in the community, could depend on contextual factors; action is needed at all levels to address the paucity of better evidence. Eye protection might provide additional benefits. Globally collaborative and well conducted studies, including randomised trials, of different personal protective strategies are needed regardless of the challenges, but this systematic appraisal of currently best available evidence could be considered to inform interim guidance.

Contributors

DKC, EAA, SD, KS, SY, and HJS designed the study. SY, SD, KS, and HJS coordinated the study. SY and LH designed and ran the literature search. All authors acquired data, screened records, extracted data, and assessed risk of bias. DKC did statistical analyses. DKC and HJS wrote the report. All authors provided critical conceptual input, analysed and interpreted data, and critically revised the report.

COVID-19 Systematic Urgent Review Group Effort (SURGE) study authors
Argentina—German Hospital of Buenos Aires (Ariel Izcovich); Canada—Cochrane Consumer Executive (Maureen Smith); McMaster University (Mark Loeb, Anisa Hajizadeh, Carlos A Cuello-Garcia, Gian Paolo Morgano, Leila Harrison, Tejan Baldeh, Karla Solo, Tamara Lotfi, Antonio Bognanni, Rosa Stalteri, Thomas Piggott, Yuan Zhang, Stephanie Duda, Derek K Chu, Holger J Schünemann); Southlake Regional Health Centre (Jeffrey Chan); University of British Columbia (David James Harris); Chile—Pontificia Universidad Católica de Chile (Ignacio Neumann); China—Beijing University of Chinese Medicine, Dongzhimen Hospital (Guang Chen); Guangzhou University of Chinese Medicine, The Fourth Clinical Medical College (Chen Chen); China Academy of Chinese Medical Sciences (Hong Zhao); Germany—Finn Schünemann; Italy—Azienda USL–IRCCS di Reggio Emilia (Paolo Giorgi Rossi); Universita Vita-Salute San Raffaele, Milan, Italy (Giovanna Elsa Ute Muti Schünemann); Lebanon—American University of Beirut (Layal Hneiny, Amena El-Harakeh, Fatimah Chamseddine, Joanne Khabsa, Nesrine Rizk, Rayane El-Khoury, Zahra Saad, Sally Yaacoub, Elie A Akl); Rafik Hariri University Hospital (Pierre AbiHanna); Poland—Evidence Prime, Krakow (Anna Bak, Ewa Borowiack); UK—The London School of Hygiene & Tropical Medicine (Marge Reinap); University of Hull (Assem Khamis).

Declaration of interests
ML is an investigator of an ongoing clinical trial on medical masks versus N95 respirators for COVID-19 (NCT04296643). All other authors declare no competing interests.

Acknowledgments
This systematic review was commissioned and in part paid for by WHO. The authors alone are responsible for the views expressed in this article and they do not necessarily represent the decisions, policy, or views of WHO. We thank Susan L Norris, April Baller, and Benedetta Allegranzi (WHO) for input in the protocol or the final article; Xuan Yu (Evidence Based Medicine Center of Lanzhou University, China), Eliza Poon, and Yuqing (Madison) Zhang for assistance with Chinese literature support; Neera Bhatnagar and Aida Farha (information specialists) for peer-reviewing the search strategy; Artur Nowak (Evidence Prime, Hamilton, ON, Canada) for help with searching and screening using artificial intelligence; and Christine Keng for additional support. DKC is a CAAIF-CSACI-AllerGen Emerging Clinician-Scientist Research Fellow, supported by the Canadian Allergy, Asthma and Immunology Foundation (CAAIF), the Canadian Society of Allergy and Clinical Immunology (CSACI), and AllerGen NCE (the Allergy, Genes and Environment Network).

Editorial note: the *Lancet* Group takes a neutral position with respect to territorial claims in published maps and institutional affiliations.

References

1 Worldometer. COVID-19 coronavirus pandemic. 2020. https://www.worldometers.info/coronavirus/ (accessed May 28, 2020).
2 Guo ZD, Wang ZY, Zhang SF, et al. Aerosol and surface distribution of severe acute respiratory syndrome coronavirus 2 in hospital wards, Wuhan, China, 2020. *Emerg Infect Dis* 2020; published online April 10. DOI:10.3201/eid2607.200885.
3 Chia PY, Coleman KK, Tan YK, et al. Detection of air and surface contamination by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in hospital rooms of infected patients. *medRxiv* 2020; published online April 9. DOI:10.1101/2020.03.29.20046557 (preprint).
4 Santarpia JL, Rivera DN, Herrera V, et al. Transmission potential of SARS-CoV-2 in viral shedding observed at the University of Nebraska Medical Center. *medRxiv* 2020; published online March 26. DOI:10.1101/2020.03.23.20039446 (preprint).
5 Cheng V, Wong S-C, Chen J, et al. Escalating infection control response to the rapidly evolving epidemiology of the coronavirus disease 2019 (COVID-19) due to SARS-CoV-2 in Hong Kong. *Infect Control Hosp Epidemiol* 2020; **41:** 493–98.
6 Wong SCY, Kwong RT-S, Wu TC, et al. Risk of nosocomial transmission of coronavirus disease 2019: an experience in a general ward setting in Hong Kong. *J Hosp Infect* 2020; **105:** 119–27.
7 Faridi S, Niazi S, Sadeghi K, et al. A field indoor air measurement of SARS-CoV-2 in the patient rooms of the largest hospital in Iran. *Sci Total Environ* 2020; **725:** 138401.
8 Ong SWX, Tan YK, Chia PY, et al. Air, surface environmental, and personal protective equipment contamination by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) from a symptomatic patient. *JAMA* 2020; **323:** 1610–12.
9 Qualls N, Levitt A, Kanade N, et al. Community mitigation guidelines to prevent pandemic influenza: United States, 2017. *MMWR Recomm Rep* 2017; **66:** 1–34.
10 Feng S, Shen C, Xia N, Song W, Fan M, Cowling BJ. Rational use of face masks in the COVID-19 pandemic. *Lancet Respir Med* 2020; **8:** 434–36.
11 MacIntyre R, Chughtai A, Tham CD, Seale H. COVID-19: should cloth masks be used by healthcare workers as a last resort? April 9, 2020. https://blogs.bmj.com/bmj/2020/04/09/covid-19-should-cloth-masks-be-used-by-healthcare-workers-as-a-last-resort/ (accessed May 12, 2020).
12 Loeb M, Dafoe N, Mahony J, et al. Surgical mask *vs* N95 respirator for preventing influenza among health care workers: a randomized trial. *JAMA* 2009; **302:** 1865–71.
13 Bartoszko JJ, Farooqi MAM, Alhazzani W, Loeb M. Medical masks vs N95 respirators for preventing COVID-19 in healthcare workers: a systematic review and meta-analysis of randomized trials. *Influenza Other Respir Viruses* 2020; published online April 4. DOI:10.1111/irv.12745.
14 Schünemann HJ, Moja L. Reviews: rapid! Rapid! Rapid! . . . and systematic. *Syst Rev* 2015; **4:** 4.
15 Cochrane Training. Cochrane handbook for systematic reviews of interventions, version 6. 2019. https://training.cochrane.org/handbook/current (accessed May 12, 2020).
16 Guyatt GH, Oxman AD, Vist GE, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ* 2008; **336:** 924–26.
17 Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *J Clin Epidemiol* 2009; **62:** 1006–12.
18 Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. *JAMA* 2000; **283:** 2008–12.
19 Jefferson T, Del Mar CB, Dooley L, et al. Physical interventions to interrupt or reduce the spread of respiratory viruses. *Cochrane Database Syst Rev* 2011; **7:** CD006207.
20 Offeddu V, Yung CF, Low MSF, Tam CC. Effectiveness of masks and respirators against respiratory infections in healthcare workers: a systematic review and meta-analysis. *Clin Infect Dis* 2017; **65:** 1934–42.
21 Guyatt GH, Oxman AD, Kunz R, et al. GRADE guidelines, 7: rating the quality of evidence—inconsistency. *J Clin Epidemiol* 2011; **64:** 1294–302.
22 Iorio A, Spencer FA, Falavigna M, et al. Use of GRADE for assessment of evidence about prognosis: rating confidence in estimates of event rates in broad categories of patients. *BMJ* 2015; **350:** h870.
23 Moskalewicz A, Oremus M. No clear choice between Newcastle-Ottawa Scale and Appraisal Tool for Cross-Sectional Studies to assess methodological quality in cross-sectional studies of health-related quality of life and breast cancer. *J Clin Epidemiol* 2020; **120:** 94–103.
24 Wells GA, Shea B, O'Connell D, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. 2019. http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp (accessed May 12, 2020).
25 Sterne JAC, Savović J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ* 2019; **366:** l4898.
26 Guyatt G, Oxman AD, Akl EA, et al. GRADE guidelines, 1: introduction—GRADE evidence profiles and summary of findings tables. *J Clin Epidemiol* 2011; **64:** 383–94.
27 Guyatt GH, Thorlund K, Oxman AD, et al. GRADE guidelines, 13: preparing summary of findings tables and evidence profiles—continuous outcomes. *J Clin Epidemiol* 2013; **66:** 173–83.
28 Santesso N, Carrasco-Labra A, Langendam M, et al. Improving GRADE evidence tables part 3: detailed guidance for explanatory footnotes supports creating and understanding GRADE certainty in the evidence judgments. *J Clin Epidemiol* 2016; **74:** 28–39.
29 Santesso N, Glenton C, Dahm P, et al. GRADE guidelines, 26: informative statements to communicate the findings of systematic reviews of interventions. *J Clin Epidemiol* 2020; **119:** 126–35.

30 Higgins JP, Thompson SG. Controlling the risk of spurious findings from meta-regression. *Stat Med* 2004; **23:** 1663–82.

31 Jefferson T, Jones M, Al Ansari LA, et al. Physical interventions to interrupt or reduce the spread of respiratory viruses, part 1: face masks, eye protection and person distancing—systematic review and meta-analysis. *medRxiv* 2020; published online April 7. DOI:10.1101/2020.03.30.20047217 (preprint).

32 Sutton AJ, Abrams KR. Bayesian methods in meta-analysis and evidence synthesis. *Stat Methods Med Res* 2001; **10:** 277–303.

33 Goligher EC, Tomlinson G, Hajage D, et al. Extracorporeal membrane oxygenation for severe acute respiratory distress syndrome and posterior probability of mortality benefit in a post hoc Bayesian analysis of a randomized clinical trial. *JAMA* 2018; **320:** 2251–59.

34 Alraddadi BM, Al-Salmi HS, Jacobs-Slifka K, et al. Risk factors for Middle East respiratory syndrome coronavirus infection among healthcare personnel. *Emerg Infect Dis* 2016; **22:** 1915–20.

35 Arwady MA, Alraddadi B, Basler C, et al. Middle East respiratory syndrome coronavirus transmission in extended family, Saudi Arabia, 2014. *Emerg Infect Dis* 2016; **22:** 1395–402.

36 Bai Y, Wang X, Huang Q, et al. SARS-CoV-2 infection in health care workers: a retrospective analysis and a model study. *medRxiv* 2020; published online April 1. DOI:10.1101/2020.03.29.20047159 (preprint).

37 Burke RM, Balter S, Barnes E, et al. Enhanced contact investigations for nine early travel-related cases of SARS-CoV-2 in the United States. *medRxiv* 2020; published online May 3. DOI:10.1101/2020.04.27.20081901 (preprint).

38 Caputo KM, Byrick R, Chapman MG, Orser BJ, Orser BA. Intubation of SARS patients: infection and perspectives of healthcare workers. *Can J Anaesth* 2006; **53:** 122–29.

39 Chen WQ, Ling WH, Lu CY, et al. Which preventive measures might protect health care workers from SARS? *BMC Public Health* 2009; **9:** 81.

40 Cheng H-Y, Jian S-W, Liu D-P, Ng T-C, Huang W-T, Lin H-H. High transmissibility of COVID-19 near symptom onset. *medRxiv* 2020; published online March 19. DOI:10.1101/2020.03.18.20034561 (preprint).

41 Wang X, Pan Z, Cheng Z. Association between 2019-nCoV transmission and N95 respirator use. *J Hosp Infect* 2020; **105:** 104–05.

42 Ha LD, Bloom SA, Hien NQ, et al. Lack of SARS transmission among public hospital workers, Vietnam. *Emerg Infect Dis* 2004; **10:** 265–68.

43 Hall AJ, Tokars JI, Badreddine SA, et al. Health care worker contact with MERS patient, Saudi Arabia. *Emerg Infect Dis* 2014; **20:** 2148–51.

44 Heinzerling A, Stuckey MJ, Scheuer T, et al. Transmission of COVID-19 to health care personnel during exposures to a hospitalized patient: Solano County, California, February 2020. *MMWR Morb Mortal Wkly Rep* 2020; **69:** 472–76.

45 Ho KY, Singh KS, Habib AG, et al. Mild illness associated with severe acute respiratory syndrome coronavirus infection: lessons from a prospective seroepidemiologic study of health-care workers in a teaching hospital in Singapore. *J Infect Dis* 2004; **189:** 642–47.

46 Van Kerkhove MD, Alaswad S, Assiri A, et al. Transmissibility of MERS-CoV infection in closed setting, Riyadh, Saudi Arabia, 2015. *Emerg Infect Dis J* 2019; **25:** 1802–09.

47 Ki HK, Han SK, Son JS, Park SO. Risk of transmission via medical employees and importance of routine infection-prevention policy in a nosocomial outbreak of Middle East respiratory syndrome (MERS): a descriptive analysis from a tertiary care hospital in South Korea. *BMC Pulm Med* 2019; **19:** 190.

48 Kim T, Jung J, Kim SM, et al. Transmission among healthcare worker contacts with a Middle East respiratory syndrome patient in a single Korean centre. *Clin Microbiol Infect* 2016; **22:** e11–13.

49 Kim CJ, Choi WS, Jung Y, et al. Surveillance of the Middle East respiratory syndrome (MERS) coronavirus (CoV) infection in healthcare workers after contact with confirmed MERS patients: incidence and risk factors of MERS-CoV seropositivity. *Clin Microbiol Infect* 2016; **22:** 880–86.

50 Lau JTF, Lau M, Kim JH, Tsui HY, Tsang T, Wong TW. Probable secondary infections in households of SARS patients in Hong Kong. *Emerg Infect Dis* 2004; **10:** 235–43.

51 Liu W, Tang F, Fang LQ, et al. Risk factors for SARS infection among hospital healthcare workers in Beijing: a case control study. *Trop Med Int Health* 2009; **14** (suppl 1): 52–59.

52 Liu ZQ, Ye Y, Zhang H, Guohong X, Yang J, Wang JL. Analysis of the spatio-temporal characteristics and transmission path of COVID-19 cluster cases in Zhuhai. *Trop Geogr* 2020; published online March 12. DOI:10.13284/j.cnki.rddl.003228.

53 Loeb M, McGeer A, Henry B, et al. SARS among critical care nurses, Toronto. *Emerg Infect Dis* 2004; **10:** 251–55.

54 Ma HJ, Wang HW, Fang LQ, et al. A case-control study on the risk factors of severe acute respiratory syndromes among health care workers. *Zhonghua Liu Xing Bing Xue Za Zhi* 2004; **25:** 741–44 (in Chinese).

55 Nishiura H, Kuratsuji T, Quy T, et al. Rapid awareness and transmission of severe acute respiratory syndrome in Hanoi French Hospital, Vietnam. *Am J Trop Med Hyg* 2005; **73:** 17–25.

56 Nishiyama A, Wakasugi N, Kirikae T, et al. Risk factors for SARS infection within hospitals in Hanoi, Vietnam. *Jpn J Infect Dis* 2008; **61:** 388–90.

57 Olsen SJ, Chang HL, Cheung TY, et al. Transmission of the severe acute respiratory syndrome on aircraft. *N Engl J Med* 2003; **349:** 2416–22.

58 Park BJ, Peck AJ, Kuehnert MJ, et al. Lack of SARS transmission among healthcare workers, United States. *Emerg Infect Dis* 2004; **10:** 244–48.

59 Park JY, Kim BJ, Chung KH, Hwang YI. Factors associated with transmission of Middle East respiratory syndrome among Korean healthcare workers: infection control via extended healthcare contact management in a secondary outbreak hospital. *Respirology* 2016; **21** (suppl 3): 89 (abstr APSR6-0642).

60 Peck AJ, Newbern EC, Feikin DR, et al. Lack of SARS transmission and U.S. SARS case-patient. *Emerg Infect Dis* 2004; **10:** 217–24.

61 Pei LY, Gao ZC, Yang Z, et al. Investigation of the influencing factors on severe acute respiratory syndrome among health care workers. *Beijing Da Xue Xue Bao Yi Xue Ban* 2006; **38:** 271–75.

62 Rea E, Laflèche J, Stalker S, et al. Duration and distance of exposure are important predictors of transmission among community contacts of Ontario SARS cases. *Epidemiol Infect* 2007; **135:** 914–21.

63 Reuss A, Litterst A, Drosten C, et al. Contact investigation for imported case of Middle East respiratory syndrome, Germany. *Emerg Infect Dis* 2014; **20:** 620–25.

64 Reynolds MG, Anh BH, Thu VH, et al. Factors associated with nosocomial SARS-CoV transmission among healthcare workers in Hanoi, Vietnam, 2003. *BMC Public Health* 2006; **6:** 207.

65 Ryu B, Cho SI, Oh MD, et al. Seroprevalence of Middle East respiratory syndrome coronavirus (MERS-CoV) in public health workers responding to a MERS outbreak in Seoul, Republic of Korea, in 2015. *Western Pac Surveill Response J* 2019; **10:** 46–48.

66 Scales DC, Green K, Chan AK, et al. Illness in intensive care staff after brief exposure to severe acute respiratory syndrome. *Emerg Infect Dis* 2003; **9:** 1205–10.

67 Seto WH, Tsang D, Yung RWH, et al. Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS). *Lancet* 2003; **361:** 1519–20.

68 Teleman MD, Boudville IC, Heng BH, Zhu D, Leo YS. Factors associated with transmission of severe acute respiratory syndrome among health-care workers in Singapore. *Epidemiol Infect* 2004; **132:** 797–803.

69 Tuan PA, Horby P, Dinh PN, et al. SARS transmission in Vietnam outside of the health-care setting. *Epidemiol Infect* 2007; **135:** 392–401.

70 Wang Q, Huang X, Bai Y, et al. Epidemiological characteristics of COVID-19 in medical staff members of neurosurgery departments in Hubei province: a multicentre descriptive study. *medRxiv* 2020; published online April 24. DOI:10.1101/2020.04.20.20064899 (preprint).

71 Wiboonchutikul S, Manosuthi W, Likanonsakul S, et al. Lack of transmission among healthcare workers in contact with a case of Middle East respiratory syndrome coronavirus infection in Thailand. *Antimicrob Resist Infect Control* 2016; **5:** 21.

72 Wilder-Smith A, Teleman MD, Heng BH, Earnest A, Ling AE, Leo YS. Asymptomatic SARS coronavirus infection among healthcare workers, Singapore. *Emerg Infect Dis* 2005; **11:** 1142–45.

73 Wong TW, Lee CK, Tam W, et al. Cluster of SARS among medical students exposed to single patient, Hong Kong. *Emerg Infect Dis* 2004; **10:** 269–76.

74 Wu J, Xu F, Zhou W, et al. Risk factors for SARS among persons without known contact with SARS patients, Beijing, China. *Emerg Infect Dis* 2004; **10:** 210–16.

75 Yin WW, Gao LD, Lin WS, et al. Effectiveness of personal protective measures in prevention of nosocomial transmission of severe acute respiratory syndrome. *Zhonghua Liu Xing Bing Xue Za Zhi* 2004; **25:** 18–22.

76 Yu ITS, Wong TW, Chiu YL, Lee N, Li Y. Temporal-spatial analysis of severe acute respiratory syndrome among hospital inpatients. *Clin Infect Dis* 2005; **40:** 1237–43.

77 Yu IT, Xie ZH, Tsoi KK, et al. Why did outbreaks of severe acute respiratory syndrome occur in some hospital wards but not in others? *Clin Infect Dis* 2007; **44:** 1017–25.

78 Verbeek JH, Rajamaki B, Ijaz S, et al. Personal protective equipment for preventing highly infectious diseases due to exposure to contaminated body fluids in healthcare staff. *Cochrane Database Syst Rev* 2019; **7:** CD011621.

79 MacIntyre CR, Wang Q, Seale H, et al. A randomized clinical trial of three options for N95 respirators and medical masks in health workers. *Am J Respir Crit Care Med* 2013; **187:** 960–66.

80 Campbell A. Chapter eight: it's not about the mask: SARS Commission final report, volume 3. December, 2006. http://www.archives.gov.on.ca/en/e_records/sars/report/v3-pdf/Vol3Chp8.pdf (accessed May 12, 2020).

81 Webster P. Ontario issues final SARS Commission report. *Lancet* 2007; **369:** 264.

82 Rimmer A. COVID-19: experts question guidance to reuse PPE. *BMJ* 2020; **369:** m1577.

83 Mackenzie D. Reuse of N95 masks. *Engineering* 2020; published online April 13. DOI:10.1016/j.eng.2020.04.003.

84 Greenhalgh T, Schmid MB, Czypionka T, Bassler D, Gruer L. Face masks for the public during the covid-19 crisis. *BMJ* 2020; **369:** m1435.

85 Bahl P, Doolan C, de Silva C, Chughtai AA, Bourouiba L, MacIntyre CR. Airborne or droplet precautions for health workers treating coronavirus disease 2019? *J Infect Dis* 2020; published online April 16. DOI:10.1093/infdis/jiaa189.

86 Schünemann HJ, Khabsa J, Solo K, et al. Ventilation techniques and risk for transmission of coronavirus disease, including COVID-19: a living systematic review of multiple streams of evidence. *Ann Intern Med* 2020; published online May 22. DOI:10.7326/M20-2306.

87 Leung NHL, Chu DKW, Shiu EYC, et al. Respiratory virus shedding in exhaled breath and efficacy of face masks. *Nat Med* 2020; **26:** 676–80.

TECHNICAL REPORT

COVID-19 in children and the role of school settings in transmission - first update

23 December 2020

Note regarding the evolving situation surrounding the new SARS-CoV-2 variant of concern (VOC 202012/01) identified in the United Kingdom

- This report does not consider the epidemiology of COVID-19 in relation to new variants of concern for SARS-CoV-2, such as one recently observed in the United Kingdom (VOC 202012/01), for which robust evidence on the potential impact in school settings is not yet available.
- The United Kingdom has released a statement that, on preliminary analysis, this variant appears to be more transmissible. There are media reports that the new variant may be more able to infect children, but this is not yet confirmed, and detailed data are awaited [1].
- Should these initial reports about increased transmissibility of VOC 20212/01 in children prove to be accurate, this could have implications for the effectiveness of intervention measures in school settings, and of potential school closures, in countries where there are high rates of circulation of this variant.
- ECDC will continue to monitor developments in relation to this new variant and its impact on transmissibility in children and any implications for school settings.

Key messages

- There is a general consensus that the decision to close schools to control the COVID-19 pandemic should be used as a last resort. The negative physical, mental health and educational impact of proactive school closures on children, as well as the economic impact on society more broadly, would likely outweigh the benefits.
- In surveillance data, among childhood COVID-19 cases, children between 1-18 years of age have lower rates of hospitalisation, severe hospitalisation and death than do all other age groups.
- Children of all ages are susceptible to and can transmit SARS-CoV-2. Younger children appear to be less susceptible to infection, and when infected, less often lead to onward transmission than older children and adults.
- This report does not consider the epidemiology of COVID-19 in relation to new variants of SARS-CoV-2, for which robust evidence on the potential impact in school settings is not yet available, such as one recently observed in the United Kingdom.
- School closures can contribute to a reduction in SARS-CoV-2 transmission, but by themselves are insufficient to prevent community transmission of COVID-19 in the absence of other non-pharmaceutical interventions (NPIs) such as restrictions on mass gathering.

Suggested citation: European Centre for Disease Prevention and Control. COVID-19 in children and the role of school settings in transmission - first update. Stockholm; 2020.
Erratum 12 January 2021: The reference list was corrected

- The return to school of children around mid-August 2020 coincided with a general relaxation of other NPI measures in many countries and does not appear to have been a driving force in the upsurge in cases observed in many EU Member States from October 2020. Trends in case notification rates observed since August 2020 for children aged 16-18 years most closely resemble those of adults aged 19-39 years.
- Transmission of SARS-CoV-2 can occur within school settings and clusters have been reported in preschools, primary and secondary schools. Incidence of COVID-19 in school settings appear to be impacted by levels of community transmission. Where epidemiological investigation has occurred, transmission in schools has accounted for a minority of all COVID-19 cases in each country.
- Educational staff and adults within the school setting are generally not seen to be at a higher risk of infection than other occupations, although educational roles that put one in contact with older children and/or many adults may be associated with a higher risk.
- Non-pharmaceutical interventions in school settings in the form of physical distancing that prevent crowding as well as hygiene and safety measures are essential to preventing transmission. Measures must be adapted to the setting and age group and consider the need to prevent transmission as well as to provide children with an optimal learning and social environment.

Glossary

School structures within EU/EEA Member States and the UK are heterogeneous, with children entering and moving through educational establishments at different ages [2]. Given this variation, it is not possible to define the age of attendance in EU education establishments with full consistency. Therefore, for the purposes of this document, the following classification has been used:

Adolescents	In this document older secondary school students are, at times, referred to as adolescents in order to reflect the term used in the literature.
Children	Children for this document are defined as 1-18 years. This report does not explicitly assess infants (0-1 years), although in some cases, children less than one year of age may have been included in reports on preschool or childcare settings.
Non-pharmaceutical intervention (NPI)	Non-pharmaceutical interventions (NPI) are public health measures that aim to prevent and/or control SARS-CoV-2 transmission in the community. NPIs can also be referred to as mitigation measures, and public health responses.
Proactive school closures	Early and planned closure of schools and daycare facilities to limit local virus transmission and spread at schools and into the community. School closure might also include provision of distance learning.
Reactive school closure	Closure in response to increased community transmission and/or a localised outbreak in a single educational facility and/or due to increased absenteeism among staff and students making it different to keep teaching going. School closure might also include provision of distance learning.
Schools/educational settings	The generic term used to define all educational establishments within the scope of the document, and it can be inferred that this includes all three categories of schools referred to above, unless otherwise stated. The terms school and educational setting are used interchangeably in this document.
Preschools/daycare	Establishments including childcare and daycare centres, nurseries and kindergartens for children approximately under five years of age, although these may include older children in some EU settings.
Primary schools	Establishments providing early-years compulsory education, which in most EU settings include children aged approximately 5–11 years.
Secondary schools	Education establishments for children aged approximately 12–18 years. Adolescents are included in this group.
Staff	Includes teachers, administrators and management, school nurses, janitors, cleaning and kitchen personnel, and other adults working in childcare and educational settings.

Scope of this document

The aim of this document is to provide an update on the knowledge surrounding the role of children in the transmission of SARS-CoV-2 and the role of schools in the COVID-19 pandemic, based on the experience in the EU from August–December, 2020. This document also addresses transmission to and from staff in school settings, school-related mitigation measures including risk communication, testing, contact tracing and the efficacy of partial and full school closures. This document draws upon and updates evidence presented in the previous report from ECDC on this topic, which was published on August 6, 2020 [3]. This report does not consider educational settings related to young adults or adults, such as universities or vocational schools or any school with overnight stays, such as boarding schools. This report does not consider the epidemiology of COVID-19 in relation to new variants of SARS-CoV-2, for which robust evidence on the potential impact in school settings is not yet available, such as one recently observed in the United Kingdom [4].

Target audience

The target audience for this report is public health authorities in EU/EEA countries and the UK.

Methodological approach

This document is based upon evidence presented in the ECDC document 'COVID-19 in children and the role of school settings in COVID-19 transmission', published on 6 August 2020. In addition to the evidence presented there, this current version draws upon evidence from the following sources:

- case-based epidemiological surveillance analysis from The European Surveillance System (TESSy);
- literature review (Annex 1);
- results from a survey sent out to EU Member States in November 2020 about COVID-19 cases in educational settings. The online survey included 10 questions (with follow-up questions), and was distributed across the EU/EEA countries and the UK (Annexes 2, V);
- ECDC Response measures database compiled from public online sources (Annex 3).

Detailed explanations on the methodology and description of the evidence can be found in the corresponding Annexes.

In the body of the document, the main findings are summarised and where feasible, an assessment of the confidence in the evidence is presented (see Table 1). The overall confidence in the evidence for key summary points has been estimated in the 'summary' sections in this report. ECDC experts assessed key summary statements according to GRADE criteria as well as the certainty/confidence of evidence (Table 1). Confidence in evidence was deemed to be lower where few empirical studies addressed a given topic or where a wide heterogeneity of study findings has been reported, and higher where multiple empirical studies have reported similar findings.

It is important to note that this document was not developed as a formal GRADE process. However, given the rapidly growing available evidence surrounding SARS-CoV-2 and COVID-19, it was deemed to be important to attempt to provide such assessments. As GRADE more generally notes: 'Quality of evidence is a continuum; any discrete categorisation involves some degree of arbitrariness. Nevertheless, advantages of simplicity, transparency, and vividness outweigh these limitations' [5].

Table 1. GRADE definitions for the ratings of the overall confidence of evidence [5]

Rating	Definition
High	This research provides a very good indication of the likely effect. The likelihood that the effect will be substantially different is low.
Moderate	This research provides a good indication of the likely effect. The likelihood that the effect will be substantially different is moderate.
Low	This research provides some indication of the likely effect. However, the likelihood that it will be substantially different (a large enough difference that it might have an effect on a decision) is high.
Very Low	This research does not provide a reliable indication of the likely effect. The likelihood that the effect will be substantially different (a large enough difference that it might have an effect on a decision) is very high.

A draft version of this report was circulated to all EU/EEA countries and the UK in order to provide the opportunity to validate country data and its interpretation.

1. What is the epidemiology of SARS-CoV-2 in children?

Summary

- Children aged 1-11 years are under-represented among cases compared with the general population, whereas the proportion of cases aged 12-18 years is broadly in line with the population distribution. As cases captured by COVID-19 surveillance may not be representative of all SARS-CoV-2 infections, surveillance data cannot determine whether younger children are less likely to be infected or are simply less likely to become a confirmed case; population-based studies are required (see Section 2.3).
- Among childhood COVID-19 cases in surveillance data, children between 1-18 years of age have lower rates of hospitalisation, severe hospitalisation and death than all other age groups. There is no evidence of a difference by age or sex in the risk of these severe outcomes among children, which contrasts with the strong age-sex association observed among adults (high confidence).
- Trends in case notification rates observed since August 2020 for children aged 16-18 years most closely resemble those of young adults. Increases in case notification rates were less steep and/or started later among the other childhood age groups, with decreasing age leading to shallower gradients and lower peak rates (high confidence).
- The return to school by children around mid-August 2020 does not appear to have been a driving force in the upsurge in cases observed in many EU Member States from October 2020 (moderate confidence).

1.1 Severity of COVID-19 among children

There was substantial media attention around cases of paediatric inflammatory multisystem syndrome that was temporally associated with SARS-CoV-2 infection. In an ECDC risk assessment on this topic it was found to be a rare event [6]. Analysis of over 1.8 million case-based records for a subset of EU/EEA countries submitted to TESSy between 1 August[i] and 29 November 2020 (Table 2) demonstrates the following:

- Children aged 1-11 years are under-represented among cases compared with the general population (aged >1 year in the countries included in the analysis). However, the proportion of cases in children aged 12-15 and 16-18 are roughly equal and slightly exceed, respectively, the proportion of the population between these ages. From surveillance data it is not possible to determine whether younger children <12 years of age are less likely to be infected by SARS-CoV-2 or are simply less likely to become a confirmed COVID-19 case (e.g. due to clinical presentation and/or testing strategies).
- Children of all ages are under-represented among cases experiencing severe outcomes (hospitalisation, severe hospitalisation, defined as admission to ICU or requiring respiratory support, or death).
- Absolute numbers of severely hospitalised or fatal cases among children are very low.
- In general, the age-specific risk (attack rate) of severe outcomes among children is low and increases with age among adults.

Table 2. Distribution and attack rates (AR) by age group and severe outcome of cases in TESSy, 1 August to 29 November 2020

Age group (years)	Population distribution (%)	Total cases n (%)	Hospitalised		Severe hospitalisation		Fatal	
			n (%)	AR, %	n (%)	AR, %	n (%)	AR, %
01-04	3.8	23 182 (1.3)	450 (0.4)	1.94	15 (0.1)	0.06	2 (0)	0.01
05-11	6.8	75 287 (4.2)	464 (0.4)	0.62	21 (0.1)	0.03	4 (0)	0.01
12-15	3.8	67 092 (3.7)	452 (0.4)	0.67	16 (0.1)	0.02	16 (0.1)	0.02
16-18	3.0	66 960 (3.7)	580 (0.5)	0.87	28 (0.2)	0.04	6 (0)	0.01
19-39	26.1	560 665 (31.0)	10 859 (9)	1.94	530 (3.4)	0.09	127 (0.6)	0.02
40-64	35.7	713 368 (39.4)	38 257 (31.5)	5.36	4 777 (31)	0.67	1 693 (8.1)	0.24
65+	20.8	301 905 (16.7)	70 212 (57.9)	23.26	10 025 (65)	3.32	19 036 (91.2)	6.31
Total	**100.0**	**1 808 459 (100.0)**	**121 274 (100.1)**	**6.71**	**15 412 (99.9)**	**0.85**	**20 884 (100)**	**1.15**

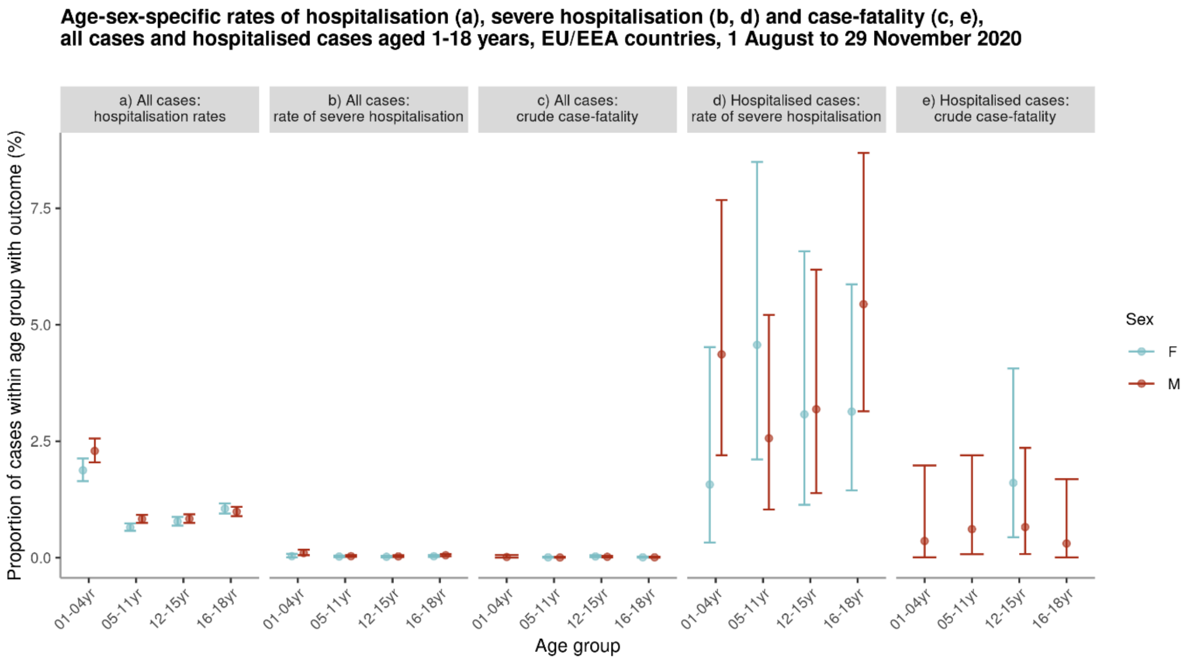
[i] 1 August 2020 was chosen as the start date for the analysis since most countries were experiencing low circulation and had greatly increased testing capacity compared with earlier in the pandemic, thus increasing the likelihood of detecting cases in children

Source: case-based data submitted to TESSy by Austria, Estonia, Finland, Germany, Ireland, Italy, Luxembourg, Malta, Norway, Poland and Slovakia, with date used for statistics between 1 August and 29 November 2020, restricted to records with complete information on hospitalisation, ICU and outcome. Severe hospitalisation: hospitalised cases requiring admission to ICU or respiratory support.

Table 2 suggests an elevated risk of hospitalisation among children aged 1 to 4 years compared with other childhood age groups. Additional analysis of a subset of these data, looking at age/sex-specific attack rates for severe outcomes in the same period, also showed this pattern, but when restricting the analysis to hospitalised patients only, there was no difference by age or sex in the risk of severe hospitalisation or death (Figure 1). Furthermore, the observed patterns of elevated risk of severe outcomes among adult males compared with females of the same age, and of risk that increases with age [7], are not present among children (Figure 1).

Overall, we can conclude from the surveillance data in TESSy that there is no evidence of a difference by age or sex in the risk of severe outcome among children.

Figure 1. Age-sex-specific rates of hospitalisation (a), severe hospitalisation (b, d) and case-fatality (c, e), all cases and hospitalised cases aged 1-18 years, EU/EEA countries, 1 August to 29 November 2020



Note: countries included in the above analysis were those with at least 50% variable completeness for the outcome among the population being analysed: a) Austria, Estonia, Finland, Germany, Ireland, Italy, Luxembourg, Malta, Norway, Poland and Slovakia; b) Austria, Finland, Germany, Ireland, Italy, Luxembourg and Slovakia; c) Germany, Italy, Norway, Poland and Slovakia; d) Germany, Ireland, Italy and Slovakia; e) Germany, Italy, Poland and Slovakia.

1.2 Age trends in notifications of COVID-19

Data from over 4.5 million case-based records submitted to TESSy from 17 countries show a notable increase in age-specific case notification rates among children aged 16-18 years that started in August 2020, which very closely matched that of adults aged 19-39 years, suggesting the behaviour and exposure of older teens is comparable with that of younger adults. Increases were less steep and/or started later among the other childhood age groups, with decreasing age leading to shallower gradients and lower peak rates (Figure 2). The start of the school year in mid-August to mid-September does not appear to have been temporally associated with any sudden increase in case rates among children, and the proportion of weekly cases notified among children followed similar curves between August and October, with the age groups older than 12 years peaking higher than the younger age groups (Figure 3). In contrast, a sharp increase in the proportion of cases aged 19-39 years was observed during August before this pattern shifted up the age bands, with a steady increase observed since September in the relative contribution of people aged 40-64 and 65 years and above to weekly case numbers (Figure 3). The temporal trends related to schools reopening in August and September are discussed further in Section 6.2.

Figure 2. 14-day age-specific COVID-19 case notification rate, selected EU/EEA countries

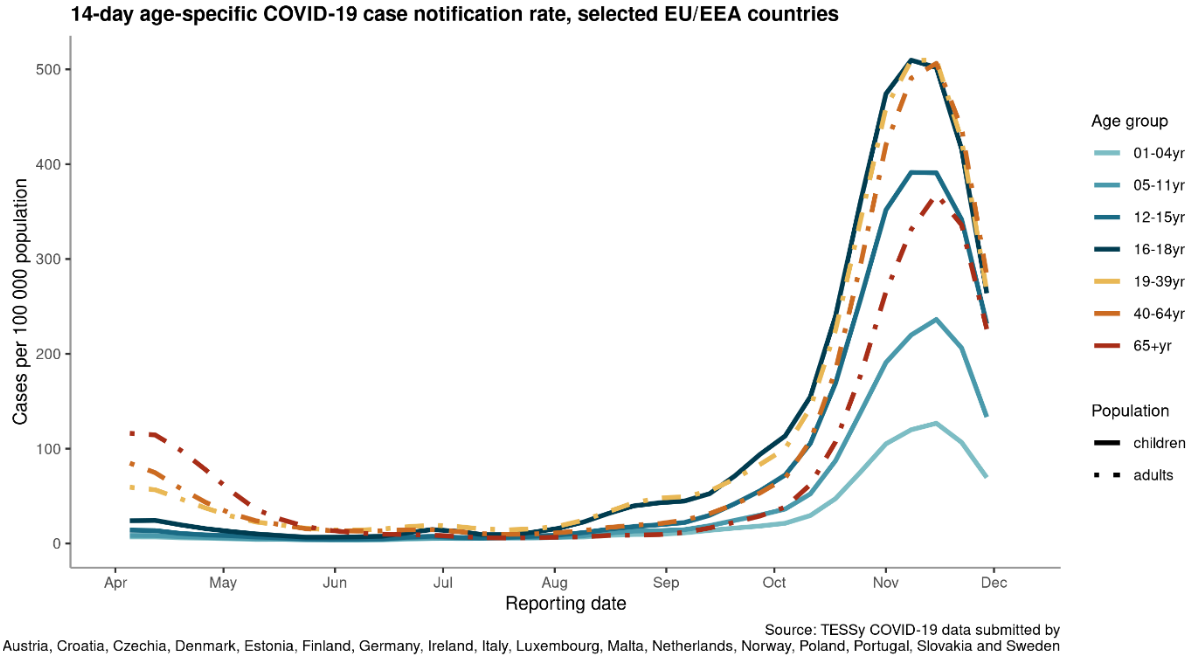
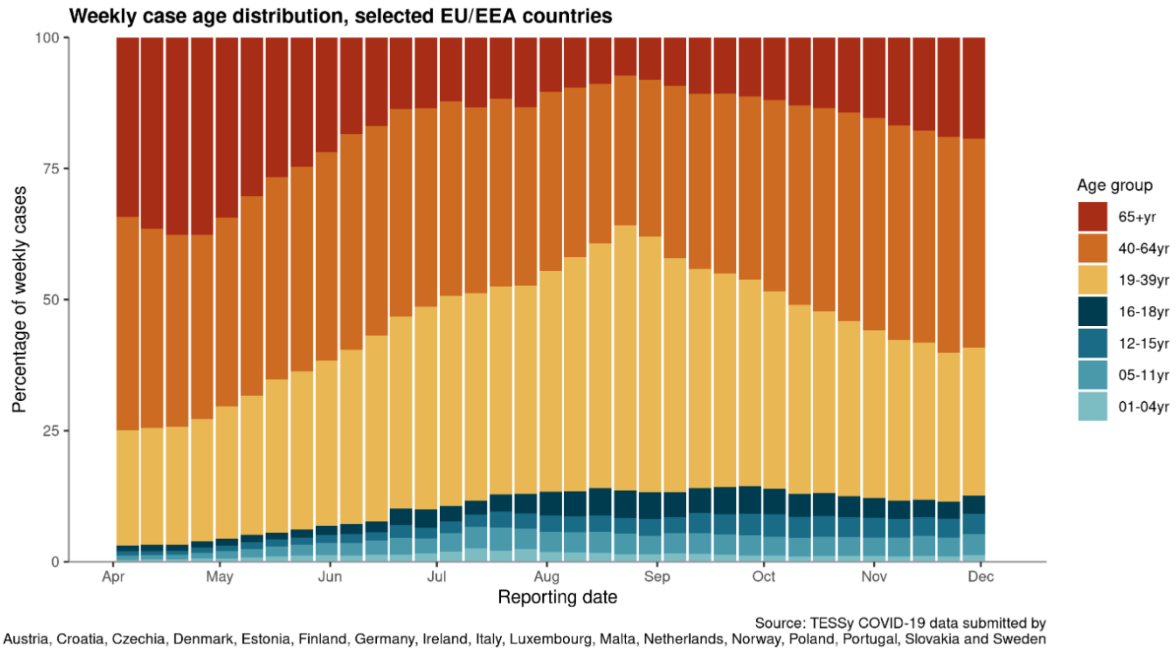


Figure 3. Weekly distribution of COVID-19 cases by age, selected EU/EEA countries



2. What is known about children and transmission of SARS-CoV-2 in household and community settings?

Summary

- Household and contact tracing studies indicate that younger children are less susceptible to SARS-CoV-2 infection than adults (low confidence).
- Infected children shed equivalent amounts of SARS-CoV-2 as adults (moderate confidence).
- Children appear to be asymptomatic for SARS-CoV-2 infection at least as often as adults (high confidence). However, estimating the proportion of asymptomatic infections among children is challenging, especially in younger children.
- Younger children (preschool and primary school aged) appear to transmit SARS-CoV-2 less often than adolescents and adults (low confidence), but younger children may also have been tested for SARS-CoV-2 less frequently than other age groups, while also having fewer opportunities for social mixing during periods of school closures than adolescents.
- Onward transmission by adolescents may occur as often as by adults in household and community settings, given social mixing patterns (moderate confidence).
- The literature, particularly for household studies, is currently reporting mixed results for secondary transmission by children. One factor behind this may be that many of the earlier available household and community studies were conducted when lockdowns and school closures were in full or partial effect, meaning that children had fewer social contacts than normal.
- The available literature does not consider the epidemiology of COVID-19 in relation to new variants of SARS-CoV-2, for which robust evidence on the potential impact in school settings is not yet available, such as one recently observed in the United Kingdom [1].
- Case identification in children may also have been limited by capacity gaps in testing or reluctance to test young children, particularly during the 'first wave', where children may not have been prioritised for testing or medical care due to significantly less frequent severe outcomes than e.g. older adults. Further, adequately powered prospective household and contact-tracing studies as well as population-based studies are required to make definitive statements about the relative rates of secondary transmission by children and adolescents compared with adults. Studies conducted among children that coincide with school openings may provide a more representative view of SARS-CoV-2 transmission among and by these age groups.

2.1 Viral shedding of SARS-CoV-2 among children

As presented previously [3], the shedding of viral RNA through the upper respiratory tract may be of a shorter duration in children than in adults. A systematic literature review identified an association between mean age and mean duration of viral RNA shedding in upper respiratory tract specimens [8]. In contrast, children may show prolonged viral shedding via the gastrointestinal route after clearing the virus from the respiratory tract [9].

It has been suggested that nasopharyngeal viral load in children under five years with mild to moderate COVID-19 symptoms is higher than in older children and adults [10]. There does not appear to be a significant difference in levels of viral RNA detected in nasopharyngeal swab samples between symptomatic children and symptomatic adults, indicating that children shed viral RNA (whether viable or not) in a similar manner to adults [10-12]. This does not, however, indicate if children transmit the infection to an equal extent, given that the exact load of viable virus is unknown.

2.2 Asymptomatic SARS-CoV-2 infection in children

Asymptomatic infection at the time of testing is well documented for SARS-CoV-2. A systematic review of 79 included studies of all age groups, estimated the proportion of people with asymptomatic SARS-CoV-2 infection to be 20% (95% CI: 17%-25%) [13-15]. The proportion was higher in seven studies where detection occurred through screening of all people in defined populations who were potentially exposed (31%; 95% CI: 26%-37%) [13]. A nationwide SARS-Cov-2 seroprevalence study from Spain concluded that asymptomatic cases represent between 21.9% and 35.8% of all SARS-CoV-2 infections [16].

Asymptomatic infection in children has been described in several large case series from China, which reported 4% to 28% asymptomatic paediatric cases among cases tested based on symptoms, signs or contact tracing [17-20]. A systematic review presenting data on 2 914 paediatric patients with COVID-19 from China, Spain, Iran, the Republic of Korea and the United States identified 14.9% asymptomatic cases in children [10]. A meta-analysis of 551 laboratory-confirmed cases in children reported 18% asymptomatic cases [21], while another study reported 16% asymptomatic cases among a European cohort of 582 children [22]. Similar observations were made for infants and neonates. In a review of 160 infants with confirmed COVID-19, 16% were asymptomatic [23]. A systematic review noted that the estimated proportion of asymptomatic infections was higher in hospitalised children than it was for hospitalised adults, noting 27% across 10 studies for children (95% CI: 22%-32%), and 11% across 15 studies for adults (95% CI: 6%-19%) [13]. In a study of all suspected cases and their contacts from Apulia, Italy, 104 of 166 (62.6%) children ascertained to be positive for SARS-CoV-2 were found to be asymptomatic [24].

Distinguishing between children who remain asymptomatic throughout the course of infection and those that are asymptomatic at the time of testing but who go on to develop symptoms after a positive PCR test (pre-symptomatic) is extremely challenging, particularly in younger children, because of challenges in reporting or describing mild symptoms and loss to follow-up. Studies that enrol children based upon the presentation of symptoms will under-estimate the extent of asymptomatic infection and over-estimate severe outcomes.

Seroprevalence studies may facilitate the evaluation of exposure rates and infection characteristics in children. When compared with adult populations, lower seroprevalence in children has been reported in Spain [16], Switzerland [25] and Italy [26]. Seroprevalence studies in Germany [27] and Belgium [28] found that 47% and 60%, respectively, of children with positive antibodies for SARS-CoV-2 reported having had COVID-19 compatible symptoms. However, more specialised seroprevalence studies need to be performed with a focus on children to better understand infection characteristics, infectiousness and antibody dynamics.

It has been observed that the risk of transmission varies by the symptom status of the index case. Two systematic reviews have reported that household secondary attack rates are significantly higher from symptomatic index cases than from asymptomatic or presymptomatic index cases [29,30]. However, few studies have been designed to estimate the proportion of asymptomatic infections among the general population.

2.3 Susceptibility of children to SARS-CoV-2 infection

Children, particularly those younger than 10-14 years, appear to be less susceptible to SARS-CoV-2 than adults 20 years and older, which would thus lead to lower prevalence among children and fewer opportunities for onward transmission (Annex 1.2). This finding is fairly consistent across three systematic literature reviews [30,31], although heterogeneity in study results has been reported [30,31]. In one of these studies, children (under 20 years of age) had a pooled odds ratio of being an infected contact of 0.56 (95% CI 0.37-0.85) compared with adults; albeit with substantial study heterogeneity [31]. Where studies categorised by age, the authors note lower susceptibility tended to be limited to those younger than 10-14 years [31].

Thus far, many published studies were conducted when schools were closed and social mixing opportunities, particularly for younger children, may have been quite limited. Explanations for lower infection rates in children have included low case ascertainment and asymptomatic or mild infection, but the age differential in infection rates has also been observed where asymptomatic contacts have been tested [29].

In assuming that all household contacts have an equal exposure risk to a given household index case, the authors of one systematic review hypothesised that assessing household contacts could provide a clearer indication of SARS-CoV-2 infection susceptibilities. In looking at household contacts only, the pooled OR of child household contacts versus adult household contacts was 0.41 (95% CI: 0.22-0.76) [31]. However, an elevated risk to spousal household contacts has also been reported; there appears to be a research gap in comparing child contacts to non-spouse adult contacts [29].

Children tend to have less severe COVID-19 outcomes than adults (Section 1.1) and, thus, children positive for SARS-CoV-2 may be under-represented in case-based reporting as well as in studies that have not tested asymptomatic contacts. Population-based studies, such as representative sampling, may help to address this gap. In Austria, a population-based study challenges the findings about childhood susceptibility to SARS-CoV-2 infection. A representative sample of 243 schools tested over 10 000 randomly sampled staff and students from primary and secondary school levels. Participants performed mouth and throat rinses through gargling for one minute. RT-qPCR tests for a SARS-CoV-2 infection were then conducted on these samples. Each positive test result is based on multiple independent PCR tests. For the first round, study period September 28–October 22, there was neither a statistically significant difference between prevalence of SARS-CoV-2 positive tests among primary school students and middle or lower secondary school students, nor between students and teachers [32]. This study did find that the risk of SARS-CoV-2 positivity in children was substantially higher among schools with higher shares of children from socially disadvantaged backgrounds (OR: 3.58). This study is ongoing and study participants are planned to be tested every 3-5 weeks at 10 different time points during the academic year 2020/2021.

2.4 Transmission of SARS-CoV-2 by children in community settings

There is evidence of children transmitting SARS-CoV-2 in community settings, but the existing literature is heterogeneous with regards to the relative rate at which they do so compared to adults (see Annex 1.2 for further details). Studies following paediatric cases in South Korea and Thailand, for example, found very few secondary cases. In South Korea, only one adult case was identified across all known close and casual contacts of the child [33]. In Thailand, all caregivers tested negative [34].

In contrast, a large contact tracing study from India concluded that that highest probability of transmission was between case-contact pairs of similar age, and that this pattern of enhanced transmission risk was highest among children 0-4 years of age as well as adults 65 years of age and older [35]. Although it is not reported, the assumption is that as this study occurred during a time of school closures, the data in this study reflects household transmission predominantly, suggesting that the enhanced transmission between similarly aged children is due to sibling interaction.

Adolescents and adults may be particularly amendable to onward transmission in settings with interactions like those in the household setting, notably overnight camps with mixed populations of children. This is demonstrated by two separate outbreaks in overnight camps where adolescent index cases led to outbreaks with high attack rates in Wisconsin, USA [36] and Georgia, USA [37], as well as by an outbreak at a three-week family gathering where an adolescent was also the index case [38].

2.5 Transmission of SARS-CoV-2 by children in household settings

There is a growing body of peer-reviewed studies that has assessed household child-to-child and child-to-adult transmission within shared living/household settings (see Annex I.3) [39]. There is a high degree of heterogeneity across these study findings.

Children have been rarely identified as index cases in household studies, although during the early phases of the COVID-19 pandemic, many children were not attending school and their social mixing opportunities were likely significantly lower than normal. Studies from Switzerland [40], USA [41], Israel [42] and Greece [43] each found few instances where children were the index cases among family clusters. Children were also found to very rarely lead to secondary transmission in Greece (no evidence of secondary transmission) and South Korea (secondary attack rate estimated to be 0.5%) [44].

Conversely, other studies have suggested relatively high secondary transmission rates from children and adolescents. Among the prominent examples is a household study from the USA which concluded that household transmission of SARS-CoV-2 is common, whether from children or adults. The overall secondary infection rate was 53%; where index cases were <12 years of age the secondary attack rate was also 53% (95% CI: 31%-74%), and from index patients aged 12-17 years the secondary attack rate was 38% (95% CI: 23%-53%) [45]. A study of 10 592 household contacts from South Korea identified COVID-19 in 11.8% of household contacts. Just 0.5% of index cases were 0-9 years old and 2.2% were between 10-19 years of age. For index cases under nine years old, the household secondary attack rate was 5.3%, the lowest rate in the study, but for index cases 10-19 years of age, the secondary attack rate among household contacts was 18.6%, the highest rate in the study [46]. Schools were closed at the time of this study, and the authors note that they were not able to assess the amount of interaction that children may have had with each other during this time.

3. What is known about SARS-CoV-2 transmission in school settings?

Summary

- Transmission of SARS-CoV-2 can occur within school settings and clusters have been reported by countries in preschool, primary and secondary schools (high confidence).
- In situations with high levels of community transmission, prevalence of COVID-19 within the school is influenced by the prevalence in the community (moderate confidence).
- Where epidemiological investigation is carried out and setting of infection data is available, transmission in schools account for a minority of all COVID-19 cases in a given country (moderate confidence).
- The available literature does not consider the epidemiology of COVID-19 in relation to new variants of SARS-CoV-2, such as one recently observed in the United Kingdom [1].
- Educational staff and adults within the school setting are generally at no higher risk of infection than other occupations although educational roles that put one in contact with many older children and/or many adults may be associated with higher risk (moderate confidence).
- The detection of multiple COVID-19 cases within a school does not automatically imply that transmission occurred within the school setting itself, making the calculation of reliable secondary attack rates in these settings challenging. Factors related to the level of community transmission and nature of contact with others appear to have a higher impact on one's risk of exposure than presence in a school. Although potentially influenced by mitigation measures enacted, similar COVID-19 rates in teachers and non-teachers indicate that schools are not settings of higher transmission and that schools are not settings that are fuelling community transmission.

3.1 Reported COVID-19 clusters in school settings in the EU

Since re-opening educational settings for the autumn term, 12 of the 17 countries[i] (71%) who responded to the survey reported that they detected clusters (≥2 cases with epidemiological link) of COVID-19 in these settings. Most clusters reported were in secondary school settings (n=1 185), followed by primary schools (n=739) and preschools (n=283) (Annex 3.1)[ii]. The number of clusters reported by countries varied from one in Latvia in a preschool setting to over 400 in Spain in secondary school settings. The maximum number of cases involved in the clusters was most often below ten cases but could also reach 80 or more cases. Eleven of the twelve countries for which data were available reported that clusters included both students and teachers, aside from Denmark, which indicated that only students were included in clusters in their country.

One country responding to the survey (Liechtenstein) stated that they have only seen individual cases in schools, but no clusters with an epidemiological link. This is an important consideration that needs to be made when interpreting data on COVID-19 cases in educational settings. The detection of multiple COVID-19 cases in an educational setting does not always confirm the presence of a cluster, as transmission in the school setting may not have taken place. The presence of multiple cases detected in the same school can be a consequence of community spread and multiple children bringing the infection from the community to the school. Robust outbreak investigations are needed to disentangle transmission chains and to draw conclusions about the role of school settings in community transmission. Nevertheless, as one country responding to the survey explained, such detailed outbreak investigations may not always be possible due to lack of human resources, making data on clusters in these settings unavailable (Annex 2.1).

Finally, in multiple countries that did not respond to the survey, the media reported on clusters of COVID-19 in educational settings [47-50]. However, it is not always known whether these cases have been fully investigated.

[i] Belgium, Bulgaria, Croatia, Denmark, Finland, Ireland, Latvia, Lithuania, the Netherlands, Romania, Spain, Sweden

[ii] During the study period, all types of school settings in the reporting countries were largely open. However, in general more countries have decided to re-close secondary schools at the end of the autumn term, compared with pre- or primary schools. See Annex 3 for an overview of school closures (at national level) reported from public sources over time in EU/EEA Member States and UK.

3.2 SARS-CoV-2 transmission in school settings: reports from the literature

The conclusion from the literature (Annex 1.4–1.7) is that SARS-CoV-2 transmission in schools is relatively uncommon. However, a limitation of these reports and other outbreak investigations in school settings is that they often do not consider asymptomatic cases. There is, furthermore, difficulty ascertaining whether transmission has occurred within the school or in community settings. In some instances, there is incomplete testing of index cases and their contacts making it difficult to determine transmissibility. There is also probably a high degree of underreporting of transmission events in school settings, given the capacity bottlenecks for contact tracing and diagnostic testing that many countries have experienced.

Schools comprise a minority of settings for COVID-19 transmission in countries with data on suspected location infection, and countries that have comprehensive data on cases in the school setting have found very low (<1%) prevalence of SARS-CoV-2 [32,51-55]. A case-control study from the USA of 397 paediatric SARS-CoV-2 infection found that in-person school or childcare attendance in the two weeks preceding the positive test was not associated with an increased likelihood of SARS-CoV-2 infection, whereas cases were more likely to have attended social activities and gatherings with people outside of the household [56].

Studies from England and Germany concluded that outbreaks of COVID-19 in schools comprise a relatively low share of all COVID-19 outbreaks during periods when schools were open [55,57]. A prospective, cross-sectional analysis of educational settings in England concluded that SARS-CoV-2 infections and outbreaks were uncommon in educational settings during the summer half-term, when schools were open [58]. A strong association with community transmission was observed: the risk of an outbreak in an educational setting increased by 72% (95CI: 28-130) for every increase in community incidence of five cases per 100 000. Most cases linked to outbreaks were staff, but observed probable transmission directions included staff-to-staff (26 outbreaks), staff-to-student (eight outbreaks), student-to-staff (16 outbreaks), and student-to-student (five outbreaks).

Investigations in Germany [59], France [60], Ireland [61], Australia [62], Singapore [63]and the USA [64] have found no or very low secondary attack rates within preschool, primary school, and secondary school settings. A contact tracing study from Italy identified a secondary attack rate of 0% in infant-toddler centres, 0.44% in primary schools, but a higher rate of 6.46% in secondary schools [65]. A large outbreak in secondary school setting occurred in Israel, in which some 260 persons were infected (students, staff members, relatives and friends) [66]. In Norway, a prospective contact tracing study of paediatric COVID-19 cases which followed 13 index cases and 292 primary school contacts found very low secondary attack rates; less than 1% among child contacts and less than 2% among adult staff contacts [67].

There are instances of reported outbreaks in preschool settings in the aforementioned studies from Australia [62] and USA [64]. A report from Salt Lake City, USA, identified three childcare facilities where 22 confirmed COVID-19 cases were identified across 101 staff and children [68]. In Poland, a cluster of 29 cases originated through a probable index case of an adult staff at a nursery. The authors concluded that there was a high infection attack rate among children but did not provide specific attack rates [69].

When it comes to adult-to-child transmission in school settings (Annex 1.5), reports from Poland [69], Australia [62] and Finland [70] refer to adults as index cases in school settings leading to secondary transmission among children, although in the Finnish study household or community transmission for some of the child cases could not be ruled out. Studies from Germany [59] and Italy [71,72], meanwhile, have suggested that if a child is infected by an adult, it is more likely to be in the household setting than a school setting.

Rates on transmission to adults, whether from children or adults in school settings have seldom been reported (Annex 1.6), which highlights the importance of assessing SARS-CoV-2 incidence across educational staff (Section 4.3). A study of educational settings in Australia noted an overall child-to-adult attack rate of 1.0% [62]. Staff were reported to have been infected in other school outbreaks, such as reported in Poland [69], Israel [62,66], Rhode Island, USA [64], and Salt Lake City, USA [68], but specific secondary attack rate data was not provided.

3.3 COVID-19 among educational staff

Transmission of SARS-CoV-2 within the workplace is difficult to assess, especially when there is ongoing transmission within the community, given that adults may become infected outside of the workplace. WHO finds that staff-to-staff transmission was the most common and that in school outbreaks, the virus is most likely introduced by adult personnel [73].

Data from the Public Health Agency of Sweden linked case-based data for the period 15 March-19 October with occupational registries and found that preschool, primary school and secondary school teachers were not at an increased risk of being diagnosed with COVID-19 compared with other occupational groups [74,75]. However, they did find an increased risk among principals for all school levels (RR 1.23, 95% CI 1.03-1.47).

The study does not differentiate the risk between teachers of children ages 6 to 12 years and teachers of children aged 13 to 15 years which may dilute the risk. Further, it mainly covers the first wave of the pandemic which may not be representative for the second wave where community transmission was identified in all age groups.

Data from the 2 September (the start of the school year) to 16 October 2020 from England found no differences in COVID-19 positivity rates between primary and secondary school teachers and other professions. A similar trend was seen when including household members of teachers, where no evidence of difference in positivity rates was noted [76].

An analysis of national data on occupation and COVID-19 infection and hospitalisation risk through 20 October 2020, from the Norwegian Institute of Public Health, found that when data were adjusted by age, sex and country of birth, teachers were not at significantly higher risk of COVID-19 infection [77]. However, preschool and childcare workers were at moderately increased risk of severe disease once COVID-19 was contracted compared with the Norwegian working population as a whole. National data from Denmark also indicates that COVID-19 infection rates in persons within the teaching sector do not differ from those of other working adults [78].

Other countries reported low prevalence in teachers. France reported 0.09% (1 020/1 162 850) of teaching personnel tested positive for SARS-CoV-2 on 27 November 2020 [51] and Austria reported 0.6% test positivity in teachers from a sample of 10 000 gargle tests taken from students and staff in educational settings between September and October 2020 [79].

Only a few countries responding to the survey had an overview of teacher/school staff absenteeism (Annex 2.3) making it difficult to assess whether this has increased since the start of the pandemic.

4. What can be done to mitigate SARS-CoV-2 transmission in school settings?

Summary

- An appropriate combination of non-pharmaceutical interventions in educational facilities can limit SARS-CoV-2 transmission (high confidence).
- The available evidence suggests that the combination of physical distancing approaches that prevent crowding (class room distancing, staggered arriving times, cancellation of certain indoor activities), especially in older age groups, together with hygiene and safety measures to minimise transmissions (hand washing, respiratory etiquette, cleaning, ventilation, face masks in certain circumstances), will have a role in preventing transmission in educational facilities. Measures should be implemented taking into consideration the age groups and the measures' impact on learning and psychosocial development.
- EU/EEA Member States and the United Kingdom currently recommend and implement physical distancing as well as hygiene and safety measures in educational facilities aimed at preventing SARS-CoV-2 transmission. Member States perceive a combination of measures to be the most effective approach.
- Risk communication and community engagement are crucial components of an effective response in the school setting.
- COVID-19 testing and contact tracing should be applied following the identification of SARS-CoV-2 positive cases in schools in order to rapidly identify cases and prevent further transmission.

4.1 Non-pharmaceutical interventions relevant to school settings

The ECDC COVID-19 guidelines for non-pharmaceutical interventions present public health measures that aim to prevent and/or control SARS-CoV-2 transmission in the community, many of which will also apply to the school setting [80]. These will consist of physical distancing measures as well as safety and hygiene-related measures. Physical distancing measures can be achieved with different approaches, some common approaches being:

- cohorts of classes and groups
- ensuring physical distance in the classroom (e.g. separating tables)
- reducing class sizes

- staggering arrival times as well as meal and break times
- holding classes outdoors.

Physical distancing measures should aim at decreasing the number of individuals and contacts in tight or closed spaces whilst ensuring schooling can take place. The selection of measures should consider the current knowledge of disease transmission in different age groups, and the feasibility and appropriateness of the measures for the age group, including the need to ensure learning and psychosocial development. It is important to consider the interactions within facilities among children/students, between educational staff and the children/students as well as among the educational staff/adults.

Examples of safety and hygiene-related measures include:

- the promotion of 'stay-at-home when sick' policy
- promoting respiratory hygiene and hand hygiene
- ensuring appropriate facility-cleaning
- ensuring appropriate ventilation
- implementing the use of face masks in the community for older age groups and adults (see WHO Advice on the use of masks for children in the community) [81].

Detailed information on the measures described above, including considerations for their implementation, can be found in dedicated ECDC guidelines and guidance, including the ECDC COVID-19 in children and the role of school settings and the ECDC COVID-19 guidelines for non-pharmaceutical interventions [3,80,82,83], as well as the WHO Advice on the use of masks for children in the community [81].

Looking at the scientific literature, a limited number of studies assessing the impact and effectiveness of measures in the school setting are currently available. A modelling study saw that in combination, the reduction of class density, the implementation of infection control measures (use of masks, distancing students in classroom, cleaning and outdoor teaching) and the rapid detection of infectious cases (through testing), would together have an impact on reducing SARS-CoV-2 prevalence [84]. Similarly, a pre-print study on New York City schools calculated that infection control measures (including physical distancing, hand washing and access to sanitisers, ventilation and face masks use) had the greatest impact on reducing transmission in the school setting, followed by class cohorts with the option of remote learning [85].

A recent study based in Korea did not observe an impact on the number of reported paediatric COVID-19 cases when schools were opened [86] after a two-month closure period. The authors further reported that the number of identified school outbreaks were limited in all levels of education (daycare through to high school) after the re-opening of schools, indicative of the impact of the introduced protective measures (symptom monitoring, personal hygiene, wearing masks and distancing among students).

After experiencing a large SARS-CoV-2 outbreak in a high school in Jerusalem, authors pointed to the importance of; preventing crowded gatherings within the schools (e.g. smaller classes, limiting mixing of students in activities and transportation), complying to safety and hygiene measures (hand washing, use of mask), ensuring compliance to 'stay at home if sick' policies and considering remote teaching, in preventing SARS-CoV-2 transmission in the school setting [66].

In the ECDC survey conducted for the purpose of this guidance, when asked what measures, in their opinion, were the most effective, Member States generally noted that a combination of measures was needed to be effective (Annex 2.5.). In general, hygiene and distancing (reducing close contacts, staying home when sick, etc.) were cited as commonly effective measures with ventilation and contact tracing.

In summary, from the limited number of available studies, non-pharmaceutical interventions in schools to prevent SARS-CoV-2 transmission do play a role. It has not been possible, thus far, to assess the effectiveness of individual measures. However, although limited, the available evidence suggests that common physical distancing (cohorts, smaller groups, class room distancing) approaches that prevent crowding, especially in older age groups, together with common safety and hygiene measures to minimise transmission (hand washing, respiratory etiquette, cleaning, ventilation, facial masks in certain circumstances), do have a role in supporting a transmission-free school environment.

4.2 EU Member State implementation and perspectives on NPIs in school settings

Of the 17 countries that responded to the ECDC survey, all countries reported having implemented multiple in-school mitigation measures in the majority of schools, and the measures addressed both physical distancing, as well as hygiene and safety (Table 3 and Annex 2.5). The mean and median number of in-school mitigation measures recommended by responding countries was 13 with a range of 7 to 20 measures, and an interquartile range of 11 to 16 measures in school settings (Annex 2.5).

The most commonly recommended physical distancing measures were ensuring physical distance (e.g., separating tables in the classroom), staggered arrival times in educational facilities, and cancellation of indoor activities (e.g., indoor sport lessons, dances/prom, and social gatherings). The least commonly recommended physical distancing measures were not allowing re-entry after the school day has begun, closing common play areas, and reduced class sizes.

All responding Member States reported having hygiene and safety measures in place in educational facilities (Table 3). Specifically, Member States either recommend and/or implement hand hygiene and respiratory etiquette, as well as stay-at-home when sick. All of the hygiene and safety measures presented in the survey were reported by at least 76% of countries including: promoting hand hygiene and respiratory etiquette (e.g., through provision of hand sanitizers, regular ventilation of classrooms, staying home when sick, disinfection of classroom or school environments, and mandatory mask use (masks for children >12 years or secondary school age). Almost all (82%) countries recommend schools carry out contact tracing of positive cases linked to educational settings (in collaboration with public health authorities).

Other measures less frequently recommended and rarely implemented by reporting countries included temperature screening, enabling parents to keep their kids home for distance learning, testing students (symptoms screening, testing, and isolation of positive students), and the traffic light system linked to the community transmission situation(Table 3).

From the responses to the survey, Member States in the EU/EEA and the UK are focused on implementing NPIs in school settings. In addition to the survey replies, Annex 4 lists the available national guidance and guidelines on measures in educational facilities. Without detailed outbreak investigation studies it is not possible to determine whether transmission is ongoing within the school settings, but considering that most countries are implementing numerous physical distancing and hygiene and safety measures within the school setting itself, it is unlikely that the school setting is driving transmission

It is important to note that the survey captured measures recommended on a national level and adopted by the schools, based on the respondent's knowledge. These results may not reflect all the in-school mitigation measures implemented in schools that may go above and beyond officially/nationally recommended measures.

Table 3. In-school mitigation measures as recommended and implemented in the EU/EEA and the UK, November 2020

School settings mitigation measures	Number of countries recommending measures n=17 (%)	Recommended measure which is also implemented in majority of schools (%)
Physical distancing measures		
Ensuring physical distance (e.g. separating tables in the classroom)	16 (94)	8/16 (50)
Staggered arrival times in educational facilities (in person)	15 (88)	6/15 (40)
Cancellation of indoor activities (e.g. indoor sport lessons, dances/prom, social gatherings)	14 (82)	9/14 (64)
Cohort or 'bubble'/small group system	13 (76)	9/13 (69)
Enabling/arranging remote learning	13 (76)	6/13 (46)
Staggered lunch and breaks	12 (71)	7/12 (58)
Physical education outdoors	12 (71)	8/12 (67)
Hybrid model (e.g. rotating distance and in-person days)	10 (59)	4/10 (40)
Reduced class sizes	9 (53)	2/9 (22)
Closing common play areas	7 (41)	4/7 (57)
No re-entry after school day has begun	2 (12)	2/2 (100)
Hygiene and safety measures		
Stay-at-home when sick	15 (88)	12/15 (80)
Promote hand hygiene and respiratory etiquette (e.g. through provision of hand sanitizers)	15 (88)	11/15 (73)
Regular ventilation of classrooms	14 (82)	11/14 (79)
Disinfection of classroom or school environments	13 (76)	10/13 (77)
Mandatory mask use*	13 (76)	9/13 (69)

School settings mitigation measures	Number of countries recommending measures n=17 (%)	Recommended measure which is also implemented in majority of schools (%)
Other types of measures		
Contact tracing of positive cases linked to educational settings (in collaboration with public health authorities)	14 (82)	12/14 (86)
'Traffic light system' linked to community epidemiological situation	7 (41)	3/7 (43)
Testing of students (symptoms screening, testing, and isolation of positive students)	6 (35)	4/6 (67)
Enabling parents to decide to keep kids home for distance learning	5 (29)	3/5 (60)
Temperature screening	4 (24)	1/4 (25)

**Mask use was noted for older students only (≥12 years or secondary school age)*

4.3 Risk communication and community engagement

Approaches to school closures and reopening have been a topic of high attention, debate and even polarisation throughout the pandemic [87,88]. The public debate has highlighted the challenges of balancing the negative effects of school closures on children and youth learning and wellbeing, with the possible risks of further spread of COVID-19 within or linked to school settings. The dilemmas and controversies that arise in a context of uncertainty, highlight the importance of effective risk communication in order to build trust and diminish concerns [89].

Considerations for effective risk communication include:

- Clear information on the recommendations and measures implemented to protect health, and how each individual can contribute to prevent disease spread. For example, in March, the United Nations Children's Fund (UNICEF), WHO and the International Federation of the Red Cross (IFRC) compiled a series of key messages and considerations for engaging children, teachers, staff, parents and the wider community in promoting safe and healthy schools[90].
- Coordination of communication across sectors (government, health authorities and public health experts, as well as educational authorities) and levels (national, regional or local as appropriate), in order to ensure consistency in the communication. For example, a press conference to announce changes in measures, where the different authorities involved participate, signals coordinated work and helps to relay consistent messaging.
- Information regarding decision-making for reopening, closure and other related measures. Some countries in the EU use traffic light systems that can help to visualise current levels of risk, the corresponding response measures in place and the protective behaviours to be followed [91].
  - In line with the evidence on the importance of community engagement [92], the school community should be viewed as a partner and resource to optimise the response. This can include dialogues with community representatives. Engagement should also include the voices of children and adolescents [93]. For example, WHO Europe launched a consultation that includes students, for the development of advice on schooling during the pandemic [94].

Multiple channels can be used to communicate with the school community:

- Community structures (e.g. parents', teachers' and pupils' associations) as well as the digital communication channels used to share school-related information, can support frequent dissemination of information on measures and recommendations.
- Q&A sessions, webinars, live session on social media channels organised by educational authorities and/or public health experts can provide opportunities to address concerns of parents and carers, or specifically from young people [95].
- Signpost trusted sources where members of the school community can find more information, for example for parents and caregivers on the school protocols if there are cases in the school [96], guidance for schools [97] or materials schools can use to promote hygiene and prevent disease spread [98].
- Empathy in communication, recognising the challenges and sacrifices that the school community faces. Given the difficulties and disruptions that arise, for example, when moving from in-school to remote learning, information should also be given on support mechanisms in place.

Schools are important venues for science education and learning good health practice such as handwashing. Further, through education students can become advocates for disease prevention and control in their homes, the school and the community at large [99].

Specific educational and communication activities targeting children, youth and other members of the school community in relation to COVID-19 prevention, can include:

- Educational resources specifically designed for children, such as visuals, songs to sing while handwashing, online games to teach effective handwashing [100], or websites and resources such as storybooks to explain how to prevent spread of COVID-19 and the concept of 'school bubbles' [101].
- Campaigns targeting youth to raise awareness on how they can contribute to limit the spread of disease. This can include materials to be used in educational settings [102] and also strategies to reach youth via social media channels [103].
- Information for parents and carers on measures in place in a country [104], what they need to know about re-openings [105] and suggestions on how to speak with children about COVID-19 [106].
- Online resources for parents and teachers that address the multiple questions that arise in relation to spread of COVID-19 in schools [107].

4.4 Testing at schools and other educational settings

Testing guidelines and how to apply them in schools have been outlined in previous ECDC publications: COVID-19 testing strategies and objectives [108], and Objectives for COVID-19 testing in school settings – first update [109]. ECDC recommends that testing efforts, in community settings generally and in educational settings specifically, are maximised with the aim of offering timely testing to all symptomatic cases in order to ensure isolation of cases and tracing and quarantine of their contacts [108]. Since the aforementioned documents were published, rapid antigen tests have been introduced by many Member States to increase testing capacity or shorten turnaround times for testing. Testing should be part of active surveillance aimed at early detection of all symptomatic cases and should be developed and adapted through an ongoing assessment of the local epidemiological situation and laboratory capacity [108]. According to the contact tracing guidelines, asymptomatic high-risk exposure (close) contacts of cases could also be considered for SARS-CoV-2 testing [110]. This allows for prompt isolation of new potential cases and early contact tracing of the contacts of these new cases. Active testing will also enable early detection of infection in students and staff at high risk of developing severe disease due to underlying conditions.

When there are clusters of pupils with confirmed COVID-19, a school-wide testing approach may be considered, on the condition that clear objectives for the testing activity are determined and there is an agreed plan of action, following the test results [83,110].

Well-defined studies on transmission in school settings involving testing may reveal important epidemiological insight. Such studies do, however, require clear objectives, careful set-up, and should include both symptomatic and asymptomatic cases [111]. A protocol for the investigation of COVID-19 clusters and outbreaks in schools and other educational settings is available as part of the World Health Organization's Unity studies. It describes the different steps to investigate SARS-CoV-2 transmission following the notification of a COVID-19 case in a school, and provides guidance and links to case definitions, study design, questionnaires for cases and contacts, and contact tracing [111].

Testing methods

The choice of the best testing method will depend on the surveillance objectives and the epidemiological situation. Reverse transcription polymerase chain reaction (RT-PCR) that is characterised by both high sensitivity and specificity to detect viral RNA remains the gold standard for SARS-CoV-2 testing. Rapid antigen tests, in addition to contributing to the overall testing capacity, offer multiple benefits in comparison with RT-PCR tests for the detection of SARS-CoV-2. They have been developed as both laboratory-based tests and for near-patient use (point-of-care), and results are normally generated in 10 to 30 minutes after the start of the analysis, and at low cost. The European Commission and ECDC have published recommendations for the use of rapid antigen tests in different settings [112,113]. ECDC has furthermore outlined considerations for the use of rapid antigen tests in settings of low and high infection prevalence and the need for confirmatory testing [112].

Within educational settings, rapid antigen detection tests can be applied in the following ways:

- In the context of contact tracing (Section 4.5), rapid antigen detection tests can allow for a more rapid identification of infectious contacts. Rapid antigen detection tests have been shown to be more efficient in detecting cases in up to five days after the onset of symptoms and should therefore be used within this window of time, when the viral load is highest. For asymptomatic contacts of cases, tests should be performed as soon as possible after the contact has been traced. If more than seven days have passed since a known exposure, there may be an increased risk of a false negative test result by rapid antigen detection test due to a reduction at the viral load. In such cases, the test should be repeated by RT-PCR as quickly as possible.
- Rapid antigen detection tests can be used for screening staff or students in high-prevalence settings for example a large outbreak in a school setting as part of school-wide testing approach.

The validated performance criteria of rapid antigen tests, and the importance of considering the overall prevalence of SARS-CoV-2 in the population, should be taken into account [112]. Trained healthcare or laboratory staff, or trained operators, are needed to carry out sampling, testing, test analysis and reporting of test results to clinical staff and public health authorities at the local, regional, national and international level.

In a situation where a nasopharyngeal or other upper respiratory specimen is not acceptable and/or to increase the acceptance of children being tested, saliva could be considered as an alternative specimen for RT-PCR testing, but not for rapid antigen detection test as those tests have not been validated for use with saliva specimens [114,115].

4.5 Contact tracing in the school setting

Contact tracing is important in school settings to rapidly identify secondary cases in order to avoid large outbreaks and the interruption of school activities. ECDC has published general guidelines for management of persons who have had contact with COVID-19 cases [110,116].

Contact tracing should be carried out by local public health authorities, who may work closely with school authorities to define the most appropriate response based on an assessment of the local situation. Authorities should seek to ensure that decisions are well understood by staff, students and guardians.

Contact tracing should be initiated promptly following the identification of a confirmed case and should include contacts in the school (classmates, teachers and other staff), household and other relevant settings, in accordance with ECDC or national guidance. Table 4 provides a general classification of contacts in line with the ECDC contact tracing guidance [110].

Table 4. Classification of a contact in school settings, based on level of exposure

High-risk exposure (close contact)	Low-risk exposure
A person: • having had face-to-face contact with a COVID-19 case within two metres for more than 15 minutes over a 24-hour period (even if not consecutive); • having had physical contact with a COVID-19 case; • having had unprotected direct contact with the infectious secretions of a COVID-19 case (e.g. being coughed on); • who was in a closed environment (e.g. household, classroom, meeting room, etc.) or travelling with a COVID-19 case for more than 15 minutes.	A person: • having had face-to-face contact with a COVID-19 case within two metres for less than 15 minutes; • who was in a closed environment or travelling with a COVID-19 case for less than 15 minutes.

Contacts should be managed based on their exposure category, as outlined in the ECDC contact tracing guidance [110]. High-risk contacts in school settings should be quarantined and actively followed up by the school or public health authorities. If symptoms occur in contacts, they should immediately be isolated and promptly tested. The testing of asymptomatic high-risk exposure contacts allows for prompt isolation of new potential cases and early initiation of contact tracing of these new cases. Decisions on which contacts should be tested requires a careful assessment of the local situation.

ECDC guidance on contact tracing [108] provides details on quarantine related to household exposure. Further details on quarantine relating to household exposure may be found in the ECDC guidance on contact tracing [110].

5. What is the impact of school closures?

Summary

- School closures are associated with substantial adverse physical and mental health and educational impacts in children. They can also exacerbate existing inequalities in a society, by having a disproportionate impact on more vulnerable children, caregivers, families and communities (high confidence).
- The economic costs of school closures due to COVID-19 are estimated to be high and include direct learning lost, labour lost from working parents as well as long term consequences such as lower skills in the labour force and less productivity (moderate confidence).
- Given the severe consequences of school closures on children and their communities, this measure should be employed as a last resort for disease control and, even then, should be time-limited, with close attention paid to mitigating the impacts of the closure on children, particularly those with vulnerabilities.

5.1 Health and educational impact on children due to school closure

A number of organisations have identified negative impacts on children's wellbeing, learning opportunities and safety caused by school closures [117-120], even when face-to-face classroom learning is replaced by (theoretically) full-time, online, distance learning. These range from the interruption of learning and the exacerbation of disparities and mental health issues, to an increased risk of domestic violence. The negative impacts disproportionately affect children from vulnerable and marginalised population groups (see Section 5.2 below).

A range of health impacts, both physical and mental, need consideration here. Research has highlighted the importance of an active social life at school for children aged 2–10 years, which helps them to learn from peers and positively impacts upon their personality and sense of identity, while disruptions of close peer relationships have been associated with depression, guilt, and anger in children [121]. Furthermore, school and extracurricular activities provide structure, meaning and a daily rhythm for children and youth. For those suffering from anxiety and depression, the loss of such activities can worsen symptoms and reinforce social withdrawal and feelings of hopelessness [122].

Children have also been found to be at increased risk of domestic violence when schools are closed [123,124]. Under these circumstances, children no longer have regular face-to-face interaction with teachers who can detect and report child abuse, and children do not have an external social network or other support for coping with abuse at home [124]. Beyond the immediate damaging effects, child-abuse and neglect also have long-term effects, including mental health disorders, sexually transmitted infections, unwanted pregnancies, and substance abuse [125].

A modelling study in the USA concluded that the decision to close primary schools could lead to more years of life lost than if they had remained open, based upon a model that linked school closures, reduced educational attainment, and the association between reduced educational attainment and life expectancy [125].

While the focus of this report is on the impact of school closure on children, it is important to note that teachers in many schools have also endured substantial mental health challenges over the course of the pandemic as a result of their work. These have been brought about by, among other issues, concerns about being infected with COVID-19 themselves, having colleagues hospitalised with COVID-19, challenging pupil behaviour (including non-compliance with COVID-19 preventive measures), and being on the receiving end of parents' fears and frustrations as well as potentially increased workload linked to absences and the adaptation of work routines at school [126]. Furthermore, teachers have often had to adapt to distance teaching in situations that might not have been optimal and where technical means have only gradually been implemented. An increase in workload and ergonomic issues is to be expected under these circumstances.

5.2 School closure and social inequalities

The UN secretary general António Guterres has stated that the COVID-19 pandemic had led to the largest disruption of education in history, with schools closed in more than 160 countries in mid-July and more than a billion students affected globally [127]. Within the EU/EEA, some sort of school closure – whether at the level of higher education, secondary school, primary school, or daycare – has been implemented in each country [128], and it is estimated that approximately 58 million primary and secondary school children in the EU were deprived of their usual face-to-face school-based learning for several weeks starting in March 2020 [129].

This has been detrimental to all children, even if online teaching was offered as an alternative, but it has had a disproportionate and negative effect on children who were already marginalised and/or vulnerable prior to the pandemic [119,120,130,131].

For many students living in poverty, schools are not only a place for learning, but they also act as a key provider of daily meals. Research suggests that school closures exacerbate student food insecurity and decrease nutrient intake [132,133], and it is likely that this in turn will adversely affect the learning capabilities of poor children during the period of school closure [129].

Students who are obliged to study at home during a period of school closure require access to the hardware and connectivity required for distance learning, as well as a quiet, conducive place to work. A multi-country study in the EU found that the risk for disadvantaged students to have no internet access was more than three times that of advantaged pupils. Using a reading achievement scale for Year 4 students, the study also found a 5% increase in educational inequalities associated with physical school closures resulting from COVID-19 [129]. Similar trends have been found in other studies [130]. In addition, for a range of reasons, children from lower socio-economic backgrounds are also less likely to receive parental support with homework [118,129].

Children with disabilities may face particular challenges during school closures, as they can feel more isolated than other people, and the special support services that they need may also be closed [118]. Further, it is important to note that parents caring for children with chronic conditions (e.g. asthma, autism, attention deficit hyperactivity disorder, anxiety and diabetes) and who are taking part in home/online schooling, often experience higher levels of stress compared with the parents of children without these conditions. This can have implications for their job security, their own mental health, and ultimately thereby the safety and security of their child [134].

5.3 Cost to schools and the economic impact of school closure

Studies conducted prior to the COVID-19 pandemic have assessed the cost effectiveness of school closure. Due to the different transmission dynamics of SARS-CoV-2 compared with pandemic influenza, as well as the absence of widely available and proven antiviral drugs or vaccines for SARS-CoV-2 at the time of writing, these studies included in the review are not directly transferable to the current context of the COVID-19 pandemic. However, one study, that estimated the economic burden of school closure in the UK from a societal perspective, showed that the estimated costs of school closure ranged from 0.28 – 1.68 billion Euros per week [135]. The authors highlighted the economic burden on the health system through staff absenteeism. A separate study assessed school closure as part of a mixture of interventions including antiviral prophylaxis and prevaccination and concluded that although health outcomes were improved, it was the least cost-effective measure among those assessed [136]. A modelling study from Canada found that suites of measures that included school closures were the least cost-effective, as they led to large costs due to lost work and school days, with relatively little benefit in terms of life-years saved [137]. Two studies found that limited duration school closures together with measures such as household antiviral prophylaxis were the most cost-effective [137,138].

The estimated economic impact of school closure due to COVID-19 are enormous. The OECD assessed long-term GDP loss due to learning loss in 2020 of a third of a lost learning year among students in grades 1-12, which would lead to lower skills in the labour force and less productivity. The projected costs were substantial: over 3 087 billion USD (~2 546 billion Euros) for Germany and 2 137 billion USD (~1 762 billion Euros) for France [139]. The indirect economic impact of school closure to either mitigate or supress epidemic growth of the COVID-19 epidemic was estimated for the UK economy. The simulation was performed for two scenarios: a mitigation scenario for 12 weeks and a suppression scenario for seven months, starting on 23rd of March 2020. Labour lost from working parents attributable to school closures was estimated at 74 billion Euros (2.9% of GDP) for pandemic mitigation and 186 billion Euros (7.3% of GDP) for suppression. In contrast, the direct health-related economic burden on the UK economy accounted for 45 billion Euros (1.73% of GDP). A Cochrane systematic review of 42 studies found that five studies assessed societal and economic implications. Loss of parental economic activity due to prolonged school closures or remote learning lead to immediate economic harm for the family and further, to a reduction in gross domestic product on the macro level [140]. Thus, the economic cost of school closures alone may exceed the direct health costs of the disease [141].

Successfully operating schools during the COVID-19 pandemic requires sufficient resources to implement and sustain effective mitigation strategies. Estimated average cost per student for the implementation of CDC's recommended mitigation strategies in pre-kindergarten through grade 12 in the USA was $55 for materials and consumables. This cost increases to a maximum average of $442 per student if a school district needs or chooses to employ the maximum number of additional custodial staff members per school and add additional transportation. Costs might be lower, depending on the extent of the learning model as schools transition from virtual to hybrid or in-person learning [142].

6. What evidence is there for the effectiveness of school closures for containing COVID-19?

6.1 Evidence on the effectiveness of school closures

Summary

- School closures can contribute to a reduction in SARS-CoV-2 transmission (high confidence) but assessing the relative effectiveness of school closures compared with other NPIs is highly challenging.
- Proactive school closures are insufficient to prevent community transmission of COVID-19 in the absence of other NPIs such as restrictions on mass gathering (high confidence).
- The reopening of schools in the summer/autumn of 2020 coincided with a general relaxation of NPIs and was followed by an increase in the incidence of SARS-CoV-2 among all age groups, however schools are not thought to be a driving force for increased community transmission (moderate confidence).
- While school closures will probably lead to less social mixing and, thus, reduced SARS-CoV-2 transmission in the community as well as in the schools themselves, research with more granularity on the relative impacts of school closures as opposed to in-school NPI measures as well as community-level NPI measures (such as remote-working orders and workplace closures), requires further analysis. Similarly, although there is some modelling work that suggests that targeting secondary schools would have the highest impact on transmission, the relative effectiveness of closing preschools, primary schools, and secondary schools requires further assessment, as do analyses of various implemented mitigation measures or partially open approaches (such as through blended remote and in-person learning).
- Decisions to proactively or reactively close schools need to account for evidence not only on the effectiveness of this measure for containing SARS-CoV-2 in the community, but also the other NPIs in place, as well as the adverse physical and mental health and educational impact of school closures on children.
- The effectiveness of school closures cannot yet be assessed in relation to new variants of SARS-CoV-2, for which robust evidence on the potential impact in school settings is not yet available such as one recently observed in the United Kingdom [1].

In a rapid review of 23 official documents regarding the prevention and management of cases in primary and secondary schools, school closures were commonly considered as the very last resort for COVID-19 control [143].

As detailed in Annex I.7, there is no direct means for assessing proactive school closure (early and planned closure of schools and daycare facilities to limit local virus transmission and spread at schools and into the community) [80,144] as an independent NPI, given that school closures have often been introduced alongside a wide range of additional mitigation measures. There are numerous modelling studies on the impact of school closure for curtailing SARS-CoV-2 transmission and they have common limitations, such as: varying assumptions about the susceptibility and infectiousness of children; challenges in disentangling the impact of school closure vis-à-vis other NPI (notably workplace closures and remote work policies); the scale of analysis tends to be national, whilst transmission and NPI measures may vary sub-nationally; and difficulties in (or abstaining from) accounting for varying in-school mitigation measures. An additional general limitation is that models have not typically distinguished between the closure of different types of school e.g. between primary and secondary schools.

Despite these limitations and some heterogeneity across study findings, many modelling studies conclude that school closures can reduce SARS-CoV-2 transmission (see Annex 1.7). School closures by themselves have not been generally concluded to be sufficient to contain the pandemic, but have been deemed to be most effective when part of a suite of other NPIs [145-147]. This finding is consistent with the previous ECDC document on this topic [3], as well as with more recent studies that have examined data across multiple countries globally [145,146,148,149].

Reductions in social mixing due to school closures has been inferred by separate studies [150,151]. An age-structured model from the Netherlands concluded that, with unchanged non-school contacts, closing schools in November 2020 could reduce R_e by 8% for 10-20 year olds, 5% for 5-10 year olds, and by a negligible amount for 0-5 year olds [152]. The biggest impact on community transmission was thus achieved by reducing contacts in secondary schools.

The efficacy of school closures is likely driven by two factors. Firstly, children at home have fewer social contacts, secondly and, potentially more significantly, school closures have the indirect impact of parents needing to stay home with their children and thus curtailing their social mixing. Importantly however, models have not generally been able to decipher between these two factors [153]. A particularly challenging aspect is that school closures have often been implemented alongside remote working orders and workplace closures. In addition, it is not certain that older children, such as 16-18-year olds, have decreased social interactions when schools are closed or switch to remote learning. One modelling study that examined cross-country impacts of a range of NPIs from the period 22 January to May 30, identified a benefit of closing schools and universities when implemented in conjunction, but the study could neither differentiate between the relative contribution of school and university closures nor between the direct and indirect effects of these closures [154].

Empirical studies of school closures, while relatively few, also present a heterogeneity of findings. One study from the USA found an association between school closures and decreased weekly COVID-19 incidence and mortality [155]. Another study from the USA found an increase in mortality risk where school closures were delayed [156], while one from study from Europe found that school closures were associated with lower incidence rates [157]. However, since school closures were implemented in conjunction with other measures, the authors noted it was difficult to ascertain the effect of each individual measure and whether or not early school closures during the first wave could be seen as a proxy for early introduction of other NPIs. Meanwhile, a study in Japan [158] did not find school closures having a strong impact on SARS-CoV-2 transmission, while one study in Finland [159] found that daycare closures led to a decrease in paediatric hospital visits, but reopening daycares did not lead to an increase in paediatric hospital visits.

During the COVID-19 pandemic, a wide range of mitigation measures have been implemented to reduce the potential spread of SARS-CoV-2 in educational settings (Section 4). Currently, the majority of modelling studies do not account for these types of measures. One exception is a modelling study from Shanghai, which found that schools could be reopened without leading to excessive transmission, provided that daily contacts among children 10-19 years could be reduced to 33% of baseline levels [145].

Many European countries closed schools during the first wave of COVID-19 but have elected to keep schools open during the autumn term of 2020, a time coinciding with the second wave of COVID-19 cases in many countries (Annex 3). However, the reopening of primary and secondary schools should not be considered to be similar to the ways in which schools were open prior to the pandemic. In addition, even as schools are open, there are generally a wide range of separate NPIs in place in countries that must also be accounted for.

Reactive school closures (closure in response to increased community transmission and/or a localised outbreak in a single educational facility [80] and/or due to increased absenteeism among staff and students making it different to keep teaching going [144]) can also be considered as a non-pharmaceutical intervention, and to be a more common and targeted approach than closing all schools as a preventive (proactive) measure. The expectation is that higher powered empirical and modelling studies comparing the first and second waves of COVID-19 across multiple countries may provide additional insights into the effects of school closures on SARS-CoV-2 transmission. Studies that: model a range of assumptions about the infectiousness of children; tease out primary and secondary school closures; consider school closures across a range of community transmission scenarios; and differentiate between the direct and indirect impact of school closures on SARS-CoV-2 transmission if other measures (notably workplace closures and remote working) are in place, should be prioritised.

6.2 Evidence on the impact of reopening schools

If schools are not a primary setting for SARS-CoV-2 transmission, then one would not expect to see any rise in cases upon the reopening of schools provided community transmission is low. However, it must be noted that increases in case numbers may not be apparent for up to two months following the relaxing of a measure [160]. Reopening schools for on-site education allows parents to return to work (on-site) and interact more broadly with the community. When schools reopen in conjunction with the relaxation of other physical distancing measures that reduce crowding, modelling studies indicate there would be a subsequent increase in cases, peaking in December 2020 [161].

It remains difficult to isolate the impact that schools reopening might have on rates of COVID-19 cases as many measures are relaxed simultaneously, and the colder seasonal weather drives people to indoor settings resulting in an increased mixing of both children and adults in various settings within the community. As presented in Section 1.2, the start of the school year in mid-August to mid-September does not appear to have been temporally associated with an increase in case rates among children, based upon European surveillance data.

In the spring of 2020, when Denmark allowed students aged 2-12 years to attend school on 15 April 2020 following a one month school closure, they saw no increase in cases following the reopening of schools [162].

Almost all EU/EEA countries and the UK re-opened schools after the summer break in August/September (Annex 3), most opening fully for all levels of schooling. A number of countries partially opened schools (especially secondary schools), mostly in the form of distance learning. As reported by countries through the survey, EU/EEA and UK schools reopened with multiple mitigation measures in place.

South Korea found no sudden increase in paediatric cases after the schools reopened in a stepwise approach between April and June 2020 [86] and Finland did not report an increase in paediatric hospital visits following their reopening of daycares [159]. A study from England reported that SARS-CoV-2 clusters and outbreaks were uncommon across all educational settings during the first month upon the re-opening of schools when the national lockdown was eased [58]. Similarly, a study from Germany noted a very small proportion of school outbreaks among all COVID-19 outbreaks after re-opening them in April and introducing mitigation measures within schools, and concluded that there is limited onward transmission in school settings [163]. A modelling study from Shanghai found that schools could be reopened without leading to excessive transmission, provided that daily contacts among children 10-19 years could be reduced to 33% of baseline levels [164]. As mentioned previously in this report, a large outbreak in a high school in Israel was related to high community transmission and the failure to implement in-school mitigation measures resulting in a reactive school closure within 13 days of having re-opened [66].

It is important to incorporate schools into the contact tracing system with local public health authorities to break the chains of onward transmission within school cohorts and their families/households.

Limitations

This technical report is based on information and data available to ECDC at the time of publication.

This report does not consider, for which robust evidence on the potential impact in school settings is not yet available, the epidemiology of COVID-19 in relation to new variants of SARS-CoV-2, such as one recently observed in the United Kingdom [4].

Most case-based surveillance systems in the EU/EEA countries do not collect information that would allow public health authorities to identify outbreaks or clusters in specific schools without notification from the school itself.

A key limitation from currently available household and community studies is that many were conducted when lockdowns and school closures were in full or partial effect, meaning that children had fewer than normal social contacts. Case identification in children may also have been limited, particularly during the 'first wave', where children may not have been prioritised for testing or medical care due to significantly less frequent severe outcomes than e.g. older adults.

Many countries are not testing asymptomatic cases, so it is difficult to detect and understand transmission among mild or asymptomatic children and teachers.

It is difficult to identify all potential routes of transmission within school settings as some activities have been limited (e.g. school sporting events, mixed mass gatherings of students and adults such as school concerts, performances, and graduations, etc.). The potential impact of allowing such events to take place within the school setting is still unknown.

Studies that have modelled and/or assessed the impact of school closures on the control of SARS-CoV-2 transmission are challenged due to the potential overlaps with many other NPIs introduced concomitantly, particularly during the first half of 2020.

This document only considers the school setting/educational facilities and therefore does not consider other settings where children may commonly gather when away from home.

Conclusions

As countries perform their own risk assessments on how to prevent SARS-CoV-2 transmission in schools and whether to close educational facilities, this technical report provides information on:

- the epidemiological situation and disease characteristics relating to COVID-19 among children (1–18 years) in EU/EEA countries and the UK
- the evidence of the role of children in COVID-19 transmission
- the evidence of COVID-19 clusters and transmission in school (preschool, primary and secondary schools) settings
- mitigation measures/non-pharmaceutical interventions within the school setting
- the impact of full and partial school closures
- effectiveness of school closures for containing COVID-19.

Aside from very rare instances, COVID-19 poses relatively little direct severe health risk to children (Section 1).

As documented in Section 3, it is certainly possible that both young and older children can transmit SARS-CoV-2 in school settings, although the documented evidence suggests that this is more likely to occur in settings such as households. An emerging picture appears to show that there may be an age-gradient for susceptibility to and infectiousness of SARS-CoV-2, but further research is required. Meanwhile, there are documented instances where adult staff have been the index cases of outbreaks in school settings.

While proactive school closures, in combination with other measures, can play a role in reducing community SARS-CoV-2 transmission, they can also have substantial negative impacts on child health and development, may exacerbate social inequalities, and have large associated economic impacts (as detailed in Section 5).

As detailed in Section 1.2 and 6.2, evidence suggests that schools do not amplify SARS-CoV-2 transmission but rather reflect the background levels of community transmission. There are, moreover, numerous in-school mitigation measures that can and have been implemented in school settings (Section 4); while no single mitigation measure is likely to be 100% effective, combinations of measures are expected to significantly reduce infection risks.

Considerations for decision-making surrounding schools during the COVID-19 pandemic

There is a general consensus that keeping schools open is important and closing schools is a policy of last resort when it comes to controlling the COVID-19 pandemic [165]. Yet, it is also acknowledged that high levels of community SARS-CoV-2 transmission, in combination with capacity shortages in the healthcare system, may necessitate that all possible NPI measures, including school closures and/or the transition to remote learning, are considered for implementation. As, for example, a modelling study from the Netherlands concluded, where other NPI measures are exhausted or deemed to be undesirable for other reasons and if R_e is close to 1, then there may benefits from school-based measures [152].

The evidence presented in this report addresses many of the factors that decision-makers would need to consider to prevent the transmission of SARS-CoV-2 in schools, and to weigh whether to keep schools open during the COVID-19 pandemic. It is important to note that research on SARS-CoV-2 is rapidly increasing, and as new evidence comes to light, decisions on schools may need to be revised accordingly.

Decisions to close schools or to keep them open during the COVID-19 pandemic should consider the following issues:

- What are the objectives? Is it to protect children, educational staff, or to limit community transmission? Have other means been explored for reaching these objectives?
- If schools are kept open, have complementary NPI measures that may have a similar or synergistic effect to school closures, such as gathering limits or remote-working policies, been considered?
- Have partial school openings/closures (such as blended remote and in-school learning for older children) been considered or implemented?
- What in-school mitigation measures are currently being implemented, considering medically vulnerable students and staff?
- Is the latest knowledge on SARS-CoV-2 susceptibility and infectiousness among children accounted for?
- Does decision-making consider the potential negative educational, social, economic and mental health impacts that are linked to school closures?
- In the event of a partial or total school closure, are measures in place to address particularly vulnerable and/or marginalised groups of students?

Contributing experts

ECDC experts (in alphabetical order): Nick Bundle, Eeva Broberg, Orlando Cenciarelli, Charlotte Deogan, Erika Duffell, Lisa Ferland, Tjede Funk, John Kinsman, Annette Kraus, Tommi Kärki, Angeliki Melidou, Lina Nerlander, Ajibola Omokanye, Daniel Palm, Pasi Penttinen, Anastasia Pharris, Emmanuel Robesyn, Jan Semenza, Ettore Severi, Jonathan Suk, Emma Wiltshire, Andrea Würz

External experts: Elke Schneider, EU-OSHA

All external experts have submitted declarations of interest, and a review of these declarations did not reveal any conflicts of interest.

Acknowledgements

ECDC gratefully acknowledges Operational Focal Points and National Focal Points in Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Finland, Greece, Ireland, Latvia, Liechtenstein, Lithuania, the Netherlands, Romania, Slovenia, Spain, and Sweden, who responded to the country-based data collection survey, and Operational Contact Points in all Member States who submit COVID-19 surveillance data to TESSy.

ECDC acknowledges Constantine Vardavas, Katerina Nikitara, Revati Phalkey, Jo Leondari-Bee for conducting the literature review referred to in Annex 2, and to Katerina Papathanasaki, Chrysa Chatzopoulou and Ioanna Lagou for their assistance in this project. This work was commissioned and overseen by ECDC and conducted according to direct service contract ECD.10660.

References

1. Public Health England (PHE). Investigation of novel SARS-COV-2 variant Variant of Concern 202012/01. [cited 23 December 2020]. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/947048/Technical_Briefing_VOC_SH_NJL2_SH2.pdf
2. European Commission/EACEA/Eurydice. The Structure of the European Education Systems 2018/19: Schematic Diagrams. [cited 4 December 2020]. Available from: https://eacea.ec.europa.eu/national-policies/eurydice/sites/eurydice/files/the_structure_of_the_european_education_systems_2018_19.pdf
3. European Centre for Disease Prevention and Control (ECDC). COVID-19 in children and the role of school settings in COVID-19 transmission. [updated 3 December 2020; cited 30 November 2020]. Available from: https://www.ecdc.europa.eu/en/publications-data/children-and-school-settings-covid-19-transmission
4. European Centre for Disease Prevention and Control (ECDC). Rapid increase of a SARS-CoV-2 variant with multiple spike protein mutations observed in the United Kingdom. [updated 20 December 2020; cited 21 December 2020]. Available from: https://www.ecdc.europa.eu/en/publications-data/threat-assessment-brief-rapid-increase-sars-cov-2-variant-united-kingdom
5. GRADE Handbook. [updated October 2013; cited 02 Dicember 2020]. Available from: https://gdt.gradepro.org/app/handbook/handbook.html#h.s1fsemn2yjpm
6. European Centre for Disease Prevention and Control (ECDC). Paediatric inflammatory multisystem syndrome and SARS-CoV-2 infection in children. [updated 15 May 20208 December 2020]. Available from: https://www.ecdc.europa.eu/en/publications-data/paediatric-inflammatory-multisystem-syndrome-and-sars-cov-2-rapid-risk-assessment
7. European Centre for Disease Prevention and Control (ECDC). COVID-19 Surveillance Report - Week 48, 2020. [updated 4 December 2020; cited 8 December 2020]. Available from: https://covid19-surveillance-report.ecdc.europa.eu/
8. Cevik M, Tate M, Lloyd O, Maraolo AE, Schafers J, Ho A. SARS-CoV-2, SARS-CoV, and MERS-CoV viral load dynamics, duration of viral shedding, and infectiousness: a systematic review and meta-analysis. The Lancet Microbe [Preprint]. 19 November 2020; Available from: https://www.thelancet.com/journals/lanmic/article/PIIS2666-5247(20)30172-5/fulltext
9. Xu CLH, Raval M, Schnall JA, Kwong JC, Holmes NE. Duration of Respiratory and Gastrointestinal Viral Shedding in Children With SARS-CoV-2: A Systematic Review and Synthesis of Data. Pediatr Infect Dis J. 2020;39(9):e249-e56. Available from: https://journals.lww.com/pidj/Fulltext/2020/09000/Duration_of_Respiratory_and_Gastrointestinal_Viral.25.aspx
10. Heald-Sargent T, Muller WJ, Zheng X, Rippe J, Patel AB, Kociolek LK. Age-Related Differences in Nasopharyngeal Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Levels in Patients With Mild to Moderate Coronavirus Disease 2019 (COVID-19). JAMA Pediatrics. 2020;174(9):902-3. Available from: https://doi.org/10.1001/jamapediatrics.2020.3651
11. Wölfel R, Corman VM, Guggemos W, Seilmaier M, Zange S, Müller MA, et al. Virological assessment of hospitalized patients with COVID-2019. Nature. 2020;581(7809):465-9. Available from: https://www.nature.com/articles/s41586-020-2196-x
12. L'Huillier AG, Torriani G, Pigny F, Kaiser L, Eckerle I. Culture-competent SARS-CoV-2 in nasopharynx of symptomatic neonates, children, and adolescents. Emerging Infectious Diseases. 2020;26(10):2494. Available from: https://wwwnc.cdc.gov/eid/article/26/10/20-2403_article
13. Buitrago-Garcia D, Egli-Gany D, Counotte MJ, Hossmann S, Imeri H, Ipekci AM, et al. Occurrence and transmission potential of asymptomatic and presymptomatic SARS-CoV-2 infections: A living systematic review and meta-analysis. PLoS Med. 2020;17(9):e1003346. Available from: https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1003346
14. Li B, Zhang S, Zhang R, Chen X, Wang Y, Zhu C. Epidemiological and Clinical Characteristics of COVID-19 in Children: A Systematic Review and Meta-Analysis. Front Pediatr. 2020;8:591132. Available from: https://www.frontiersin.org/articles/10.3389/fped.2020.591132/full
15. Liu C, He Y, Liu L, Li F, Shi Y. Children with COVID-19 behaving milder may challenge the public policies: a systematic review and meta-analysis. BMC Pediatr. 2020;20(1):410. Available from: https://bmcpediatr.biomedcentral.com/articles/10.1186/s12887-020-02316-1
16. Pollán M, Pérez-Gómez B, Pastor-Barriuso R, Oteo J, Hernán MA, Pérez-Olmeda M, et al. Prevalence of SARS-CoV-2 in Spain (ENE-COVID): a nationwide, population-based seroepidemiological study. Lancet.

2020;396(10250):535-44. Available from: https://www.sciencedirect.com/science/article/pii/S0140673620314835

17. Dong Y, Mo X, Hu Y, Qi X, Jiang F, Jiang Z, et al. Epidemiology of COVID-19 Among Children in China. Pediatrics. 2020;145(6):e20200702. Available from: https://pediatrics.aappublications.org/node/150035.full
18. Streng A, Hartmann K, Armann J, Berner R, Liese JG. [COVID-19 in hospitalized children and adolescents]. Monatsschrift Kinderheilkunde. 2020;168:615-27. Available from: https://link.springer.com/article/10.1007%2Fs00112-020-00919-7
19. Hoehl S, Rabenau H, Berger A, Kortenbusch M, Cinatl J, Bojkova D, et al. Evidence of SARS-CoV-2 infection in returning travelers from Wuhan, China. New England Journal of Medicine. 2020;382(13):1278-80. Available from: https://www.nejm.org/doi/pdf/10.1056/NEJMc2001899
20. Pan X, Chen D, Xia Y, Wu X, Li T, Ou X, et al. Asymptomatic cases in a family cluster with SARS-CoV-2 infection. The Lancet Infectious Diseases. 2020;20(4):410-1. Available from: https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(20)30114-6/fulltext
21. Zhang L, Peres TG, Silva MVF, Camargos P. What we know so far about Coronavirus Disease 2019 in children: A meta-analysis of 551 laboratory-confirmed cases. Pediatric Pulmonology. 2020;55(8):2115-27. Available from: https://onlinelibrary.wiley.com/doi/full/10.1002/ppul.24869
22. Götzinger F, Santiago-García B, Noguera-Julián A, Lanaspa M, Lancella L, Calò Carducci FI, et al. COVID-19 in children and adolescents in Europe: a multinational, multicentre cohort study. The Lancet Child & Adolescent Health. 2020;4(9):653-61. Available from: https://www.thelancet.com/journals/lanchi/article/PIIS2352-4642(20)30177-2/fulltext
23. Raba AA, Abobaker A, Elgenaidi IS, Daoud A. Novel Coronavirus Infection (COVID-19) in Children Younger Than One Year: A Systematic Review of Symptoms, Management and Outcomes. Acta Paediatrica. 2020;109(10):1948-55. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/apa.15422
24. Loconsole D, Caselli D, Centrone F, Morcavallo C, Campanella S, Aricò M, et al. SARS-CoV-2 Infection in Children in Southern Italy: A Descriptive Case Series. Int J Environ Res Public Health. 2020;17(17):6080. Available from: https://www.mdpi.com/1660-4601/17/17/6080/htm
25. Stringhini S, Wisniak A, Piumatti G, Azman AS, Lauer SA, Baysson H, et al. Seroprevalence of anti-SARS-CoV-2 IgG antibodies in Geneva, Switzerland (SEROCoV-POP): a population-based study. The Lancet. 2020;1(396):313-9. Available from: https://www.sciencedirect.com/science/article/pii/S0140673620313040
26. Pagani G, Conti F, Giacomelli A, Bernacchia D, Rondanin R, Prina A, et al. Seroprevalence of SARS-CoV-2 significantly varies with age: preliminary results from a mass population screening. The Journal of Infection. 2020;81(6):E10-E2. Available from: https://www.journalofinfection.com/article/S0163-4453(20)30629-0/fulltext
27. Hippich M, Holthaus L, Assfalg R, Zapardiel-Gonzalo J, Kapfelsperger H, Heigermoser M, et al. A Public Health Antibody Screening Indicates a 6-Fold Higher SARS-CoV-2 Exposure Rate than Reported Cases in Children. Med [Preprint]. 29 October 2020; Available from: http://www.sciencedirect.com/science/article/pii/S2666634020300209
28. Sciensano.be. Seroprevalence of SARS-CoV-2 antibodies in school aged children in two regions with difference in prevalence of COVID-19 disease: Interim report. [cited 16 December 2020]. Available from: https://www.sciensano.be/en/biblio/seroprevalence-sars-cov-2-antibodies-school-aged-children-two-regions-difference-prevalence-covid-19
29. Madewell ZJ, Yang Y, Longini IM, Jr, Halloran ME, Dean NE. Household Transmission of SARS-CoV-2: A Systematic Review and Meta-analysis. JAMA Network Open. 2020;3(12):e2031756-e. Available from: https://doi.org/10.1001/jamanetworkopen.2020.31756
30. Koh WC, Naing L, Chaw L, Rosledzana MA, Alikhan MF, Jamaludin SA, et al. What do we know about SARS-CoV-2 transmission? A systematic review and meta-analysis of the secondary attack rate and associated risk factors. PloS one. 2020;15(10):e0240205. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0240205
31. Viner RM, Mytton OT, Bonell C, Melendez-Torres GJ, Ward J, Hudson L, et al. Susceptibility to SARS-CoV-2 Infection Among Children and Adolescents Compared With Adults: A Systematic Review and Meta-analysis. JAMA Pediatr [Preprint]. 25 September 2020 2020; Available from: https://jamanetwork.com/journals/jamapediatrics/fullarticle/2771181
32. Bundesministerium - Bildung WuF. Die „Gurgelstudie" an Schulen. [updated 13 November 2020; cited 2 December 2020]. Available from: https://www.bmbwf.gv.at/Themen/schule/beratung/corona/gs.html
33. Jung J, Hong M, Kim E, Lee J, Kim M-N, Kim S-H. Investigation of a nosocomial outbreak of coronavirus disease 2019 in a paediatric ward in South Korea: successful control by early detection and extensive contact

tracing with testing. Clinical Microbiology and Infection. 2020;26(11):1574-5. Available from: https://www.clinicalmicrobiologyandinfection.com/article/S1198-743X(20)30365-7/fulltext

34. Wongsawat J, Moolasart V, Srikirin P, Srijareonvijit C, Vaivong N, Uttayamakul S, et al. Risk of novel coronavirus 2019 transmission from children to caregivers: A case series. J Paediatr Child Health. 2020;56(6):984-5. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/jpc.14965

35. Laxminarayan R, Wahl B, Dudala SR, Gopal K, Mohan BC, Neelima S, et al. Epidemiology and transmission dynamics of COVID-19 in two Indian states. Science. 2020;370(6517):691-7. Available from: https://science.sciencemag.org/content/370/6517/691

36. Pray IW, Gibbons-Burgener SN, Rosenberg AZ, Cole D, Borenstein S, Bateman A, et al. COVID-19 Outbreak at an Overnight Summer School Retreat—Wisconsin, July–August 2020. Morbidity and Mortality Weekly Report. 2020;69(43):1600. Available from: https://www.cdc.gov/mmwr/volumes/69/wr/mm6943a4.htm

37. Szablewski CM, Chang KT, Brown MM, Chu VT, Yousaf AR, Anyalechi N, et al. SARS-CoV-2 Transmission and Infection Among Attendees of an Overnight Camp - Georgia, June 2020. MMWR Morb Mortal Wkly Rep. 2020;69(31):1023-5. Available from: https://www.cdc.gov/mmwr/volumes/69/wr/mm6931e1.htm?s_cid=mm6931e1

38. Schwartz NG, Moorman AC, Makaretz A, Chang KT, Chu VT, Szablewski CM, et al. Adolescent with COVID-19 as the Source of an Outbreak at a 3-Week Family Gathering—Four States, June–July 2020. Morbidity and Mortality Weekly Report. 2020;69(40):1457. Available from: https://www.cdc.gov/mmwr/volumes/69/wr/mm6940e2.htm

39. Suk JE, Vardavas C, Nikitara K, Phalkey R, Leonardi-Bee J, Pharris A, et al. The role of children in the transmission chain of SARS-CoV-2: a systematic review and update of current evidence. medRxiv [Preprint]. 9 November 2020 2020; Available from: https://www.medrxiv.org/content/10.1101/2020.11.06.20227264v1

40. Posfay-Barbe KM, Wagner N, Gauthey M, Moussaoui D, Loevy N, Diana A, et al. COVID-19 in Children and the Dynamics of Infection in Families. Pediatrics. 2020;146(2):e20201576. Available from: https://pediatrics.aappublications.org/content/146/2/e20201576.long

41. Teherani MF, Kao CM, Camacho-Gonzalez A, Banskota S, Shane AL, Linam WM, et al. Burden of Illness in Households With Severe Acute Respiratory Syndrome Coronavirus 2-Infected Children. J Pediatric Infect Dis Soc. 2020;9(5):613-6. Available from: https://academic.oup.com/jpids/article/9/5/613/5891283

42. Somekh E, Gleyzer A, Heller E, Lopian M, Kashani-Ligumski L, Czeiger S, et al. The Role of Children in the Dynamics of Intra Family Coronavirus 2019 Spread in Densely Populated Area. Pediatr Infect Dis J. 2020;39(8):e202-e4. Available from: https://journals.lww.com/pidj/Fulltext/2020/08000/The_Role_of_Children_in_the_Dynamics_of_Intra.30.aspx

43. Maltezou HC, Vorou R, Papadima K, Kossyvakis A, Spanakis N, Gioula G, et al. Transmission dynamics of SARS-CoV-2 within families with children in Greece: A study of 23 clusters. J Med Virol [Preprint]. 7 August 2020 2020; Available from: https://onlinelibrary.wiley.com/doi/full/10.1002/jmv.26394

44. Kim J, Choe YJ, Lee J, Park YJ, Park O, Han MS, et al. Role of children in household transmission of COVID-19. Arch Dis Child [Preprint]. 7 August 2020 2020; Available from: https://adc.bmj.com/content/early/2020/08/06/archdischild-2020-319910.long

45. Grijalva CG, Rolfes MA, Zhu Y, McLean HQ, Hanson KE, Belongia EA, et al. Transmission of SARS-COV-2 Infections in Households - Tennessee and Wisconsin, April-September 2020. MMWR Morb Mortal Wkly Rep. 2020;69(44):1631-4. Available from: https://www.cdc.gov/mmwr/volumes/69/wr/mm6944e1.htm

46. Park YJ, Choe YJ, Park O, Park SY, Kim YM, Kim J, et al. Contact Tracing during Coronavirus Disease Outbreak, South Korea, 2020. Emerg Infect Dis. 2020;26(10):2465-8. Available from: https://wwwnc.cdc.gov/eid/article/26/10/20-1315_article

47. The New York Times. Positive Test Rate of 11 Percent? France's Schools Remain Open. [updated 30 November 2020; cited 7 December 2020]. Available from: https://www.nytimes.com/2020/11/30/world/europe/france-covid-schools.html

48. Lastampa.it. Coronavirus, l'Iss avverte: "Dalla scuola il 2,5 per cento dei nuovi focolai". [updated 9 October 2020; cited 7 December 2020]. Available from: https://www.lastampa.it/cronaca/2020/10/09/news/coronavirus-l-iss-avverte-dalla-scuola-il-2-5-per-cento-dei-nuovi-focolai-1.39400106

49. Sabado.pt. Fenprof diz haver 122 escolas no País com casos de Covid-19. Saiba quais. [updated 9 October 2020; cited 7 December 2020]. Available from: https://www.sabado.pt/portugal/detalhe/fenprof-diz-haver-122-escolas-no-pais-com-casos-de-covid-19-saiba-quais

50. Bbc.com. Coronavirus: Kingspark School cluster rises to 27. [updated 24 August 2020; cited 7 December 2020]. Available from: https://www.bbc.com/news/uk-scotland-tayside-central-53886277

51. Ministère de l'Education Nationale de la Jeunesse et des Sports. Covid19 - Point de situation du vendredi 27 novembre 2020. [cited 3 December 2020]. Available from: https://www.education.gouv.fr/covid19-point-de-situation-du-vendredi-27-novembre-2020-307572

52. Terveyden ja hyvinvoinnin laitos (THL) - Finnish Institute for Health and Welfare. Koronavirustartuntojen määrät ja ilmaantuvuus ovat nousussa. [updated 19 November 2020; cited 7 December 2020]. Available from: https://thl.fi/fi/-/koronavirustartuntojen-maarat-ja-ilmaantuvuus-ovat-nousussa

53. Santé Publique France (SPF). COVID-19 : point épidémiologique du 12 novembre 2020. [updated 12 November 2020; cited 7 December 2020]. Available from: https://www.santepubliquefrance.fr/maladies-et-traumatismes/maladies-et-infections-respiratoires/infection-a-coronavirus/documents/bulletin-national/covid-19-point-epidemiologique-du-12-novembre-2020

54. Rijksinstituut voor Volksgezondheid en Milieu (RIVM). Epidemiologische situatie COVID-19 in Nederland [updated 10 November 2020; cited 7 December 2020]. Available from: https://www.rivm.nl/sites/default/files/2020-11/COVID-19_WebSite_rapport_wekelijks_20201110_1158.pdf

55. Robert Koch Institut (RKI). Täglicher Lagebericht des RKI zur COVID-19: 27.10.2020 [updated 27 October 2020; cited 7 December 2020]. Available from: https://www.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/Situationsberichte/Okt_2020/2020-10-27-de.pdf

56. Hobbs CV, Martin LM, Kim SS, et al. Factors Associated with Positive SARS-CoV-2 Test Results in Outpatient Health Facilities and Emergency Departments Among Children and Adolescents Aged <18 Years — Mississippi, September–November 2020. Morbidity and Mortality Weekly Report (MMWR). 2020;69. Available from: https://www.cdc.gov/mmwr/volumes/69/wr/mm6950e3.htm

57. Public Health England (PHE). Weekly Influenza and COVID-19 Surveillance graph. [updated 19 November 2020; cited 7 Dicember 2020]. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936672/Weekly_COVID-19_and_Influenza_Surveillance_Graphs_w47.pdf

58. Ismail SA, Saliba V, Bernal JL, Ramsay ME, Ladhani S. SARS-CoV-2 infection and transmission in educational settings: cross-sectional analysis of clusters and outbreaks in England. The Lancet Infectious Diseases [Preprint]. 8 December 2020; Available from: https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(20)30882-3/fulltext

59. Ehrhardt J, Ekinci A, Krehl H, Meincke M, Finci I, Klein J, et al. Transmission of SARS-CoV-2 in children aged 0 to 19 years in childcare facilities and schools after their reopening in May 2020, Baden-Württemberg, Germany. Euro Surveill. 2020;25(36). Available from: https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2020.25.36.2001587

60. Danis K, Epaulard O, Bénet T, Gaymard A, Campoy S, Bothelo-Nevers E, et al. Cluster of coronavirus disease 2019 (Covid-19) in the French Alps, 2020. Clinical Infectioues Diseases. 2020;71(15):825-32. Available from: https://academic.oup.com/cid/article/71/15/825/5819060

61. Heavey L, Casey G, Kelly C, Kelly D, McDarby G. No evidence of secondary transmission of COVID-19 from children attending school in Ireland, 2020. Euro Surveill. 2020;25(21). Available from: https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2020.25.21.2000903

62. Macartney K, Quinn HE, Pillsbury AJ, Koirala A, Deng L, Winkler N, et al. Transmission of SARS-CoV-2 in Australian educational settings: a prospective cohort study. Lancet Child Adolesc Health. 2020;4(11):807-16. Available from: https://www.thelancet.com/journals/lanchi/article/PIIS2352-4642(20)30251-0/fulltext

63. Yung CF, Kam KQ, Nadua KD, Chong CY, Tan NWH, Li J, et al. Novel coronavirus 2019 transmission risk in educational settings. Clinical Infectious Diseases [Preprint]. 25 June 2020; Available from: https://academic.oup.com/cid/advance-article/doi/10.1093/cid/ciaa794/5862649

64. Link-Gelles R, DellaGrotta AL, Molina C, Clyne A, Campagna K, Lanzieri TM, et al. Limited Secondary Transmission of SARS-CoV-2 in Child Care Programs - Rhode Island, June 1-July 31, 2020. MMWR Morb Mortal Wkly Rep. 2020;69(34):1170-2. Available from: https://www.cdc.gov/mmwr/volumes/69/wr/mm6934e2.htm

65. Larosa E, Djuric O, Cassinadri M, Cilloni S, Bisaccia E, Vicentini M, et al. Secondary transmission of COVID-19 in preschool and school settings in northern Italy after their reopening in September 2020: a population-based study. Euro Surveill. 2020;25(49):2001911. Available from: https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2020.25.49.2001911

66. Stein-Zamir C, Abramson N, Shoob H, Libal E, Bitan M, Cardash T, et al. A large COVID-19 outbreak in a high school 10 days after schools' reopening, Israel, May 2020. Euro Surveill. 2020;25(29). Available from: https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2020.25.29.2001352

67. Brandal LT, Ofitserova TS, Meijerink H, Rykkvin R, Lund NM, Hungnes O, et al. Minimal transmission of SARS-CoV-2 from pediatric COVID-19 cases in primary schools in Norway, August to November 2020. [In Press].

68. Lopez AS, Hill M, Antezano J, Vilven D, Rutner T, Bogdanow L, et al. Transmission dynamics of COVID-19 outbreaks associated with child care facilities—Salt Lake City, Utah, April–July 2020. 2020;69(37):1319. Available from: https://www.cdc.gov/mmwr/volumes/69/wr/mm6937e3.htm

69. Okarska-Napierała M, Mańdziuk J, Kuchar E. SARS-CoV-2 Cluster in Nursery, Poland. Emerg Infect Dis. 2021;27(1). Available from: https://wwwnc.cdc.gov/eid/article/27/1/20-3849_article

70. Dub T, Erra E, Hagberg L, Sarvikivi E, Virta C, Jarvinen A, et al. Transmission of SARS-CoV-2 following exposure in school settings: experience from two Helsinki area exposure incidents. medRxiv [Preprint]. 30 July 2020; Available from: https://www.medrxiv.org/content/10.1101/2020.07.20.20156018v1

71. Parri N, Lenge M, Buonsenso D. Children with Covid-19 in Pediatric Emergency Departments in Italy. The New England Journal of Medicine. 2020;383(2):187-90. Available from: https://www.nejm.org/doi/full/10.1056/nejmc2007617

72. Garazzino S, Montagnani C, Donà D, Meini A, Felici E, Vergine G, et al. Multicentre Italian study of SARS-CoV-2 infection in children and adolescents, preliminary data as at 10 April 2020. Euro Surveill. 2020;25(18). Available from: https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2020.25.18.2000600

73. World Health Organization (WHO), EPI-WiN, Infodemic Management. What we know about COVID-19 transmission in schools - The latest on the COVID-19 global situation & the spread of COVID-19 in schools. [updated 21 October 2020; cited 3 December 2020]. Available from: https://www.who.int/docs/default-source/coronaviruse/risk-comms-updates/update39-covid-and-schools.pdf?sfvrsn=320db233_2

74. Folkhälsomyndigheten - Public Health Agency of Sweden (PHAS). Förekomst av covid-19 i olika yrkesgrupper inom skolan 13 mars – 19 oktober. [cited 3 December 2020]. Available from: https://www.folkhalsomyndigheten.se/contentassets/7ff1da2c3d7140809558ddae46735aa1/forekomst-covid-19-olika-yrkesgrupper-skolan.pdf

75. Folkhälsomyndigheten. COVID-19 in children and adolescents. A knowledge summary – Version 2. [cited 16 December 2020]. Available from: https://www.folkhalsomyndigheten.se/contentassets/1e5e09395b9a4f498ff635cdd2b1a888/covid-19-children-adolescents.pdf

76. Office for National Statistics (ONS). Coronavirus (COVID-19) Infection Survey, UK. [updated 6 November 2020; cited 6 December 2020]. Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/conditionsanddiseases/bulletins/coronaviruscovid19infectionsurveypilot/6november2020#analysis-of-the-number-of-school-workers-key-workers-and-other-professions-in-england-who-had-covid-19

77. Magnusson K, Nygard KM, Vold L, Telle KE. Occupational risk of COVID-19 in the 1st vs 2nd wave of infection. medRxiv [Preprint]. 3 Novembe 2020 2020; Available from: https://www.medrxiv.org/content/10.1101/2020.10.29.20220426v1

78. Statens Serum Institut (SSI). COVID-19 i Danmark. Fokusrapport: Udbrud pa grundskoler. [updated 18 November 2020; cited 16 December 2020]. Available from: https://www.ssi.dk/-/media/arkiv/subsites/covid19/fokusrapporter/fokusrapport-om-covid19-udbrud-i-grundskoler-u45.pdf?la=da

79. oesterreich.orf.at. Schulgurgeltests: 40 von 10.000 positiv. [updated 13 November 2020; cited 3 December 2020]. Available from: https://oesterreich.orf.at/stories/3075784/

80. European Centre for Disease Prevention and Control (ECDC). Guidelines for the implementation of non-pharmaceutical interventions against COVID-19. [updated 24 September 2020; cited 4 Dicember 2020]. Available from: https://www.ecdc.europa.eu/en/publications-data/covid-19-guidelines-non-pharmaceutical-interventions

81. World Health Organization (WHO). Advice on the use of masks for children in the community in the context of COVID-19. [cited 7 December 2020]. Available from: https://www.who.int/publications/i/item/WHO-2019-nCoV-IPC_Masks-Children-2020.1

82. European Centre for Disease Prevention and Control (ECDC). Heating, ventilation and air-conditioning systems in the context of COVID-19: first update. [updated 11 November 2020; cited 4 December 2020]. Available from: https://www.ecdc.europa.eu/en/publications-data/heating-ventilation-air-conditioning-systems-covid-19

83. European Centre for Disease Prevention and Control (ECDC). Guidance for discharge and ending of isolation of people with COVID-19. [updated 16 October 2020; cited 4 December 2020]. Available from: https://www.ecdc.europa.eu/en/publications-data/guidance-discharge-and-ending-isolation-people-covid-19

84. Landeros A, Ji X, Lange KL, Stutz TC, Xu J, Sehl ME, et al. An Examination of School Reopening Strategies during the SARS-CoV-2 Pandemic. medRxiv [Preprint]. 6 August 2020; Available from: https://www.medrxiv.org/content/10.1101/2020.08.05.20169086v1
85. Bershteyn A, Kim H-Y, McGillen JB, Braithwaite RS. Which policies most effectively reduce SARS-CoV-2 transmission in schools? medRxiv [Preprint]. 27 November 2020; Available from: https://www.medrxiv.org/content/10.1101/2020.11.24.20237305v1
86. Yoon Y, Kim KR, Park H, Kim S, Kim YJ. Stepwise School Opening and an Impact on the Epidemiology of COVID-19 in the Children. J Korean Med Sci. 2020;35(46):e414. Available from: https://jkms.org/DOIx.php?id=10.3346/jkms.2020.35.e414
87. Vogel G., Couzin-Frankel J. As COVID-19 soars in many communities, schools attempt to find ways through the crisis. [updated 18 November 2020; cited 6 December 2020]. Available from: https://www.sciencemag.org/news/2020/11/covid-19-soars-many-communities-schools-attempt-find-ways-through-crisis
88. Shapiro E. New York City to close public schools again as virus cases rise. [updated 23 November 2020; cited 6 December 2020]. Available from: https://www.nytimes.com/2020/11/18/nyregion/nyc-schools-covid.html
89. Leask J, Hooker C. How risk communication could have reduced controversy about school closures in Australia during the COVID-19 pandemic. Public Health Res Pract. 2020;30(2):e3022007. Available from: https://doi.org/10.17061/phrp3022007
90. United Nations Children's Fund (UNICEF), World Health Organization (WHO), and International Federation of Red Cross (IFRC). Key Messages and Actions for COVID-19 Prevention and Control in Schools. [updated March 2020; cited 6 December 2020].
91. COVID-19 Health Systems Response Monitor. What strategies and approaches are countries implementing within schools both in response to COVID-19 and to localized outbreaks? [updated 15 September 2020; cited 6 December 2020]. Available from: https://analysis.covid19healthsystem.org/index.php/2020/09/15/what-strategies-and-approaches-are-countries-implementing-within-schools-both-in-response-to-covid-19-and-to-localized-outbreaks/
92. European Centre for Disease Prevention and Control (ECDC). Guidance on community engagement for public health events caused by communicable disease threats in the EU/EEA. [updated 13 February 2020; cited 6 December 2020]. Available from: https://www.ecdc.europa.eu/en/publications-data/guidance-community-engagement-public-health-events-caused-communicable-disease
93. Schools for Health in Europe (SHE). Technical Advisory Group on Safe Schooling During the COVID-19 Pandemic. [updated 18 November 2020; cited 6 December 2020]. Available from: https://www.schoolsforhealth.org/newsroom/wed-18112020-1732-technical-advisory-group-safe-schooling-during-covid-19-pandemic
94. World Health Organization (WHO) - Regional Office for Europe (EURO). Twitter Thread. [updated 20 November 2020; cited 6 December 2020]. Available from: https://twitter.com/WHO_Europe/status/1329773344502243330
95. World Health Organization (WHO). Live Q&A on COVID-19 and young people with Dr Mike Ryan and Dr Maria Van Kerkhove. Ask your questions. [updated 12 August 2020; cited 6 December 2020]. Available from: https://www.facebook.com/154163327962392/videos/3248547315191031
96. City of Toronto. COVID-19: School Information for Parents & Caregivers. [updated 4 December 2020; cited 7 December 2020]. Available from: https://www.toronto.ca/home/covid-19/covid-19-reopening-recovery-rebuild/covid-19-reopening-information-for-the-public/covid-19-school-information-for-parents-caregivers/
97. Office of the Clinical Director - Health Protection Surveillance Centre (HPSC). Schools Pathway for Covid-19, the Public Health approach. [updated 24 August 2020; cited 6 December 2020]. Available from: https://assets.gov.ie/86158/573fe99d-e847-4bb6-b865-456e5c03b7e4.pdf
98. Bundesministerium Bildung WuF. Coronavirus (COVID-19): Hygienemaßnahmen. [cited 6 December 2020]. Available from: https://www.bmbwf.gv.at/Ministerium/Informationspflicht/corona/corona_schutz.html
99. European Centre for Disease Prevention and Control (ECDC). Communication toolkit on gastrointestinal diseases: How to support infection prevention in schools. [updated 19 november 2013; cited 8 December 2020]. Available from: https://www.ecdc.europa.eu/en/publications-data/communication-toolkit-gastrointestinal-diseases-how-support-infection
100. Younie S, Mitchell C, Bisson M-J, Crosby S, Kukona A, Laird K. Improving young children’s handwashing behaviour and understanding of germs: The impact of A Germ’s Journey educational resources in schools and public spaces. Plos One. 2020;15(11):e0242134. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0242134

101. E-Bug operated by Public Health England (PHE). Information about the Coronavirus (COVID-19). [cited 6 December 2020]. Available from: https://www.e-bug.eu/page.php?name=Information-about-the-Coronavirus

102. Fokhälsomyndigheten. Informationsinsats: Allt är inte som vanligt. [updated 17 November 2020; cited 6 December 2020]. Available from: https://www.folkhalsomyndigheten.se/smittskydd-beredskap/utbrott/aktuella-utbrott/covid-19/verksamheter/information-till-skola-och-forskola-om-den-nya-sjukdomen-covid-19/informationsinsats-allt-ar-inte-som-vanligt/

103. Sveriges Radio. Godmorgon världen. Ministrar med kepsen bak och fram - "tror det funkar". [updated 7 November 2020; cited 6 December 2020]. Available from: https://sverigesradio.se/artikel/7617291

104. Gov.uk - Department of Education. What parents and carers need to know about early years providers, schools and colleges in the autumn term. [updated 27 November 2020; cited 6 December 2020]. Available from: https://www.gov.uk/government/publications/what-parents-and-carers-need-to-know-about-early-years-providers-schools-and-colleges-during-the-coronavirus-covid-19-outbreak/what-parents-and-carers-need-to-know-about-early-years-providers-schools-and-colleges-in-the-autumn-term

105. United Nations Children's Fund (UNICEF). What will a return to school during COVID-19 look like? [updated 24 August 2020; cited 6 December 2020]. Available from: https://www.unicef.org/coronavirus/what-will-return-school-during-covid-19-pandemic-look

106. World Health Organization (WHO). How to speak to kids? (video). [cited 6 December 2020]. Available from: https://m.facebook.com/WHO/videos/390131995369205

107. World Health Organization (WHO). Coronavirus disease (COVID-19): Schools. [updated 18 Seprember 2020; cited 6 December 2020]. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/coronavirus-disease-covid-19-schools

108. European Centre for Disease Prevention and Control (ECDC). COVID-19 testing strategies and objectives. [updated 18 September 2020; cited 8 December 2020]. Available from: https://www.ecdc.europa.eu/en/publications-data/covid-19-testing-strategies-and-objectives

109. European Centre for Disease Prevention and Control (ECDC). Objectives for COVID-19 testing in school settings. [updated 10 August 2020; cited 10 December 2020]. Available from: https://www.ecdc.europa.eu/en/publications-data/objectives-covid-19-testing-school-settings

110. European Centre for Disease Prevention and Control (ECDC). Contact tracing: public health management of persons, including healthcare workers, who have had contact with COVID-19 cases in the European Union – third update. [updated 18 November 2020; cited 10 December 2020]. Available from: https://www.ecdc.europa.eu/en/covid-19-contact-tracing-public-health-management

111. World Health Organization (WHO). Schools and other educational institutions transmission investigation protocol for coronavirus disease 2019 (COVID-19). [updated 30 September 2020; cited 4 December 2020]. Available from: https://apps.who.int/iris/bitstream/handle/10665/336253/WHO-2019-nCoV-Schools_transmission-2020.1-eng.pdf

112. European Centre for Disease Prevention and Control (ECDC). Options for the use of rapid antigen tests for COVID-19 in the EU/EEA and the UK. [updated 19 November 2020; cited 10 December 2020]. Available from: https://www.ecdc.europa.eu/en/publications-data/options-use-rapid-antigen-tests-covid-19-eueea-and-uk

113. European Commission (EC). Commission Recommendation on the use of rapid antigen tests for the diagnosis of SARS-CoV-2 infection. [updated 18 November 2020; cited 10 December 2020]. Available from: https://ec.europa.eu/health/sites/health/files/preparedness_response/docs/sarscov2_rapidantigentests_recommendation_en.pdf

114. Wyllie AL, Fournier J, Casanovas-Massana A, Campbell M, Tokuyama M, Vijayakumar P, et al. Saliva or nasopharyngeal swab specimens for detection of SARS-CoV-2. New England Journal of Medicine. 2020;383(13):1283-6. Available from: https://www.nejm.org/doi/full/10.1056/NEJMc2016359

115. Czumbel LM, Kiss S, Farkas N, Mandel I, Hegyi A, Nagy Á, et al. Saliva as a Candidate for COVID-19 Diagnostic Testing: A Meta-Analysis. Frontiers in Medicine. 2020;7(465). Available from: https://www.frontiersin.org/article/10.3389/fmed.2020.00465

116. European Centre for Disease Prevention and Control (ECDC). Contact tracing for COVID-19: current evidence, options for scale-up and an assessment of resources needed. [updated 5 May 2020; cited 10 December 2020]. Available from: https://www.ecdc.europa.eu/en/publications-data/contact-tracing-covid-19-evidence-scale-up-assessment-resources

117. World Health Organization (WHO). Considerations for school-related public health measures in the context of COVID-19. 2020 [updated 14 September 2020; cited 3 December 2020]. Available from:

https://www.who.int/publications/i/item/considerations-for-school-related-public-health-measures-in-the-context-of-covid-19

118. European Network of Ombudspersons for Children (ENOC) and United Nations International Children's Fund (UNICEF). Ombudspersons and Commissioners for Children's Challenges and Responses to Covid-19. [3 December 2020]. Available from: http://enoc.eu/wp-content/uploads/2020/06/ENOC-UNICEFF-COVID-19-survey-updated-synthesis-report-FV.pdf

119. United Nations Educational Scientific and Cultural Organization (UNESCO). Adverse consequences of school closures. [3 December 2020]. Available from: https://en.unesco.org/covid19/educationresponse/consequences

120. Di Pietro G, Biagi F, Costa P, Karpiński Z., Mazza J. The likely impact of COVID-19 on education: Reflections based on the existing literature and recent international datasets. [cited 8 December 2020]. Available from: doi:10.2760/126686

121. Fantini MP, Reno C, Biserni GB, Savoia E, Lanari M. COVID-19 and the re-opening of schools: a policy maker's dilemma. Italian Journal of Pediatrics. 2020;46(1):79. Available from: https://ijponline.biomedcentral.com/articles/10.1186/s13052-020-00844-1

122. Courtney D, Watson P, Battaglia M, Mulsant BH, Szatmari P. COVID-19 Impacts on Child and Youth Anxiety and Depression: Challenges and Opportunities. Canadian Journal of Psychiatry. 2020;65(10):688-91. Available from: https://journals.sagepub.com/doi/full/10.1177/0706743720935646

123. Cluver L, Lachman JM, Sherr L, Wessels I, Krug E, Rakotomalala S, et al. Parenting in a time of COVID-19. Lancet. 2020;395(10231):e64. Available from: https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)30736-4/fulltext

124. Baron EJ, Goldstein EG, Wallace CT. Suffering in silence: How COVID-19 school closures inhibit the reporting of child maltreatment. J Public Econ. 2020;190:104258. Available from: https://www.sciencedirect.com/science/article/pii/S0047272720301225

125. Christakis DA, Van Cleve W, Zimmerman FJ. Estimation of US Children's Educational Attainment and Years of Life Lost Associated With Primary School Closures During the Coronavirus Disease 2019 Pandemic. JAMA Network Open. 2020;3(11):e2028786-e. Available from: https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2772834

126. Weale S. 'It's been tumultuous': Covid-19 stress takes toll on teachers in England. [updated 14 December 2020]. Available from: https://www.theguardian.com/education/2020/dec/14/covid-stress-takes-toll-on-teachers-in-england

127. UN News. UN chief outlines 'bold steps' for education in the face of COVID-19 disruption. [updated 4 August 2020; cited 4 December 2020]. Available from: https://news.un.org/en/story/2020/08/1069442

128. European Centre for Disease Prevention and Control (ECDC). Weekly COVID-19 country overview. [cited 4 December 2020]. Available from: https://www.ecdc.europa.eu/en/covid-19/country-overviews

129. European Commission (EC). Science for Policy Briefs - Educational inequalities in Europe and physical school closures during Covid-19 [cited 4 December 2020]. Available from: https://ec.europa.eu/jrc/sites/jrcsh/files/fairness_pb2020_wave04_covid_education_jrc_i1_19jun2020.pdf

130. Royal Society DELVE Initiative. Balancing the Risks of Pupils Returning to Schools. [updated 24 July 2020; cited 4 December 2020]. Available from: https://rs-delve.github.io/reports/2020/07/24/balancing-the-risk-of-pupils-returning-to-schools.html

131. Armitage R, Nellums LB. Considering inequalities in the school closure response to COVID-19. The Lancet Global Health. 2020;8(5):e644. Available from: https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(20)30116-9/fulltext

132. Van Lancker W, Parolin Z. COVID-19, school closures, and child poverty: a social crisis in the making. Lancet Public Health. 2020;5(5):e243-e4. Available from: https://www.thelancet.com/journals/lanpub/article/PIIS2468-2667(20)30084-0/fulltext

133. Kinsey EW, Hecht AA, Dunn CG, Levi R, Read MA, Smith C, et al. School Closures During COVID-19: Opportunities for Innovation in Meal Service. Am J Public Health. 2020;110(11):1635-43. Available from: https://ajph.aphapublications.org/doi/10.2105/AJPH.2020.305875

134. van Tilburg M.A.L., Edlynn E, Maddaloni M, van Kempen K, Díaz-González de Ferris M, Thomas J. High Levels of Stress Due to the SARS-CoV-2 Pandemic among Parents of Children with and without Chronic Conditions across the USA. Children. 2020;7(10):193. Available from: https://www.mdpi.com/2227-9067/7/10/193

135. Sadique MZ, Adams EJ, Edmunds WJ. Estimating the costs of school closure for mitigating an influenza pandemic. BMC Public Health. 2008;8:135. Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-8-135

136. Sander B, Nizam A, Garrison LP, Jr., Postma MJ, Halloran ME, Longini IM, Jr. Economic evaluation of influenza pandemic mitigation strategies in the United States using a stochastic microsimulation transmission model. Value Health. 2009;12(2):226-33. Available from: https://www.sciencedirect.com/science/article/pii/S1098301510606997

137. Saunders-Hastings P, Quinn Hayes B, Smith R, Krewski D. Modelling community-control strategies to protect hospital resources during an influenza pandemic in Ottawa, Canada. PLoS One. 2017;12(6):e0179315. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0179315

138. Halder N, Kelso JK, Milne GJ. Cost-effective strategies for mitigating a future influenza pandemic with H1N1 2009 characteristics. PLoS One. 2011;6(7):e22087. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0022087

139. Hanushek EA, Woessmann L. The Economic Impacts of Learning Losses. [updated September 2020; cited 3 December 2020]. Available from: https://www.oecd.org/education/The-economic-impacts-of-coronavirus-covid-19-learning-losses.pdf

140. Krishnaratne S, Pfadenhauer LM, Coenen M, Geffert K, Jung-Sievers C, Klinger C, et al. Measures implemented in the school setting to contain the COVID-19 pandemic: a scoping review. Cochrane Database of Systematic Reviews [Preprint]. 17 December 2020; Available from: https://doi.org//10.1002/14651858.CD013812

141. Keogh-Brown MR, Jensen HT, Edmunds WJ, Smith RD. The impact of Covid-19, associated behaviours and policies on the UK economy: A computable general equilibrium model. SSM Popul Health [Preprint]. 14 October 2020 2020; Available from: https://www.sciencedirect.com/science/article/pii/S2352827320302883

142. Rice KL. Estimated Resource Costs for Implementation of CDC's Recommended COVID-19 Mitigation Strategies in Pre-Kindergarten through Grade 12 Public Schools—United States, 2020–21 School Year. MMWR. Morbidity and Mortality Weekly Report [Preprint]. 11 December 2020 2020; Available from: https://www.cdc.gov/mmwr/volumes/69/wr/mm6950e1.htm

143. Lo Moro G, Sinigaglia T, Bert F, Savatteri A, Gualano MR, Siliquini R. Reopening Schools during the COVID-19 Pandemic: Overview and Rapid Systematic Review of Guidelines and Recommendations on Preventive Measures and the Management of Cases. International Journal of Environmental Research and Public Health. 2020;17(23):8839. Available from: https://www.mdpi.com/1660-4601/17/23/8839

144. World Health Organization (WHO). Measures in school settings - Pandemic (H1N1) 2009 briefing note 10. [updated 11 September 2009; cited 8 December 2020]. Available from: https://www.who.int/csr/disease/swineflu/notes/h1n1_school_measures_20090911/en/

145. Flaxman S, Mishra S, Gandy A, Unwin HJT, Mellan TA, Coupland H, et al. Estimating the effects of non-pharmaceutical interventions on COVID-19 in Europe. Nature. 2020;584(7820):257-61. Available from: https://www.nature.com/articles/s41586-020-2405-7

146. Piovani D, Christodoulou MN, Hadjidemetriou A, Pantavou K, Zaza P, Bagos PG, et al. Effect of early application of social distancing interventions on Covid-19 mortality over the first pandemic wave: an analysis of longitudinal data from 37 countries. Journal of Infection [Preprint]. 30 November 2020; Available from: https://www.journalofinfection.com/article/S0163-4453(20)30751-9/fulltext

147. Islam N, Sharp SJ, Chowell G, Shabnam S, Kawachi I, Lacey B, et al. Physical distancing interventions and incidence of coronavirus disease 2019: natural experiment in 149 countries. BMJ. 2020;370:m2743. Available from: https://www.bmj.com/content/370/bmj.m2743.long

148. Hsiang S, Allen D, Annan-Phan S, Bell K, Bolliger I, Chong T, et al. The effect of large-scale anti-contagion policies on the COVID-19 pandemic. Nature. 2020;584(7820):262-7. Available from: https://www.nature.com/articles/s41586-020-2404-8

149. Li Y, Campbell H, Kulkarni D, Harpur A, Nundy M, Wang X, et al. The temporal association of introducing and lifting non-pharmaceutical interventions with the time-varying reproduction number (R) of SARS-CoV-2: a modelling study across 131 countries. The Lancet Infectious Diseases [Preprint]. 22 October 2020; Available from: https://www.sciencedirect.com/science/article/pii/S1473309920307854

150. Vannoni M, McKee M, Semenza JC, Bonell C, Stuckler D. Using volunteered geographic information to assess mobility in the early phases of the COVID-19 pandemic: a cross-city time series analysis of 41 cities in 22 countries from March 2nd to 26th 2020. Globalization and Health. 2020;16(1):1-9. Available from: https://globalizationandhealth.biomedcentral.com/articles/10.1186/s12992-020-00598-9

151. Aravindakshan A, Boehnke J, Gholami E, Nayak A. Preparing for a future COVID-19 wave: insights and limitations from a data-driven evaluation of non-pharmaceutical interventions in Germany. Scientific Reports. 2020;10(1):20084. Available from: https://www.nature.com/articles/s41598-020-76244-6

152. Rozhnova G, van Dorp CH, Bruijning-Verhagen P, Bootsma MC, van de Wijgert JH, Bonten MJ, et al. Model-based evaluation of school-and non-school-related measures to control the COVID-19 pandemic. medRxiv [Preprint]. 8 December 2020 2020; Available from: https://www.medrxiv.org/content/10.1101/2020.12.07.20245506v1

153. Edmunds WJ. Finding a path to reopen schools during the COVID-19 pandemic. The Lancet Child & Adolescent Health. 2020;4(11):796-7. Available from: https://www.sciencedirect.com/science/article/pii/S2352464220302492

154. Brauner JM, Mindermann S, Sharma M, Johnston D, Salvatier J, Gavenčiak T, et al. Inferring the effectiveness of government interventions against COVID-19. Science [Preprint]. 15 December 2020; Available from: https://science.sciencemag.org/content/sci/early/2020/12/15/science.abd9338.full.pdf

155. Auger KA, Shah SS, Richardson T, Hartley D, Hall M, Warniment A, et al. Association Between Statewide School Closure and COVID-19 Incidence and Mortality in the US. JAMA. 2020;324(9):859-70. Available from: https://jamanetwork.com/journals/jama/fullarticle/2769034

156. Yehya N, Venkataramani A, Harhay MO. Statewide interventions and Covid-19 mortality in the United States: an observational study. Clinical Infectious Diseases [Preprint]. 8 July 2020; Available from: https://academic.oup.com/cid/advance-article/doi/10.1093/cid/ciaa923/5868545

157. Klimek-Tulwin M, Tulwin T. Early school closures can reduce the first-wave of the COVID-19 pandemic development. Journal of Public Health [Preprint]. 15 October 2020; Available from: https://link.springer.com/article/10.1007/s10389-020-01391-z

158. Iwata K, Doi A, Miyakoshi C. Was school closure effective in mitigating coronavirus disease 2019 (COVID-19)? Time series analysis using Bayesian inference. International Journal of Infectious Diseases. 2020;99:57-61. Available from: http://www.sciencedirect.com/science/article/pii/S1201971220305981

159. Kuitunen I, Haapanen M, Artama M, Renko M. Closing Finnish schools and day care centres had a greater impact on primary care than secondary care emergency department visits. Acta Paediatrica [Preprint]. 30 October 2020 2020; Available from: https://onlinelibrary.wiley.com/doi/10.1111/apa.15646

160. Scott N, Palmer A, Delport D, Abeysuriya R, Stuart RM, Kerr CC, et al. Modelling the impact of relaxing COVID-19 control measures during a period of low viral transmission. Medical Journal of Australia [Preprint]. 18 November 2020 2020; Available from: https://doi.org/10.5694/mja2.50845

161. Panovska-Griffiths J, Kerr CC, Stuart RM, Mistry D, Klein DJ, Viner RM, et al. Determining the optimal strategy for reopening schools, the impact of test and trace interventions, and the risk of occurrence of a second COVID-19 epidemic wave in the UK: a modelling study. Lancet Child Adolesc Health. 2020;4(11):817-27. Available from: https://www.thelancet.com/journals/lanchi/article/PIIS2352-4642(20)30250-9/fulltext

162. Reuters.com. Reopening schools in Denmark did not worsen outbreak, data shows. [updated 28 May 2020; cited 3 December 2020]. Available from: https://www.reuters.com/article/us-health-coronavirus-denmark-reopening-idUSKBN2341N7

163. Otte Im Kampe E, Lehfeld AS, Buda S, Buchholz U, Haas W. Surveillance of COVID-19 school outbreaks, Germany, March to August 2020. Euro Surveill. 2020;25(38). Available from: https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2020.25.38.2001645

164. Lee B, Hanley JP, Nowak S, Bates JHT, Hébert-Dufresne L. Modeling the impact of school reopening on SARS-CoV-2 transmission using contact structure data from Shanghai. BMC Public Health. 2020;20(1):1713. Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-020-09799-8

165. World Health Organization (WHO). Considerations for implementing and adjusting public health and social measures in the context of COVID-19. [updated 4 November 2020; cited 8 December 2020]. Available from: https://www.who.int/publications/i/item/considerations-in-adjusting-public-health-and-social-measures-in-the-context-of-covid-19-interim-guidance

166. National Collaborating Centre for Methods and Tools. Living Rapid Review Update 10: What is the specific role of daycares and schools in COVID-19 transmission? [updated 12 November 2020; cited 3 December 2020]. Available from: https://www.nccmt.ca/uploads/media/media/0001/02/2f13bcee5c59ac63961a88915866efc53822936f.pdf

167. Davies NG, Klepac P, Liu Y, Prem K, Jit M, Eggo RM. Age-dependent effects in the transmission and control of COVID-19 epidemic. Nature Medicine. 2020;16:1205–11. Available from: https://www.nature.com/articles/s41591-020-0962-9

168. Goldstein E, Lipsitch M. Temporal rise in the proportion of younger adults and older adolescents among coronavirus disease (COVID-19) cases following the introduction of physical distancing measures, Germany, March to April 2020. Euro Surveill. 2020;25(17). Available from: https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2020.25.17.2000596

169. Fateh-Moghadam P, Battisti L, Molinaro S, Fontanari S, Dallago G, Binkin N, et al. Contact tracing during Phase I of the COVID-19 pandemic in the Province of Trento, Italy: key findings and recommendations. medRxiv [Preprint]. 29 July 2020; Available from: https://www.medrxiv.org/content/10.1101/2020.07.16.20127357v1

170. Viner RM, Russell SJ, Croker H, Packer J, Ward J, Stansfield C, et al. School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review. Lancet Child & Adolescent Health. 2020;4(5):397-404. Available from: https://www.thelancet.com/journals/lanchi/article/PIIS2352-4642(20)30095-X/fulltext

171. Fong M, Cowling B, Leung G, Wu P. Letter to the editor: COVID-19 cases among school-aged children and school-based measures in Hong Kong, July 2020. Eurosurveillance. 2020;25(37):2001671. Available from: https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2020.25.37.2001671

172. Silberstein R. More indicators schools not source of coronavirus spread. [updated 2 December 2020; cited 4 December 2020]. Available from: https://www.timesunion.com/news/article/Most-Capital-Region-15769774.php?IPID=Times-Union-HP-CP-Spotlight

173. Rijksinstituut voor Volksgezondheid en Milieu (RIVM). Children, school and COVID-19. [updated 12 February 20204 December 2020]. Available from: https://www.rivm.nl/en/novel-coronavirus-covid-19/children-and-covid-19

174. Torres JP, Piñera C, De La Maza V, Lagomarcino AJ, Simian D, Torres B, et al. SARS-CoV-2 antibody prevalence in blood in a large school community subject to a Covid-19 outbreak: a cross-sectional study. Clinical infectious diseases : an official publication of the Infectious Diseases Society of America. 2020. Available from: https://doi.org/10.1093/cid/ciaa955

175. Koo JR, Cook AR, Park M, Sun Y, Sun H, Lim JT, et al. Interventions to mitigate early spread of SARS-CoV-2 in Singapore: a modelling study. The Lancet Infectious Diseases. 2020;20(6):678-88. Available from: https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(20)30162-6/fulltext

176. Zhang J, Litvinova M, Liang Y, Wang Y, Wang W, Zhao S, et al. Changes in contact patterns shape the dynamics of the COVID-19 outbreak in China. Science. 2020;368(6498):1481-6. Available from: https://science.sciencemag.org/content/368/6498/1481.full

177. Bayham J, Fenichel EP. Impact of school closures for COVID-19 on the US health-care workforce and net mortality: a modelling study. The Lancet Public Health. 2020;5(5):e271-e8. Available from: https://www.sciencedirect.com/science/article/pii/S2468266720300827

178. Kim S, Kim Y-J, Peck KR, Jung E. 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;35(13):e143. Available from: https://jkms.org/DOIx.php?id=10.3346/jkms.2020.35.e143

179. Chin ET, Huynh BQ, Lo NC, Hastie T, Basu S. Projected geographic disparities in healthcare worker absenteeism from COVID-19 school closures and the economic feasibility of child care subsidies: a simulation study. 2020;18(1):218. Available from: https://bmcmedicine.biomedcentral.com/articles/10.1186/s12916-020-01692-w

180. Abdollahi E, Haworth-Brockman M, Keynan Y, Langley JM, Moghadas SM. Simulating the effect of school closure during COVID-19 outbreaks in Ontario, Canada. BMC medicine. 2020;18(1):1-8. Available from: https://bmcmedicine.biomedcentral.com/articles/10.1186/s12916-020-01705-8

181. Prem K, Liu Y, Russell TW, Kucharski AJ, Eggo RM, Davies N, et al. The effect of control strategies to reduce social mixing on outcomes of the COVID-19 epidemic in Wuhan, China: a modelling study. The Lancet Public Health. 2020;5(5):e261-e70. Available from: https://www.sciencedirect.com/science/article/pii/S2468266720300736

182. Davies NG, Kucharski AJ, Eggo RM, Gimma A, Edmunds WJ, Jombart T, et al. Effects of non-pharmaceutical interventions on COVID-19 cases, deaths, and demand for hospital services in the UK: a modelling study. The Lancet Public Health. 2020;5(7):e375-e85. Available from: https://www.sciencedirect.com/science/article/pii/S246826672030133X

183. Rice K, Wynne B, Martin V, Ackland GJ. Effect of school closures on mortality from coronavirus disease 2019: old and new predictions. BMJ. 2020;371:m3588. Available from: https://www.bmj.com/content/371/bmj.m3588

184. Zhang J, Litvinova M, Liang Y, Zheng W, Shi H, Vespignani A, et al. The impact of relaxing interventions on human contact patterns and SARS-CoV-2 transmission in China. medRxiv [Preprint]. 4 August 2020; Available from: https://www.medrxiv.org/content/10.1101/2020.08.03.20167056v1

Annex 1. Literature review

1.1 Background

ECDC conducted a literature review to assess child-to-child and child-to-adult SARS-CoV-2 transmission and to characterise the potential role of school closures on community transmission. This review is currently available online, where the full methodology is described [39]. This review was completed for papers published up to 31 August 2020. For this report, a top-up screening using the same search strategy was conducted to identify an updated 'initial study list' of papers published between 1 September 2020 and 18 November 2020. The literature presented here also addresses transmission to and from adults in school settings. This review not only takes into account the aforementioned literature review and updated screening, but also the literature presented in the previous ECDC report on COVID-19 and children [3], as well as the findings from two separate independent and high-quality reviews of this topic [31,166]. ECDC will be conducting a follow-up systematic review, based upon the previously published protocol [39], to assess the breadth of peer review literature published through the end of March 2021.

1.2 Susceptibility and infectiousness of children in community settings

Children, particularly those younger than 10-14, appear to be less susceptible to SARS-CoV-2 than those 20 years and older, which would lead to lower prevalence among children and fewer opportunities for onward transmission [31]. A prospective cohort study from 25 educational centres in Australia observed that, at a time when school attendance was high, adult staff accounted for 10% of attendees in these settings but 56% of primary COVID-19 cases [62].

One systematic review offered further evidence that children and adolescents have lower susceptibility to SARS-CoV-2 infection than adults, reporting a pooled OR of 0.56 (95% CI, 0.37-0.85) [31]. A separate systematic review and meta-analysis noted a high heterogeneity in findings but concluded that adults have higher susceptibility to SARS-CoV-2 infection than children under 18 years of age (RR: 1.71; CI: 1.35 – 1.71) [30]. These results are consistent with those from a mathematical modelling study that concluded that susceptibility to infection among children under 20 years of age is approximately half that of adults [167].

These findings are somewhat contradicted by a report (not yet peer-reviewed) from Austria, in which a representative sample of 243 schools tested among over 10 000 randomly sampled staff and students from primary and secondary school levels. For the study period 28 September – 22 October, there was no statistically significant difference between prevalence of SARS-CoV-2 positive tests among primary school students (0.38%; 95CI: 0.23-0.62%) and middle or lower secondary school students (0.41%; 95CI: 0.26-0.65%), or between students (0.37%; 95CI: 0.26-0.53%) and teachers (0.57%; CI: 0.25-1.32%) more generally [32]. However, this study did find that the risk of SARS-CoV-2 positivity in children was substantially higher among schools with higher shares of children from socially disadvantaged backgrounds (OR: 3.58; 95CI: 1.76-7.28).

There is a significant and growing body of research that demonstrates that children can transmit SARS-CoV-2 in the community, household and school settings, even if onward transmission has been observed [31,39] less frequently than for adults.

A case study reported the contact-tracing results of nosocomial outbreak in a pediatric ward in South Korea. A total of 1 206 close and casual contacts were identified, of which PCR results were negative for every close and casual contact, except for one adult [33]. Pediatric COVID-19 cases in Thailand were detected as part of epidemiologic investigations among three family clusters. All children had very mild respiratory symptoms before admission. No other symptoms were documented. To assess the possibility of transmission to the caregivers, nasopharyngeal and throat swabs were taken. All respiratory swabs from caregivers were negative and none of them developed any symptoms throughout the period of stay in the hospital nor after two weeks of follow up [34].

In India, a large contact tracing study concluded that that highest probability of transmission was between case-contact pairs of similar age, and that this pattern of enhanced transmission risk among children 0-14 years of age as well as adults 65 years of age and older [35]. The study did, however, note that the greatest proportion of SARS-CoV-2 positive contacts were exposed to index cases aged 20-44. In another study from India, the contacts of 19 paediatric index cases were examined. Among primary familial contacts, with prolonged potential exposure to children, 11.9% adult patients became positive for SARS-CoV-2. The study also noted that among families with a similar history of exposure, children were more commonly positive for SARS-CoV-2 [REF].

In Germany the contributing roles of different age groups in COVID-19 community transmission were evaluated. According to their analysis, which compared two time periods, one prior to and one after the implementation of physical distancing measures including school closures, COVID-19 cases among 10-14 and 15-19 year olds were 0.78 times lower and 1.14 times more likely respectively to be a case, compared with other age groups in the second time period. In a comparison of all age groups, individuals aged 10-14 years had lower odds of being a case compared with 15-34 year-olds, while 15-19 year-olds were less likely to be a case (OR 0.81) than 20-24 year olds, but more likely to be one than age groups 25 years and older [168].

In Wisconsin, USA, an outbreak at an overnight summer school retreat occurred when an adolescent who had tested negative for SARS-CoV-2 within the previous seven days developed COVID-19. This led to 116/152 attendees (76%) becoming confirmed COVID-19 cases [36]. An outbreak at an overnight camp in Georgia, USA, with a presumed teenage staff member as the index case, the overall attack rate was 44% (260 of 597 staff and attendees) [37]. The attack rate was 51% (51/100) in children 6-10 years of age, 44% (180/409) in children 11-17 years of age, 33% (27/81) in those 18-21 years of age, and 29% (2/7) in those 22-59 years of age.

In the USA, an adolescent (13 year old) was the index case for an outbreak of 12 cases at a three-week family gathering [38]. Among 14 people staying in the same house, 12 were diagnosed with COVID-19. Six additional family members did not stay in the same house but visited for extended periods while maintaining outdoor physical distance without facemasks. None of these six developed symptoms; four of these 6 were tested for SARS-CoV-2, all negative.

A preprint manuscript reported on contact tracing efforts carried out during school closures in Trento, Italy, the attack rate among contacts of 0–14 year old cases was 22.4%, which is higher than that of working-age adults (approximately 13.1%)[169]. In this study, not all asymptomatic contacts were tested, and only 14 index cases among 0-14 year olds were identified.

1.3 Susceptibility and infectiousness of children in household settings

There is a growing body of peer-reviewed studies that has assessed household child-to-child and child-to-adult transmission within family settings [39]. There is a high degree of heterogeneity across these study findings [30].

Children have been rarely identified as index cases in household studies, although during the early phases of the COVID-19 pandemic, many children were not attending school and their social mixing opportunities were likely significantly lower than normal. One study assessed the clinical presentation of the 111 household contacts of the first paediatric cases of COVID-19 in Geneva, Switzerland, according to which only in 3/39 (8%) of households the study child was the index case [40]. A study from the USA conducted contact tracing among household members of 32 confirmed paediatric COVID-19 cases. In only 7/32 households were children the first to develop symptoms of COVID-19 and were assumed as the suspected index cases [41]. The role of children in household COVID-19 transmission in Israel was assessed through a cluster of 13 families. It was found that a child [42] was the index case in only one of the 13 families. Meanwhile, of 23 family clusters in Greece, the index case was a child in only two families, while there was no evidence of child-to-adult or child-to-child secondary transmission [43]. Also reporting low rates of secondary transmission, one study from South Korea among 107 index children and 248 household members, identified only one case of secondary transmission to a household member and the secondary attack rate was estimated to be 0.5% [44]. In this study, an additional 40 confirmed cases were found in household members, but it could not be determined as a secondary transmission as they had the same exposure as the paediatric index case [44].

Conversely, other studies have suggested relatively high secondary transmission rates from children. For example, a prospective household study from the USA concluded that household transmission of SARS-CoV-2 is common, whether from children or adults. The study included 191 household contacts of 101 index patients. The overall secondary infection rate was 53%; where index cases were <12 years of age the secondary attack rate was 53% (CI: 31%-74%) and from index patients aged 12-17 years the secondary attack rate was 38% (CI: 23%-53%)[45,46]. A study from South Korea assessed 5 706 COVID-19 index cases and 10 592 household contacts. The overall household secondary attack rate was 11.8%. The household secondary attack rate was 5.3% in children 0-9 years of age, the lowest rate in the study, while the highest rate in the study was among household contacts of index cases 10-19 years of age, at 18.6%[46].

There are important limitations to many of the household and community transmission studies currently available, which have been acknowledged elsewhere [31,39]. Many of these took place at times and places where schools were closed and/or general 'lockdowns' were in effect. The study designs are primarily observational, and the household studies presented here reflect a broad geographical and temporal range are limited in comparability due to varying background levels of community SARS-CoV-2 transmission, household structures and social isolation practices within households, study testing rates, and physical distancing policies including school closures [31,39].

1.4 Transmission between children in school settings

The available evidence appears to suggest that transmission among children in schools can happen but less efficiently than other respiratory viruses such as influenza [170]. However, this evidence is mainly derived from reported school outbreaks, which tend to rely on detecting symptomatic cases only and will therefore underestimate the number of infected asymptomatic, and potentially infectious children in these outbreaks. In addition, due to public health capacity constraints during the COVID-19 pandemic, it is likely that many instances of COVID-19 in school settings are not thoroughly investigated and/or reported as grey or peer-reviewed literature.

A prospective, cross-sectional analysis of educational settings in England showed that SARS-CoV-2 clusters and outbreaks were uncommon across all educational settings [58]. A strong association with community transmission was observed: the risk of an outbreak in an educational setting increased by 72% (95CI: 28-130) for every increase in community incidence of 5 cases per 100 000. Most cases linked to outbreaks were staff, but observed probable transmission directions included staff-to-staff (26 outbreaks), staff-to-student (eight outbreaks), student-to-staff (16 outbreaks), and student-to-student (five outbreaks).

A study from Germany noted a very small proportion of school outbreaks among all COVID-19 outbreaks, and concluded that there is limited onward transmission in school settings [163]. A separate study from Germany suggested that child-to-child transmission in schools and childcare settings is uncommon. The study identified 137 cases among children aged 0-19 that had attended at least one day of school between 25 May 2020 and 5 August 2020. Six of the 137 cases were found to have infected a total of 11 additional pupils. The number of contacts was not reported [86].

In France, a carefully documented study identified an infected child (age nine years) who had interactions with a large number of contacts in three different schools and did not transmit the disease, as evidenced by the large number of negative results of tested symptomatic and asymptomatic contacts [60].

In Ireland, transmission within schools was investigated prior to school closures and no evidence of secondary transmission within the school setting was found. Among the 924 child contacts and 101 adult contacts of the six cases (three children, three adults) in the school setting, there were no confirmed cases identified during the 14-day follow-up period [61]. It is important to note that this study did not consider asymptomatic infections.

In Finland, no secondary cases were identified in contact tracing and testing of 89 out of 121 contacts of a 12-year case who had attended school during their illness [70]. A report from Hong Kong noted that despite multiple introductions of positive SARS-CoV-2 students into classroom settings, no onward transmission was documented [171].

One prospective cohort study from New South Wales, Australia presented an overview of COVID-19 cases and transmission in schools. In a total number of 25 schools and 10 Early Childhood Educational and Care Settings, 27 index cases were identified, among which 12 were children and 15 staff members. Secondary transmission was noted in only four out of 25 educational settings. In three of the schools, five secondary cases of 914 contacts were reported, of which three were children and two were adults. In a fourth school, a childcare centre, an outbreak led to transmission to six adults and seven children (attack rate 35.1%; 13/37 contacts). Across all study settings, the secondary attack rate for child-to-child transmission was 0.3% (2/649 contacts) [62].

A contact tracing study from Italy identified a secondary attack rate of 0% in infant-toddler centres, 0.44% in primary schools, and 6.46% in secondary schools. The age of secondary cases was not provided [65]. New York City conducted nearly 160 000 in-school tests between 9 October and 11 November 2020 and saw only 0.28% test positivity rates indicating that the school environment can be safer than the surrounding community [172].

Transmission in childcare facilities has also been observed in the USA and Poland. In Salt Lake City, USA, 17 childcare facilities with at least two confirmed COVID-19 cases were identified. Three of these facilities were assessed in detail; among 101 staff and children at these three centres, there were 22 confirmed COVID-19 cases (10 adult and 12 pediatric) [68]. The authors concluded that onward child transmission was likely but principally in household settings. In Rhode Island, USA [64], a study of among 666 childcare programmes that reopened on 1 June 2020 after a three-month closure revealed 52 confirmed and probable cases (33 confirmed cases), of which 30 were among children and 22 among adults [64]. Secondary transmission for 10 cases was noted in only 4/666 childcare programmes, which was attributed to class distancing, the use of face masks for adults, universal symptom screening daily and disinfection [64]. In Poland, a cluster of 29 cases originated through a probable index case of an adult staff at a nursery. This included eight cases among children attending the nursery (29%), 12 family members who did not enter the facility, and five nursery staff. In noting that physical contact between nursery staff was strictly limited, the study reports that the only close contacts for these adults were children, which led the authors to conclude that there was a high infection attack rate among children [69].

In Singapore, two preschools and one secondary school identified child index cases and tested close contacts. In a case where a preschool child was the index case (mean age 4.9 years), 34 preschool student contacts developed potential COVID-19 symptoms during the incubation period, however all 34 symptomatic cases tested negative for SARS-CoV-2. In a case where the index child was in secondary school (mean age 12.8 years), a total of eight out of 77 students developed symptoms and were screened for SARS-CoV-2 during the incubation period. All eight symptomatic student contacts from the school tested negative [66,70].

In Israel, a first school outbreak emerged ten days after re-opening all schools with a requirement for daily health reports, hygiene, face masks, social distancing and minimal interaction between classes. This occurred in a school comprising 1 190 students ranging from 12-18 years of age. The first two cases were registered on 26 May and 27 May, having no epidemiological link. Testing of the complete school community revealed 153 students (attack rate: 13.2%) and 25 staff members (attack rate: 16.6%) who were COVID-19 positive. Overall, some 260 persons were infected (students, staff members, relatives and friends) [66]. The authors reported that the outbreak occurred during an extreme heatwave, which led to a discontinuation of facemask usage, while also noting closed and crowded spaces with poor ventilation. No child-to-child attack rate was reported.

In summary, in children where COVID-19 was detected and contacts followed-up, few child contacts in the school setting were detected as SARS-CoV-2 positive during the follow-up period. The conclusion from these investigations is that child-to-child transmission in schools is relatively uncommon and not the primary cause of SARS-CoV-2 infection of children whose infection onset coincides with the period during which they are attending school. However, limitations in these and other outbreak investigations in school settings relate to the possible under-reporting of asymptomatic cases, the difficulty of ascertaining whether transmission has occurred in school or community settings, and, in some instances, incomplete testing of index cases and their contacts.

1.5 Transmission from adults to children in school settings

There is very little documented evidence of potential transmission from adults to children within the school setting. In Ireland, three adult cases had a total of 102 child contacts that did not result in detection of any secondary child cases, although only symptomatic individuals were referred for follow-up testing [61]. The outbreak in a high school in Israel did not specify the age of the index cases, making identification of adult-to-student transmission within the school setting impossible without further information [66].

One study from New South Wales, Australia presented an overview of COVID-19 cases and transmission in schools. In a total number of 25 schools and 10 Early Childhood Educational and Care Settings, 27 index cases were identified, among which 12 were children and 15 staff members. The secondary attack rate from staff members to children was 1.5% across all study settings (8/536 contacts). The majority of these occurred in a single outbreak in a daycare centre, where one adult staff member led to six infections among children [62].

In Finland, following exposure to an infected teacher, seven out of 42 exposed students developed antibodies or were PCR positive, however household or community transmission may have been the source in some of these [70]. The index case of a cluster of 29 cases at a nursery in Poland was an adult staff member. In total, eight children attending the facility became infected, although some of these cases may have been due to child-to-child transmission [69].

There is nonetheless ample evidence that if a child is infected by an adult, it is more likely to be in the household setting than a school setting. A study from Germany of SARS-CoV-2 infection among children 0-19 years of age identified household settings in 41.9% of cases (190/453) versus 3.3% of infections from school settings (15/453) [59]. In that study, there were four instances in which pupils were infected by teachers. In an Italian cohort, contact with an infected person outside of the family was rarely reported and 67% of children had at least one parent who tested positive for SARS-CoV-2 infection [72]. It is also important to note that interactions between children and adults are different in the school setting to the household setting.

Summary

In summary, while there is evidence of transmission from adults to children in household settings, there are few examples of this occurring within school settings. However, perhaps notably from the examples of preschool settings in Australia and Poland, it is possible for infected staff that attend schools to lead to clusters of SARS-CoV-2 transmission.

1.6 Transmission to adults in school settings

Transmission from children to adults in school settings

In an Irish study, 101 adult contacts in the school setting of three SARS-CoV-2 positive children resulted in no additional cases [61]. It is important to note that this study did not consider asymptomatic infections.

The Netherlands has investigated clusters at secondary schools and found that transmission was spread outside of the school setting in over half of the cases during intensive contact with friends or classmates during their free time [173]. Due to this, the Netherlands does not require all classmates to be quarantined unless they had intensive contact with others outside of school.

One study from New South Wales, Australia, presented an overview of COVID-19 cases and transmission in schools. In a total number of 25 schools and 10 Early Childhood Educational and Care Settings, 27 index cases were identified, among which 12 were children and 15 staff members. Secondary transmission was noted only in four out of 25 educational settings, and the overall child-to-adult attack rate was estimated at 1.0%[62].

The outbreak in a preschool setting in Poland suggests a potential role for child-to-adult transmission as staff avoided close contact with each other, but specific rates are not provided [69].

In Israel, as noted in the section above, testing of a complete school community related to an outbreak revealed 25 staff members (attack rate: 16.6%) who were COVID-19 positive. Overall, some 260 persons were infected (students, staff members, relatives and friends) but no child-to-adult attack rate was reported [66].

Secondary transmission was not identified in 662 of 666 childcare programmes in Rhode Island, USA, but could not be ruled out in 4 of 666 programmes [64]. In those four programmes, both children and staff members who were secondary contacts were among the confirmed cases, but no secondary attack rates were provided.

Transmission between adults in school settings

There is limited evidence within the peer-reviewed literature documenting transmission between adults within the school setting.

In the aforementioned reports from Rhode Island, USA, and Israel, both students and teachers were infected, but adult-to-adult attack rates were not reported [62,64,66]. In the cluster of 29 cases at a nursery in Poland, staff, small children and their families became infected, with the possibility of adult-to-adult transmission [69].

A study documenting an apparent school outbreak of 50 people in Chile describes an index case, a teacher, participating in multiple parent conferences about five days prior to the peak of the outbreak [174] [REF]. However, the designation of the index case is based on testing as a result of symptoms and might therefore have missed asymptomatic children. Serology results 8–10 weeks after the outbreak suggest comparable levels of infections among children and adults at the school, but these infections might have occurred outside of the school setting, as the school in question was closed down rapidly after the index case was detected.

Summary

Individual-level and population-level investigations suggest that adults are not at higher risk of SARS-CoV-2 within the school setting than in other settings but, as in those settings, precautionary physical distancing measures should be adhered to, particularly when staff interact with adolescents and other adults.

1.7 The impact of school closure on COVID-19 transmission

During the COVID-19 pandemic, numerous NPIs were introduced simultaneously or in close succession with school closures, making it challenging to identify the impact of individual measures. [145,148]

Mathematical modelling studies require various assumptions on parameters driving SARS-CoV-2 transmission, including the infectiousness of SARS-CoV-2 positive children, challenging direct comparison of study results. Numerous modelling studies in principal indicated that school closure is associated with a reduction in the number of cases, a reduction of hospitalisations and ICU admissions, with the effect of school closure dependent on the transmission rate, and the duration of school closure [175-181]. School closures in combination with other measures have been generally found to be more effective than as a separate measure [145,149].

A modelling study suggested [182] that reopening schools would contribute to a second-wave in the UK [161]; however, it was unclear from the study whether the increase in cases that the model projected was due to increased contact between children or an increase in contacts between adults [153]. A separate study from the UK and following the first infection wave suggested that school closures would ultimately lead to greater deaths; this is paradoxically due to the efficacy of school closures as a measure, which would lead to subsequent waves once NPI measures were lifted, in the absence of vaccination programmes or other pharmaceutical interventions [183].

A modelling study across China, South Korea, Italy, Iran, France and the United States assessed that school closures could affect the daily growth rate of infections by -0.11 log per day, although this was not significant when accounting for confidence intervals (95% CI: -0.25%-0.03%) [148]. One study harnessing social mobility data suggested that school closures could lead to a 10% reduction in social mobility (95% CI: 4.36%-15.7%), which was less than the closure of public transport or workplaces, but more than international travel controls or the cancellation of public events [150]. A study from Germany also concluded that school closures would lead to a decrease in social mobility and contribute to a decrease in SARS-CoV-2 transmission [151]. The decrease was linked to the indirect impact of keeping parents at home to care for their children while schools were closed. An age-structured model from the Netherlands concluded that, with unchanged non-school contacts, closing schools in November 2020 could reduce R_e by 8% if schools closed for 10-20 year olds only; 5% if schools closed only for 5-10 year olds; and by a negligible amount if schools closed for 0-5 year olds [152]. The authors noted that effectively reducing non-school contacts in a similar manner to the measures implemented in the Netherlands during the spring of 2020 could have prevented a second wave without school closures.

A modelling study of non-pharmaceutical interventions in Europe found only a strong signal for the effect of lockdown; there was a negligible impact of school closures independently on SARS-CoV-2 transmissibility [183]. A modelling study across 131 countries concluded that school closures could reduce the reproduction number by 15% after 28 days, while relaxation of school closures would increase it by 24% after 28 days [149]. The study also concluded that a combination of measures, such as school and workplace closure, bans on public events and gatherings, requirements to stay home, and limits on internal movement would have greater impact than individual measures alone. The authors highlighted the limitations of study, which included that the modelling did not account for in-school precautionary measures to limit COVID-19 outbreaks; the sequencing of NPIs which challenges ascertainment of the impact of measures introduced earlier or later; the national scope of the analysis, which may mask regional heterogeneities; heterogeneity across countries; and that modelling assessed NPI policies but not compliance [149].

An ecological longitudinal study of the 37 member countries of the Organization for Economic Cooperation and Development (OECD) conclude that early application of mass gathering bans and school closures was associated with reductions in cumulative COVID-19 mortality during the first wave of the pandemic [146]. However, the authors noted that closing schools earlier without concurrent enforcement of mass gathering bans may have a negligible impact on the epidemic curve [146].

A modelling study from Shanghai found that school reopening could happen without leading to excessive transmission, provided that daily contacts among children 10-19 years could be reduced to 33% of baseline levels [164]. A preprint study from China suggested that the effectiveness of school closures depends upon background levels of community social mixing; when these are halted, school closures reduced the reproductive number by 77%, but when social mixing was at pre-pandemic levels, school closures lead to a 5% reduction in transmission [184].

A time series assessed data collected between 9 March 2020 and 7 May 2020, aimed at determining whether the closure of primary and secondary schools affects COVID-19 incidence and mortality in the USA [155]. The results (adjusted for other enacted policies and testing rates) indicated that school closure was associated with a 62% reduction of COVID-19 incidence per week and a 58% reduction in mortality per week. It was found that countries which had a low cumulative COVID-19 incidence at the time of school closure, had greater reductions in incidence and mortality compared with those with a higher cumulative incidence at the same time. A Japanese study found no mitigating effect of school closures on the transmission of SARS-CoV-2 [158]. In contrast, an analysis of mortality data from US states found that delays in closing schools were associated with an increased COVID-19 mortality risk [156]. A retrospective, observational, cross-sectional study from Finland examined the effects of school and daycare closures and found that closures decreased paediatric hospital visits but that re-opening them did not immediately increase these rates [159]. An analysis of European incidence data from the first wave of the pandemic found early school closures to be associated with lower incidence rates [157]; however, since school closures were implemented in conjunction with other measures, the authors noted it was difficult to ascertain contribution of individual measures and whether or not early school closures during the first wave can be seen as a proxy for early introduction of other NPIs.

Many European countries have elected to keep schools open during the autumn term of 2020, a time coinciding with the second wave COVID-19 cases in many countries. Similarly, many European countries elected to close schools during the first wave of COVID-19 cases. The expectation is that in comparing these time periods, higher powered empirical and modelling studies may provide additional insights into the effects of school closures on SARS-CoV-2 transmission. Studies that: model a range of assumptions about the infectiousness of children; pay attention to the differences between primary and secondary schools; and tease out the direct and indirect impacts of school closures on SARS-CoV-2 transmission if other measures, notably workplace closures, are in effect, should be prioritised.

Annex 2. COVID-19 in educational settings: Experiences from Member States

ECDC developed a survey on COVID-19 cases and clusters in educational settings that included both multiple choice and open-ended questions. The survey was distributed to the ECDC Operational Contact Points for Influenza and COVID-19, as well as the countries' National Focal Points (NFPs) for Influenza, NFPs for Surveillance, NFPs for Preparedness and Response and the National Coordinators of all EU/EEA countries and the UK. Of 31 EU/EEA and UK countries, 17i countries replied to the survey.

2.1. COVID-19 clusters in educational settings

Since re-opening educational settings for the autumn term, 12 of the 17 countries[ii] (71%) report that they have detected clusters (≥2 cases with epidemiological link) of COVID-19 in these settings. All these countries reported clusters in primary and secondary school settings, while 10 countries had also seen clusters in preschools. In total, approximately 283 clusters in preschools, 739 clusters in primary schools and 1 185 clusters in secondary schools were reported. The number of clusters reported by countries varied, as did the number of cases involved in these clusters (Table 2a).

For four countries (24%) such data was not available or the status unknown, though one of these countries confirmed that clusters had been reported but was unable to conduct detailed outbreak investigations due to a lack of epidemiologists. Though Liechtenstein was the only country to not report clusters in such settings, they did see individual cases in different classes, but with no epidemiological link.

Table 2a. Summary of number of clusters and cases reported in educational settings

	Number of countries reporting clusters	Total number of clusters reported (min, max)	Median number of clusters reported in the countries	Number of cases involved in the clusters (min, max)
Preschools (approx. ages <5)	10/12	283 (1-209)	8	2, 150
Primary schools (approx. ages 5-11)	12/12	739 (3-279)	36	2, 101
Secondary schools (approx. ages 12-18)	12/12	1 185 (20-440)	37	2, 88

Note that the ages in different school settings may differ between countries. Numbers can be based on approximations by countries. Reporting of clusters in these settings may vary between countries as educational settings have opened at different times after the summer break.

Of the 12 countries[v] for which data was available, 11 countries reported that clusters included both students and teachers, while one country (Denmark) indicated that only students were included in clusters in their country.

2.2. Reporting of clusters

Of the 12 countries[v] for which data were available, all but two countries (Bulgaria and Latvia) indicated that COVID-19 clusters detected in educational settings are reported to national public health authorities. Most of these countries described systems in which local disease units are responsible for identification and local follow-up of the case as well as contact tracing, while also notifying the case to the national level. In some countries, however, the national public health institute is responsible for the contact tracing and follow-up once notified. In one country (Croatia), school health officials and principals take a more active role in identifying cases and/or follow-up with positive cases and families. One country mentioned that surveillance improvements are needed to better capture case information on clusters.

It must generally be noted that the number of clusters reported by countries must be interpreted with caution. The data presented here only provide a slight insight into the situation of COVID-19 clusters in educational settings in countries but may not constitute all clusters seen in these countries. Furthermore, countries differ in size and number of school settings; a certain variation in number of clusters is therefore expected. Some of the data provided by countries were approximations as exact numbers might not be available. In addition, countries' reporting period differed, which is why the data are not fully comparable between countries.

[i] Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Finland, Greece, Ireland, Latvia, Liechtenstein, Lithuania, the Netherlands, Romania, Slovenia, Spain, and Sweden.

[ii] Belgium, Bulgaria, Croatia, Denmark, Finland, Ireland, Latvia, Lithuania, the Netherlands, Romania, Spain, Sweden

2.3. Teachers' absenteeism due to COVID-19

Only five of the 17 responding countries (Croatia, Cyprus, Denmark, Liechtenstein and Lithuania) have an overview of teacher/school staff absenteeism due to COVID-19. One country mentioned that absenteeism is tracked at school or local level while another indicated that it is tracked by the Ministry of Education, but that this data is not conveyed to the Ministry of Health.

Of the four countries who described their system for teacher absenteeism, one (Croatia) indicated that teacher absenteeism was increasing while another (Spain) indicated that absenteeism for COVID-19 impacts teachers and other school staff equally to other professions. In the last two countries (Cyprus and Lithuania), it was mentioned that only staff who test positive or those who are symptomatic are absent from the school setting, however an indication of the magnitude of this absenteeism was not provided.

2.4. Decision on school closures

In different countries, the decision on closing schools is taken on different administrative levels (Table 2b). In six countries (Cyprus, Greece, Ireland, Latvia, Slovenia and Sweden), decisions on school closure are taken on the national level for all levels of education, where available. However, it was reported that individual schools or classes may be closed on public health grounds whilst schools are open nationally. In three countries (Belgium, Bulgaria and Spain) the decision was taken on the regional level and six countries (Croatia, Denmark, Finland, Liechtenstein, the Netherlands and Romania) take the decision on whether to close schools on a local level. For some countries the decisions are taken on different levels for different educational levels (Table 2b).

Table 2b. Level on which school closures (preschools, primary schools or secondary schools) are decided*

	Preschools/daycare	Primary schools	Secondary schools
Belgium	Regional level	Regional level	Regional level
Bulgaria	Regional level	Regional level	Regional level
Croatia	Local level	Local level	Local level
Cyprus	National level	National level	National level
Czechia	Local level	National level	National level
Denmark	Local level	Local level	Local level
Finland	Local level	Local level	Local level
Greece	National level	National level	
Ireland	National level	National level	National level
Latvia		National level	National level
Liechtenstein	Local level	Local level	Local level
Lithuania	National level	National level	Local level
the Netherlands	National level	National level	National level
Romania	Local level	Local level	Local level
Slovenia	National level	National level	National level
Spain	Regional level	Regional level	Regional level
Sweden	National level	National level	National level

** Several countries that indicated that decisions made on national level also have the provision to close schools based on local or regional public health authorities' recommendations*

Countries were asked whether they have a certain threshold or indicator that would affect their decision to close educational settings. Ten countries reported not having such a threshold or indicator. However, it was pointed out that decisions will be taken based on specific situations/circumstances and that schools may change to distance learning due to e.g. crowding in transport to schools or sick leave of teachers. Furthermore, one country described having a colour-coded scheme, based on epidemiological indicators that will be applied to educational settings, and, depending on the different colour, different measures apply. Two countries elaborated that priority is given to teaching in the classroom and leaving schools open. It was further pointed out that evidence shows that educational settings are not the location of most known SARS-CoV-2 transmissions.

On the other hand, seven countries (Bulgaria, Cyprus, Czechia, Finland, Greece, Lithuania, Romania) indicated having a certain threshold or indicators to guide the decision on whether to close schools. The composition of the thresholds or indicators varied between countries. However, all countries considered a certain case notification/incidence rate as part of them. In addition, test positivity, percentage of students absent in class/school, hospitalisation/ICU rates, R0 calculations were also mentioned.

Of the 16 countries for which data was available, 11 reported that the reasons for school closure are the same for all levels of education (i.e. daycare/preschool, primary school, secondary school), while five countries reported differences. Two countries reported that the closure of educational settings is dependent on the individual situation and assessment.

Priority for on-site education is given to younger age groups. Factors that guide the decision to close a certain type of school as well as prioritise on-site education for younger age groups include:

- presumed lower risk of infection in younger children
- younger pupils being less able to learn remotely
- the presence of younger children at home being more disruptive to parents' working life
- increased risk for interaction with grandparents when young children staying at home
- parents of younger children being younger themselves and thus less at risk in case an infection would be carried home
- different social behaviours of younger and older children, with older children having more social interactions in the community.

2.5. Mitigation measures implemented in educational settings

The mean and median number of in-school mitigation measures recommended by responding countries was 13 with a range of 7 to 20 measures, and an interquartile range of 11 to 16 measures in school settings. Further detail is provided in Table 3 of the main report. Detailed results can be seen in Table 3, Section 4.2.

The most commonly recommended physical distancing measures were:

- ensuring physical distance (e.g., separating tables in the classroom) (16/17)
- staggered arrival times in educational facilities (15/17)
- cancellation of indoor activities (e.g. indoor sport lessons, dances/prom, social gatherings) (14/17)

The least commonly recommended physical distancing measures were:

- no re-entry after the start of the school day (2/17)
- closing common play areas (7/17)
- reduced class sizes (9/17)

All the recommended hygiene and safety measures were reported by at least 76% of respondents:

- promote hand hygiene and respiratory etiquette (e.g., through provision of hand sanitizers (15/17)
- stay at home when sick (15/17)
- regular ventilation of classrooms (14/17)
- disinfection of classroom or school environments (13/17)
- mandatory mask use (13/17)

Fourteen out of 17 of respondents (82%) recommend schools carry out contact tracing of positive cases linked to educational settings (in collaboration with public health authorities).

Other measures that were less frequently recommended and rarely implemented by reporting countries:

- temperature screening (4/17)
- enabling parents to decide to keep kids home for distance learning (5/17)
- testing of students (symptoms screening, testing, and isolation of positive students) (6/17)
- 'traffic light system' linked to community epidemiological situation (7/17)

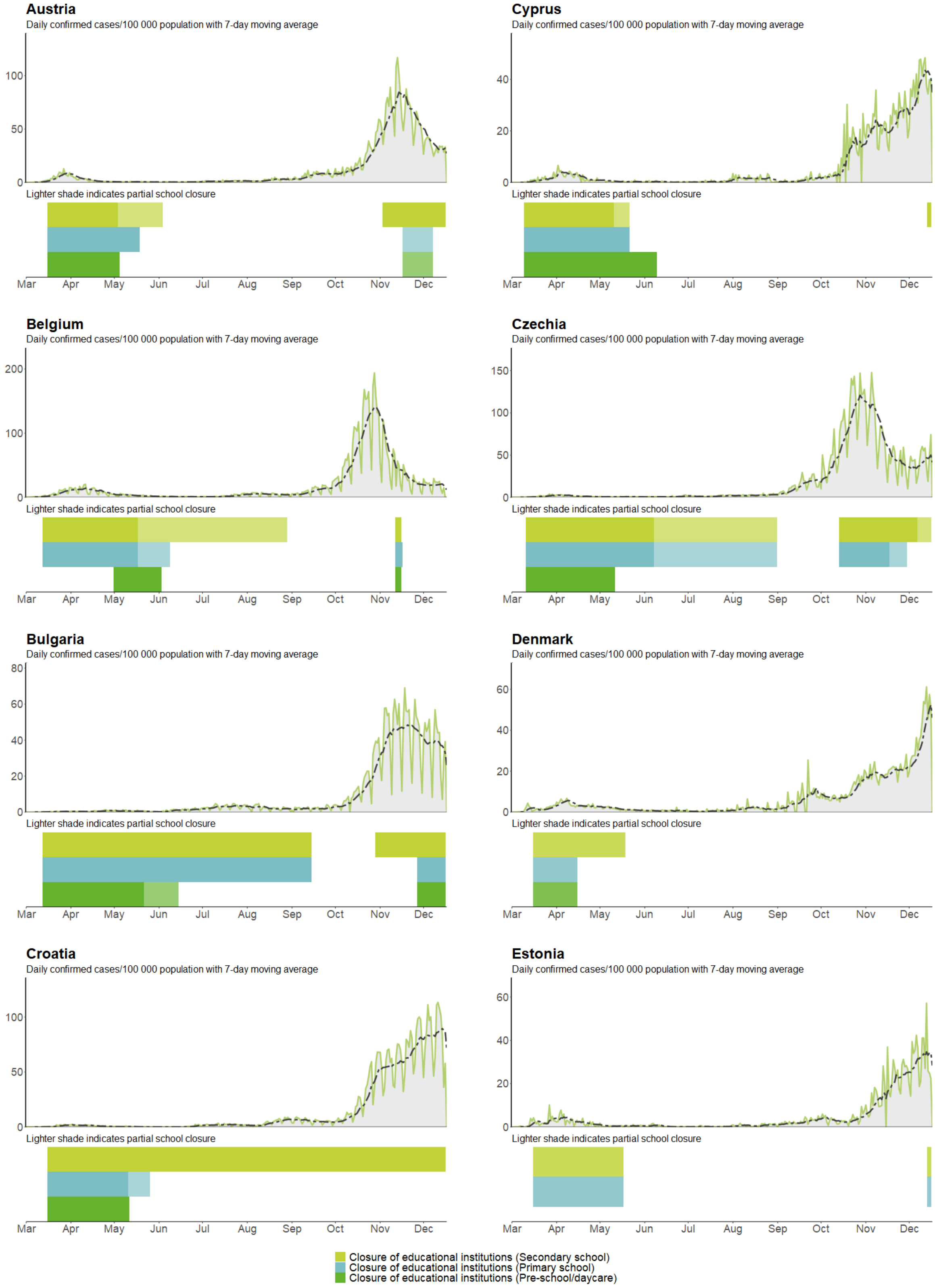
When asked what measures were, in their opinion, the most effective, respondents generally said that a combination of measures were needed to be effective. In general, hygiene and distancing (reducing close contacts, staying home when sick, etc.) were cited as commonly effective measures with ventilation and contact tracing. Respondents indicated a reduction in the frequency of other respiratory infections among children in preschool due to the COVID-19 measures in place.

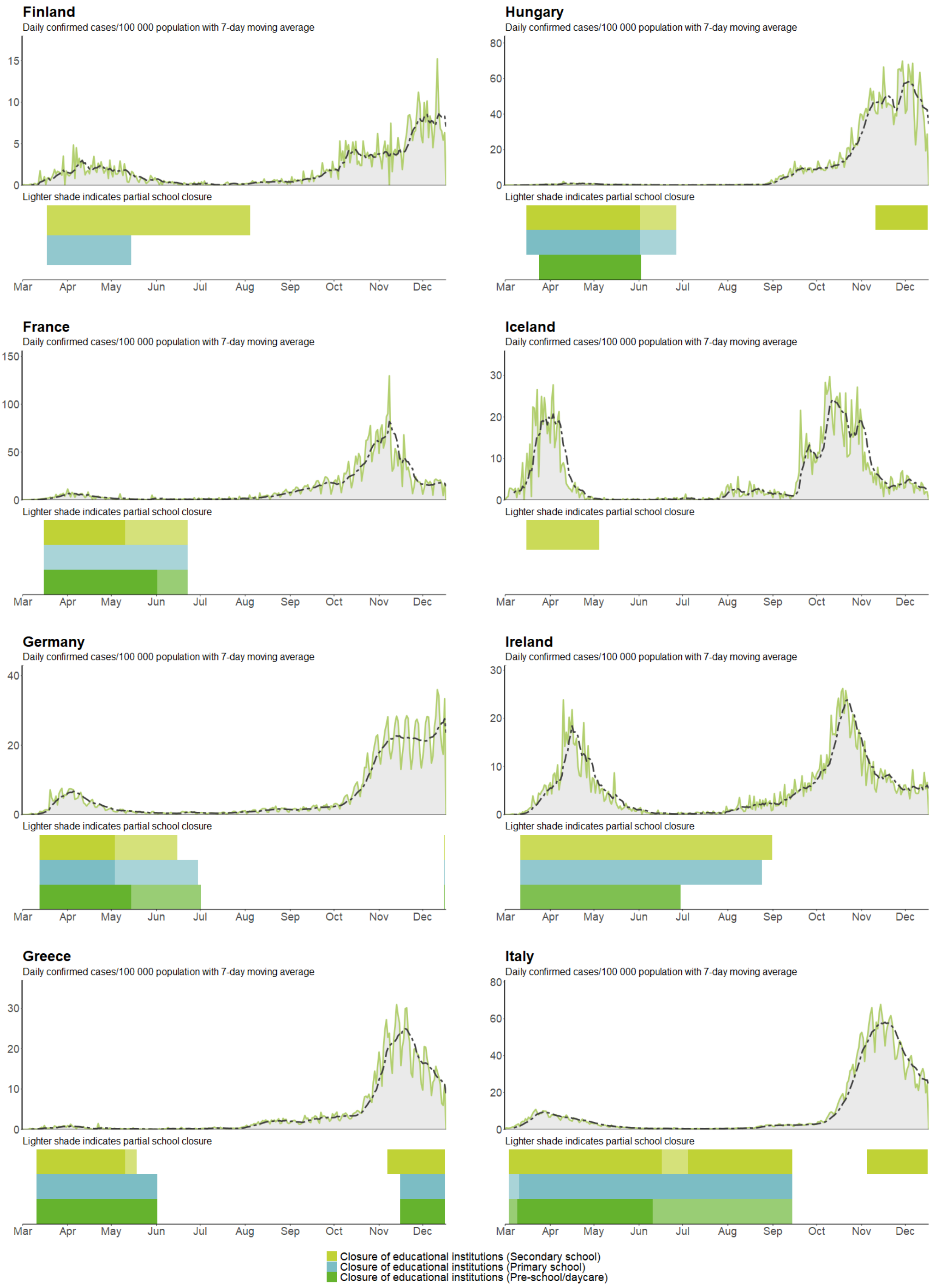
The most commonly implemented measures in schools tend to be measures that are simple, non-behavioural based and are actionable by the school staff.

Annex 3. School closures (at national level) reported from public sources and daily, confirmed cases of COVID-19 over time in EU/EEA Member States and the UK, by preschool, primary and secondary school, as of 16 December 2020

NOTE: Between the period of mid-June and mid-September, countries had school holidays during which period educational facilities were closed. Some countries report the 'closure of educational facilities' to include the summer period and others have reported the measure to be stopped when school holidays began. Therefore, the representation in the figures during the summer months will differ between countries. Autumn (mid-October/ early November) and winter holidays (mid-December–mid January) will also vary between countries.

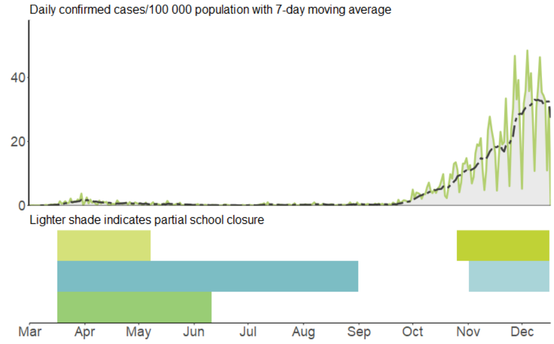
Light/hashed colours reflect partial school closures, through for example, introducing distance learning, cohorts, or only holding school open for certain age groups. This will differ between countries and is not discerned in the Figure.


Austria
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Cyprus
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Belgium
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Czechia
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Bulgaria
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Denmark
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Croatia
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Estonia
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Closure of educational institutions (Secondary school)
Closure of educational institutions (Primary school)
Closure of educational institutions (Pre-school/daycare)


Finland
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Hungary
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
France
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Iceland
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Germany
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Ireland
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Greece
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Italy
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Closure of educational institutions (Secondary school)
Closure of educational institutions (Primary school)
Closure of educational institutions (Pre-school/daycare)

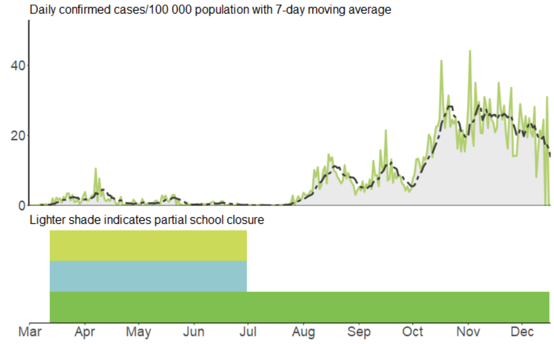
Latvia

Daily confirmed cases/100 000 population with 7-day moving average



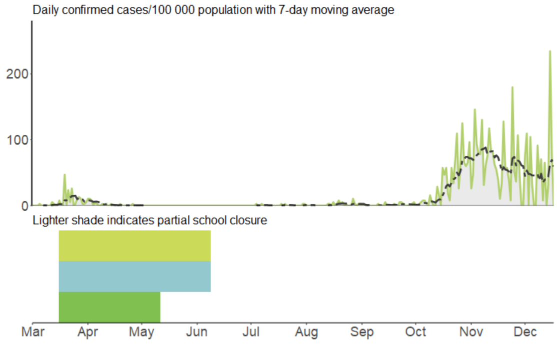
Malta

Daily confirmed cases/100 000 population with 7-day moving average



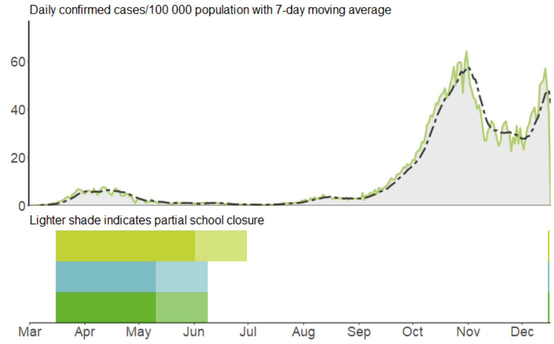
Liechtenstein

Daily confirmed cases/100 000 population with 7-day moving average



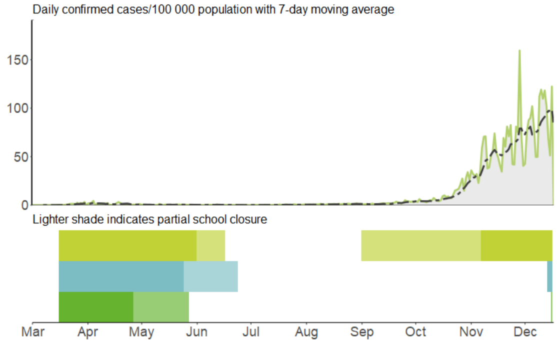
Netherlands

Daily confirmed cases/100 000 population with 7-day moving average



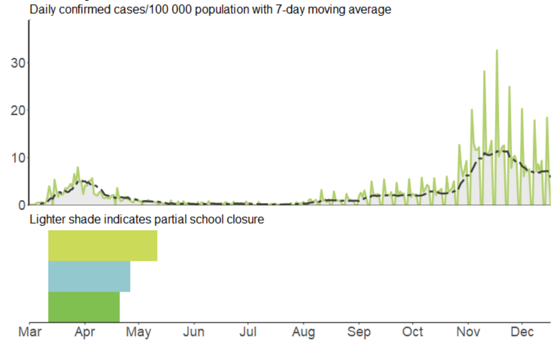
Lithuania

Daily confirmed cases/100 000 population with 7-day moving average



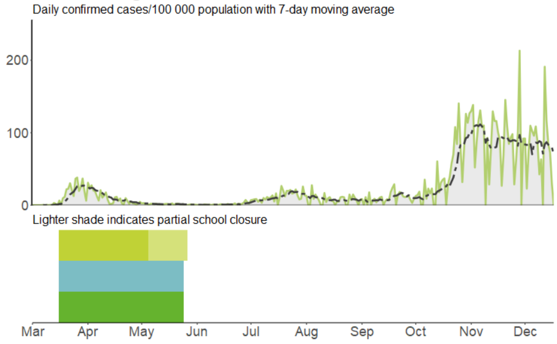
Norway

Daily confirmed cases/100 000 population with 7-day moving average



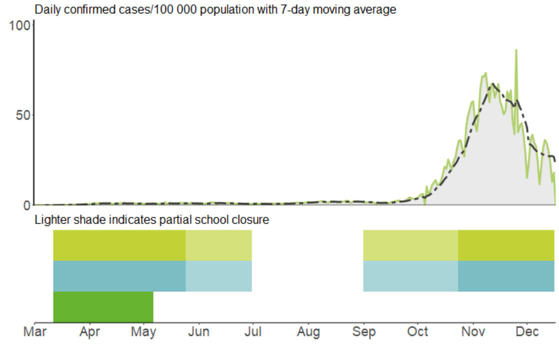
Luxembourg

Daily confirmed cases/100 000 population with 7-day moving average

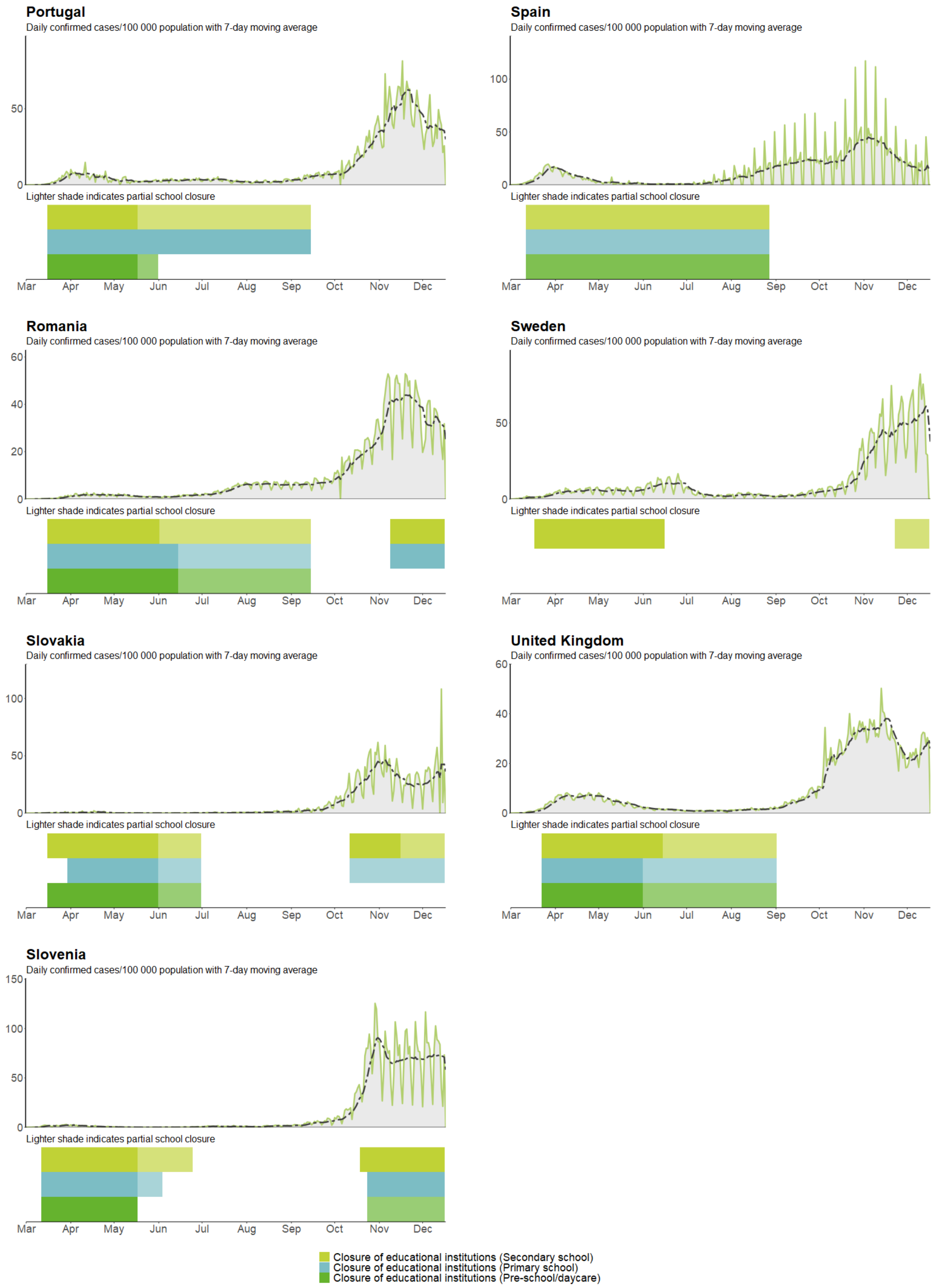


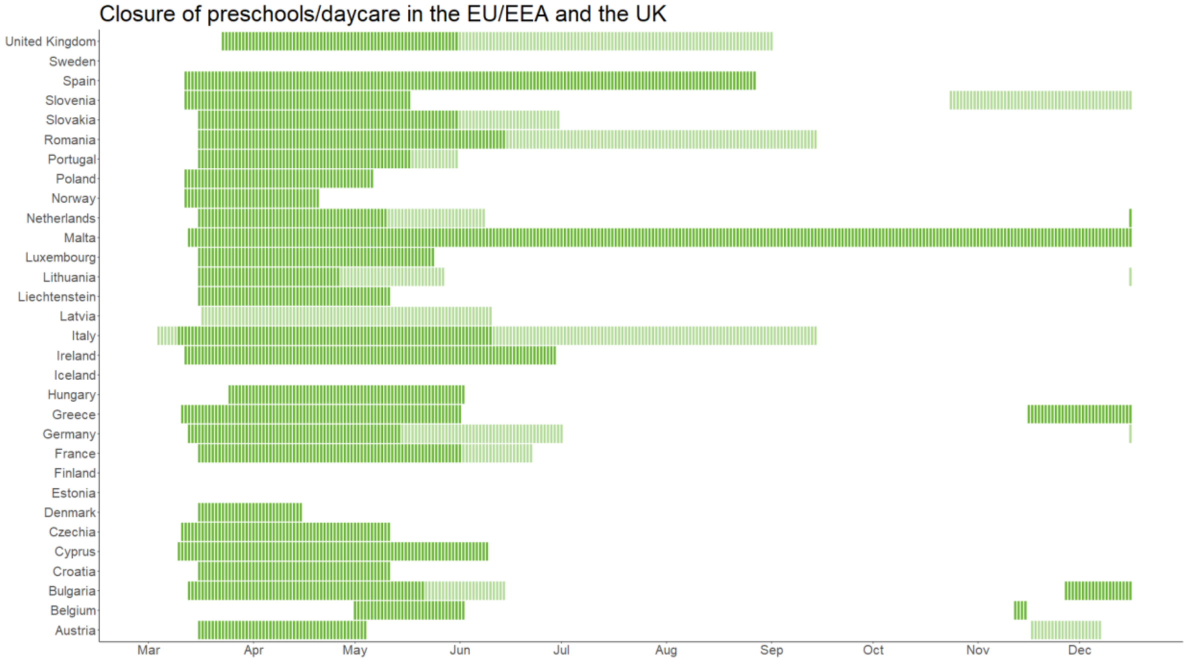
Poland

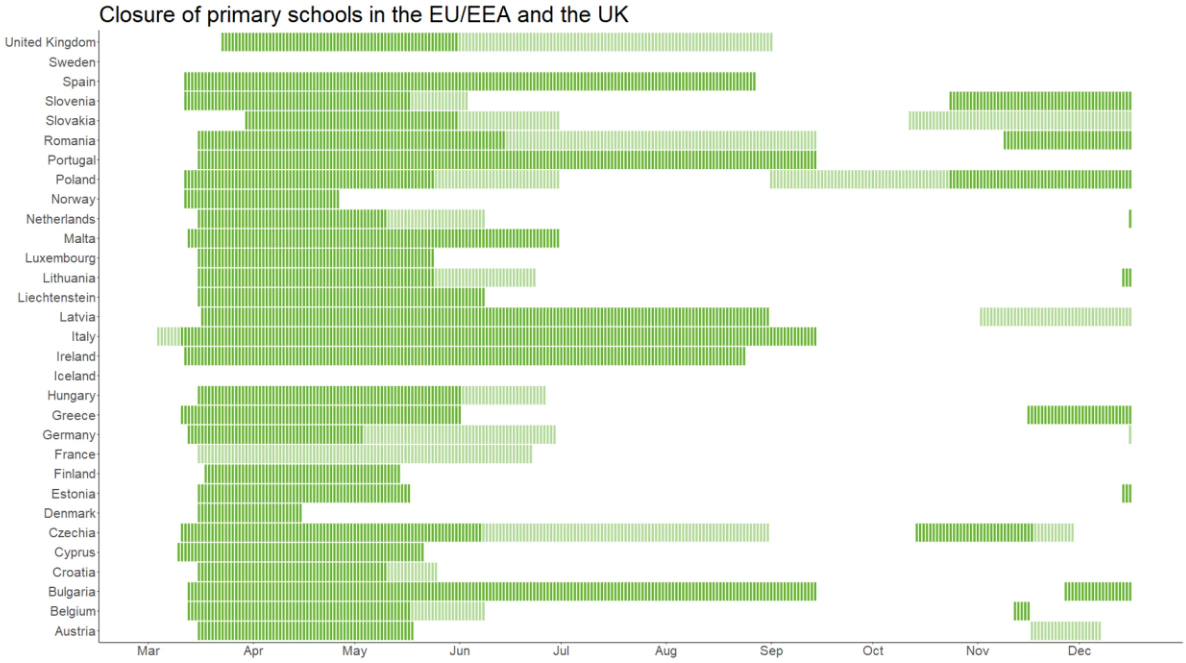
Daily confirmed cases/100 000 population with 7-day moving average

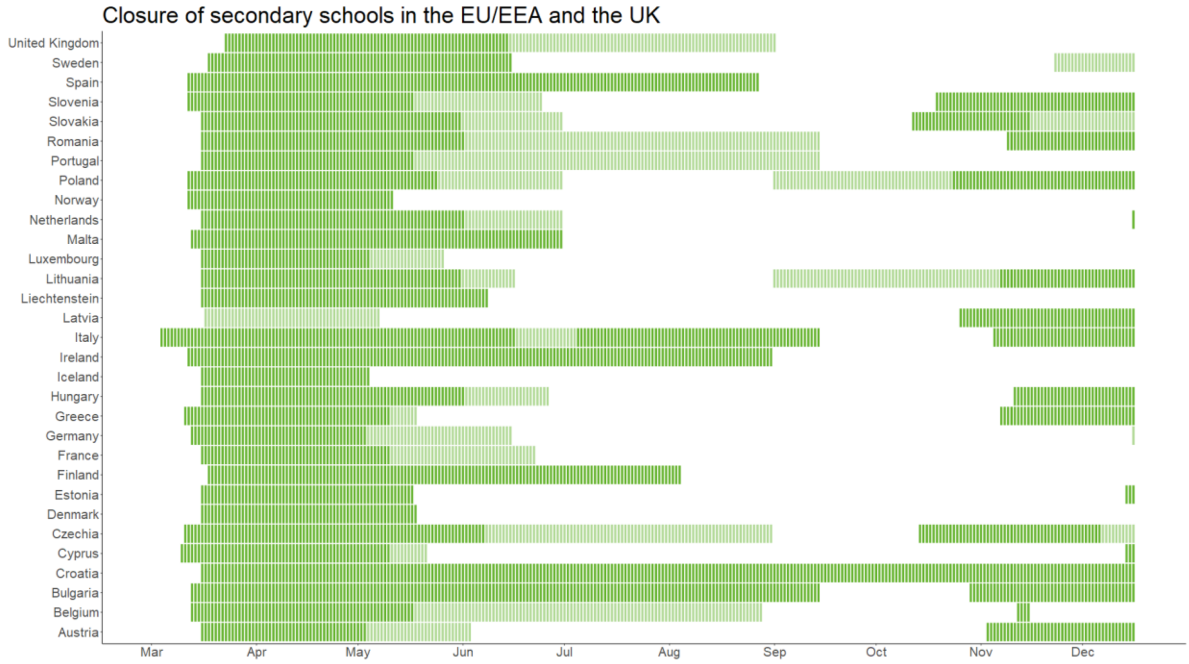


Closure of educational institutions (Secondary school)
Closure of educational institutions (Primary school)
Closure of educational institutions (Pre-school/daycare)


Portugal
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Spain
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Romania
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Sweden
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Slovakia
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
United Kingdom
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Slovenia
Daily confirmed cases/100 000 population with 7-day moving average
Lighter shade indicates partial school closure
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Closure of educational institutions (Secondary school)
Closure of educational institutions (Primary school)
Closure of educational institutions (Pre-school/daycare)


Closure of preschools/daycare in the EU/EEA and the UK
United Kingdom
Sweden
Spain
Slovenia
Slovakia
Romania
Portugal
Poland
Norway
Netherlands
Malta
Luxembourg
Lithuania
Liechtenstein
Latvia
Italy
Ireland
Iceland
Hungary
Greece
Germany
France
Finland
Estonia
Denmark
Czechia
Cyprus
Croatia
Bulgaria
Belgium
Austria
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Closure of primary schools in the EU/EEA and the UK
United Kingdom
Sweden
Spain
Slovenia
Slovakia
Romania
Portugal
Poland
Norway
Netherlands
Malta
Luxembourg
Lithuania
Liechtenstein
Latvia
Italy
Ireland
Iceland
Hungary
Greece
Germany
France
Finland
Estonia
Denmark
Czechia
Cyprus
Croatia
Bulgaria
Belgium
Austria
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec



Source: ECDC. Figure produced 16 December 2020. ECDC Response measures database compiled from public online sources. Inaccuracies may be present due to regional and local implementation of some measures.

Annex 4. List of national guidance documents for non-pharmaceutical interventions in educational facilities

Country	Entity	Guidance or guideline for school measures	Link
Austria			
Belgium	Wallonia-Brussels Federation	Covid-19 - Organisation de la vie scolaire en contexte de crise sanitaire - codescouleurs pour l'enseignement secondaire artistique à horaire réduit - ESAHR	http://www.enseignement.be/upload/circulaires/000000000003/FWB%20-%20Circulaire%207820%20(8075_20201104_120330).pdf
Belgium	Flemish Ministry of Education and Training	Veiligheidsmaatregelen per pandemieniveau 2020-2021 - Wat moet je doen als school?	https://onderwijs.vlaanderen.be/nl/veiligheidsmaatregelen-per-pandemieniveau-2020-2021
Bulgaria			
Croatia			
Cyprus			
Czechia	Ministry of Education, Youth and Sports	Soubor hygienických pokynů pro školy a školská zařízení	https://www.msmt.cz/soubor-hygienickych-pokynu-pro-ms-zs-a-ss
Denmark	Ministry of Children and Education	Børne- og Undervisningsministeriet - Lovgivning og retningslinjer	https://www.uvm.dk/aktuelt/i-fokus/information-til-uddannelsesinstitutioner-om-coronavirus-covid-19/lovgivning-og-retningslinjer
Estonia	National Board of Health	Juhend lasteaedadele ja lapsehoidudele seoses COVID-19 levikuga	https://www.terviseamet.ee/sites/default/files/Nakkushaigused/Juhendid/COVID-19/juhend_lasteaedadele_ja_lapsehoidudele_04.04.20.pdf
Finland			
France	Ministry of National Education, Youth and Sports - General Directorate of School Education	Plan de continuité pédagogique	https://eduscol.education.fr/2227/plan-de-continuite-pedagogique
Germany	Robert Koch Institut	Präventionsmaßnahmen in Schulen während der COVID-19-Pandemie (12.10.2020)	https://www.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/Praevention-Schulen.html
Greece	National Public Health Organization	New coronavirus Covid-19 - Instructions - Special categories (school units, means of transport, crews, uniforms)	https://eody.gov.gr/neos-koronaios-covid-19/
Hungary	National Center for Public Health	Tájékoztatás a bölcsődei és óvodai neveléssel kapcsolatos járványügyi szabályokról	https://www.nnk.gov.hu/index.php/koronavirus-tajekoztato/653-tajekoztatas-a-bolcsodei-es-ovodai-nevelessel-kapcsolatos-jarvanyugyi-szabalyokrol
Iceland	Ministry of Health	Reglugerð um takmörkun á skólastarfi vegna farsóttar.	https://www.reglugerd.is/reglugerdir/eftir-raduneytum/hrn/nr/1106-2020
Ireland	Department of Education and Skills	Coronavirus/COVID-19 - Resources for schools and other education settings	https://www.education.ie/covid19#guidance
	Department of Education and Skills	Roadmap for the full return to school	https://www.gov.ie/en/publication/b264b-roadmap-for-the-full-return-to-school/
Italy	Ministry of Education	Adozione del Documento per la pianificazione delle attività scolastiche, educative e formative in tutte le Istituzioni del Sistema nazionale di Istruzione per l'anno scolastico 2020/2021.	https://www.miur.gov.it/documents/20182/2467413/Le+linee+guida.pdf/4e4bb411-1f90-9502-f01e-d8841a949429
Latvia	Cabinet of Ministers	Epidemioloģiskās drošības pasākumi Covid-19 infekcijas izplatības ierobežošanai - III. Izglītības un sporta procesa organizēšanas un norises nosacījumi	https://likumi.lv/ta/en/en/id/315304-epidemiological-safety-measures-for-the-containment-of-the-spread-of-covid-19-infection
Liechtenstein			

Country	Entity	Guidance or guideline for school measures	Link
Lithuania	Ministry of Education, Science and Sports of the Republic of Lithuania.	Rekomendacijos mokykloms dėl ugdymo organizavimo	https://www.smm.lt/web/lt/naujienos/2020-2021-mokslo-metai/rekomendacijos
Lithuania	Ministry of Education, Science and Sports of the Republic of Lithuania.	Ugdymo proceso įgyvendinimo ypatumai 2020–2021 mokslo metais	https://www.smm.lt/uploads/documents/Ugdymo%20organizavimo%20rekomendacijos_2020%2008%2013.docx
Luxembourg	Ministry of National Education, Children and Youth	Le ministère de l'Éducation nationale - COVID-19	https://men.public.lu/fr/support/coronavirus.html
Luxembourg	Ministry of National Education, Children and Youth	Dispositif sanitaire (Stufeplang) à l'Éducation nationale dans le contexte de la crise COVID-19 Version 2 (13 novembre 2020)	https://men.public.lu/dam-assets/fr/coronavirus/dipositif-sanitaire-education.pdf
Malta	Ministry for Health	COVID-19 - Mandatory Standards and Guidances	https://deputyprimeminister.gov.mt/en/health-promotion/covid-19/Pages/mitigation-conditions-and-guidances.aspx
Malta	Ministry for Health	Advice and guidelines to the educational sector for the re-opening of kindergartens in Malta	https://deputyprimeminister.gov.mt/en/health-promotion/covid-19/Documents/mitigation-conditions-and-guidances/Advice_And_Guidelines_to_the_Educational_Sector_For_the_Re-opening_of_Kindergartens_in_Malta.pdf
Malta	Ministry for Health	Advice and guidelines to the educationalsector for the re-opening of PostSecondary Schools/ Institutes in Malta and Gozo	https://deputyprimeminister.gov.mt/en/health-promotion/covid-19/Documents/mitigation-conditions-and-guidances/Advice_and_Guidelines_for_Post-Secondary_Schools_Institutes_in_Malta_and_Gozo.pdf
The Netherlands	National Institute for Public Health and the Environment Ministry of Health, Welfare and Sport	Kinderen, school en COVID-19	https://www.rivm.nl/coronavirus-covid-19/kinderen
	National Institute for Public Health and the Environment Ministry of Health, Welfare and Sport	Protocol van de sociale partners: onderwijs op school tijdens corona	https://www.lesopafstand.nl/app/uploads/Protocol_Onderwijs_op_school_tijdens_corona.pdf
Norway	Norwegian Directorate for Education and Training	Veiledere om smittevern i barnehager og skoler	https://www.udir.no/kvalitet-og-kompetanse/sikkerhet-og-beredskap/informasjon-om-koronaviruset/smittevernveileder/
	Norwegian Institute of Public Health	Informasjon til barnehager, skoler og skolefritidsordning	https://www.fhi.no/nettpub/coronavirus/rad-og-informasjon-til-andre-sektorer-og-yrkesgrupper/informasjon-til-skoler-skolefritidsording-og-barnehager/?term=&h=1
Poland			
Portugal	Ministry of Health	Comunidade Escolar	https://covid19.min-saude.pt/comunidade-escolar/
	Ministry of Health	ORIENTAÇÕES Ano letivo 2020/2021	https://www.dgeste.mec.pt/wp-content/uploads/2020/07/Orientacoes-DGESTE_DGE_DGS-20_21.pdf
	Ministry of Health	DGS publicou medidas para controlo da transmissão em contexto escolar	https://covid19.min-saude.pt/dgs-publicou-medidas-para-controlo-da-transmissao-em-contexto-escolar/
	Ministry of Health	21 Maio 2020 – volume 3 saúde e atividades diárias. Medidas de Prevenção e Controlo da COVID-19 em Estabelecimentos de Ensino	https://covid19.min-saude.pt/wp-content/uploads/2020/05/manualvol3ensino.pdf

Country	Entity	Guidance or guideline for school measures	Link
Romania	Ministry of Education and Ministry of Health	ORDIN Nr. 5650/1670/2020 din 29 septembrie 2020 privind modificarea Ordinului ministrului educaţiei şi cercetării şi al ministrului sănătăţii nr. 5.487/1.494/2020 pentru aprobarea măsurilor de organizare a activităţii în cadrul unităţilor/instituţiilor de învăţământ în condiţii de siguranţă epidemiologică pentru prevenirea îmbolnăvirilor cu virusul SARS-CoV-2 Emitent: ministerul educaţiei şi cercetării - nr. 5.650 ministerul sănătăţii - nr. 1.670 publicat în: monitorul oficial nr. 893 din 30 septembrie 2020	https://www.edu.ro/sites/default/files/_fi%C8%99iere/Legislatie/2020/OMEC_5650.pdf
Slovakia	Ministry of Education, Science, Reasearch and Sport of the Slovak Republic	Manuál opatrení pre školy a školské zariadenia	https://www.minedu.sk/manual-opatreni-pre-skoly-a-skolske-zariadenia/
Slovenia	Ministry of Education, Science and Sport	Vzgoja in izobraževanje v Republiki Sloveniji v razmerah, povezanih s covid-19, Modeli in priporočila	https://www.zrss.si/digitalnaknjiznica/Covid_19/
Spain	Ministry of Health	Documentos técnicos para profesionales - Medidas de prevención, higiene y promoción de la salud relacionadas con el sector educativo	https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov/documentos.htm
Sweden	Public Health Agency of Sweden	Förslag på förebyggande åtgärder i förskolan och grundskolan	https://www.folkhalsomyndigheten.se/smittskydd-beredskap/utbrott/aktuella-utbrott/covid-19/verksamheter/information-till-skola-och-forskola-om-den-nya-sjukdomen-covid-19/forebyggande-atgarder-i-for--och-grundskola/
United Kingdom	Department of Education	Guidance for full opening: schools - Updated 3 December 2020	https://www.gov.uk/government/publications/actions-for-schools-during-the-coronavirus-outbreak/guidance-for-full-opening-schools?priority-taxon=b350e61d-1db9-4cc2-bb44-fab02882ac25#section-1-public-health-advice-to-minimise-coronavirus-covid-19-risks

Source: Links to national guidance or guidelines for non-pharmaceutical interventions in schools identified through screening of national authorities' websites. The list might not be comprehensive and failure to list a country does not indicate the lack of national guidance in this area for that country.

Annex 5. The survey instrument

COVID-19 in educational settings

Fields marked with * are mandatory.

In August, ECDC published a technical report on "COVID-19 in children and the role of school settings in COVID-19 transmission".

Since its publication, educational settings have reopened after the summer break.

This survey is being conducted as part of ECDC's efforts to understand the epidemiological situation of COVID-19 in schools and to identify effective mitigation measures for dealing with the pandemic.

The results of this survey will be used to update the ECDC technical report on children and the role of school settings in COVID-19 transmission.

The focus of the survey is on COVID-19 in children and adult staff in educational settings and addresses questions related to daycares/preschools, primary and secondary schools. Universities or higher educational facilities are out-of-scope for this survey.

Objectives of the survey:

- To identify documented examples of COVID-19 cases/clusters/outbreaks in educational settings (school settings as well as school transport, extra-curricular activities, and other school activities).
- To understand how COVID-19 cases and secondary transmission in educational settings are monitored and investigated.
- To identify what mitigation measures have been put in place in these settings and to explore perceptions on effective measures

Please note that the deadline for responding is Friday, November 20, 2020.

Thank you very much for your important contribution to this work.

ECDC Public Health Emergency Team

Part 1. COVID-19 Cases and Transmission in Educational Settings

1. Please give the name of the country that you are reporting about

- Austria
- Belgium
- Bulgaria
- Croatia
- Cyprus
- Czechia
- Denmark
- Estonia
- Finland
- France
- Germany
- Greece
- Hungary
- Iceland
- Ireland
- Italy
- Latvia
- Liechtenstein
- Lithuania
- Luxembourg
- Malta
- Netherlands
- Norway
- Poland
- Portugal
- Romania
- Slovak Republic
- Slovenia
- Spain
- Sweden
- United Kingdom

2. Since educational settings have re-opened in the autumn term, have there been documented instances of clusters (≥2 cases with epidemiological link) of COVID-19 in these settings in your country?

- Yes
- No
- Unknown or information not available

2a. If yes, please specify by filling out the table below:

	Number of cluster in this setting (please provide an approximate if exact numbers are not available)	Range of number of cases involved in the clusters (min, max)
Daycare/preschools (approx. ages <5)		
Primary schools (approx. ages 5-11)		
Secondary schools (approx. ages 12-18)		

2b. Who has been affected in these clusters?

- Students only
- Teachers/staff only
- Both students and teachers/staff

2c. Are clusters in educational settings reported to your national public health authorities?

- Yes
- No

3. Are there studies in your country (e.g. detailed epidemiological/ outbreak investigations) on transmission in educational settings?

- Yes
- No
- Unknown

If yes, please share the source(s)/link(s) and/or a contact person/entity that we might liaise with for more information:

4. Do you have an overview of teacher/staff absenteeism?

- Yes
- No

If yes, please describe the pattern of absenteeism that you have observed since school opened after the summer:

Part 2. Mitigation Measures implemented and Strategies for Closure of Educational Settings due to COVID-19

5. What mitigation measures (i.e., non-pharmaceutical interventions and/or policies) are in place and/or made available in educational settings in your country to prevent and control COVID-19 transmission in these settings?

Check all that apply.

Physical distancing measures	Measure recommended in educational settings in your country (if yes, tick the box below)	Measure implemented in the majority of schools (if yes, tick the box below)
Cohort or "bubble"/small group system		
Ensuring physical distance (e.g. separating tables in the classroom)		
Reduced class sizes		
Staggered arrival times in educational facilities (in person)		
Staggered lunch and breaks		
Physical education outdoors		
Enabling/arranging remote learning		
Hybrid model (e.g. rotating distance and in-person days)		
No re-entry after school day has begun		

Closing common play areas		
Cancellation of indoor activities (e.g. indoor sport lessons, dances/prom, social gatherings)		
Other		

Comment box if you wish to elaborate:

Hygiene and safety measures

	Measure recommended in educational settings in your country (if yes, tick the box below)	Measure implemented in the majority of schools (if yes, tick the box below)
Mandatory mask use		
Promote hand hygiene and respiratory etiquette (e.g. through provision of hand sanitizers)		
Disinfection of classroom or school environments		
Regular ventilation of classrooms		
Stay-at home when sick		
Other		

Comment box if you wish to elaborate:

Other types of measures

	Measure recommended in educational settings in your country (if yes, tick the box below)	Measure *implemented* in the majority of schools (if yes, tick the box below)
“Traffic light system” linked to community epidemiological situation		
Enabling parents to decide to keep kids home for distance learning		
Temperature screening		
Testing of students (symptoms screening, testing, and isolation of positive students)		
Contact tracing of positive cases linked to educational settings (in collaboration with public health authorities)		
Other		

Comment box if you wish to elaborate:

5. In your opinion, which approaches/mitigation measures are working well and why?

6. Are there thresholds or indicators for community transmission that impact the decision to close educational settings?
   - Yes
   - No
7. On what level is the closure of educational settings decided?

	National level	Regional level	Local level
Daycare/preschools			
Primary schools			
Secondary schools			

Comment box if you wish to elaborate:

8. Are the reasons for school closure different between the different educational settings (i.e. daycare/preschool, primary school, secondary school)?
   - Yes
   - No
9. Is there anything anything else you would like to share on this topic?