Response to reviewers and editors

Thank you for submitting your paper to The BMJ. We discussed your paper at an editorial meeting that was attended by Kara Hanson, Martin McKee, Juliet Dobson, Tom Moberly, James Ross, and Kamran Abbasi. Martin McKee recused himself for this paper.

1 First, an apology for the delay in responding to you. We wanted to review all the papers together with reviewers' comments, and therefore we've ended up holding on to some papers longer than others.
2 We would like to publish a revised version of your submission as a paper in The BMJ's covid-19 inquiry collection.

We thank the BMJ team for considering our article for submission and for the opportunity to revise this based on comment.

3 We're reminding all author groups that the overall focus of The BMJ's covid-19 inquiry collection is to consider what we can learn from how scientific advice was incorporated into pandemic policy in the UK. We want to know what you would tell a public inquiry. What further questions do you believe that a public inquiry must address? We're also asking all author groups to revise their paper so that it explicitly sets out to do this.

We thank the editors for raising this. We have now restructured the paper around a framework of questions for the Inquiry.

4 We are sending you a number of reviewers' comments. The status of the reviewers' comments is advisory only. You should consider all comments but only act on those that you believe will make your paper stronger in its ambition to achieve the aims stated above.

We thank the reviewers for their comments, and have revised the paper to incorporate these, as discussed below.

5 We appreciate that journals regularly ask authors to take on board comments at revision stage and stick to a particular word limit. Although our target length for each paper in The BMJ's covid-19 inquiry collection is 2000-3000 words, we are willing to be flexible where appropriate.

Given the controversial and complex nature of this topic, and the need to evidence all statements clearly, we request some flexibility around word count. The current article is ~4,900 words excluding panels and references.

6 You should pay particular attention to the committee's comments. If anything is unclear in the committee's comments, or in the reviewers' comments, please do not hesitate to contact . We will all work closely with you and support you through the revision process.

7 Our intention is to publish the collection of papers by the end of June. We'd like your revision back by the end of May, or earlier if at all convenient, but if this causes any problems please let us know and we will do what we can to accommodate.

8 All papers will also need to be tweaked so that they do not read as if they are out of date.

We have revised all evidence, and discussions so it is up to date.

9 We hope you might focus more tightly on the evidence in relation to implementing and not implementing preventative measures in schools. This might be best accommodated by a shift away from 'false narratives' since they are covered more fully in another article in the collection? Happy to discuss.

We accept the point that the paper needed to focus more tightly on the core argument. We have now reduced the limited discussion around flawed narratives to the section titled 'Our message to the Public Enquiry'. We believe it is important to allude to these false assumptions (and the flawed evidence put forward to support them) that informed UK policy in the article in some way, as this evidence will no doubt also contribute to the COVID-19 enquiry.

Reviewer(s)' Comments to Author:

Reviewer: 1

Recommendation:

Comments:
This review is really an eye opener on how, even the most developed nations responded to a global pandemic. The facts and policies are well described. The references of the same may be quoted from the Government Websites over the News papers.
A comparison of other nations with similar and contrary school opening policies may be presented in tabular form with relevant statistical analysis to support the hypothesis.

We thank the reviewer for these comments. Give the tight word count and the specific focus of this series on informing the UK inquiry, we feel that statistical analysis around the different policies in countries is beyond the scope of the current manuscript. However, we take the reviewer's point and have expanded on the section on policies enacted in other countries to compare with UK nations at each point in the section titled "The United Kingdom was an international outlier".

Reviewer: 2

Recommendation:

Comments:
The paper makes some good points about the inadequacy of government policy with regard to some aspects of Covid transmission in schools, such as support for schools and individuals, and the role of masks and ventilation. However, I think the treatment of some topics would benefit from more nuance.

The reviews of evidence of children's susceptibility to infection are described as flawed because they ignored the likelihood of children being infected in school and relied on symptoms for identifying secondary cases among children. I was involved in the Viner et al review and don't think these criticisms are justified. The studies reviewed included contact tracing studies e.g. where children were exposed to primary cases within their households or schools. Some but not all of these studies used comprehensive biological testing to identify secondary cases. The included studies (overall and the less biased subset of studies using testing to identify secondary cases) did indicate a significantly lower susceptibility to infection of children compared to adults.(1)

We agree that the article has benefited from more nuance and have now added this in places (see tracked changes in revised paper). The reviewer makes a good point that we had previously presented a somewhat over-simplified account of key evidence reviews. However, we respectfully disagree with this reviewer's claim that the Viner et al's review provided an adequate assessment of the evidence, for the following reason. Unfortunately, studies that simply sample contacts of the index case regularly are not sufficient to 1) identify transmission from and to children; and 2) correctly identify indexness (i.e. the case that was the primary case in the household). Subsequent work, including genome sequencing studies, often show that children can be silent spreaders, [1-3] and spread is often only picked up when an adult becomes infected and symptomatic. In this context, contact tracing studies would likely identify adults as index cases, when a child may have been the index case. The child who is tested following contact tracing may well test negative at this point because infection may have passed. Hence such studies are also likely to introduce a systematic bias by underestimating susceptibility of children. Indeed, an Austrian study that regularly sampled adults and students in schools showed PCR positivity to be similar across students and teachers.[4]

We now include this clarification as follows:

"*Why did some key decision-makers believe that transmission of covid-19 did not occur to a significant extent in schools? Documents from government advisory groups seem to have consistently warned about the significant role schools played in community transmission since early in the pandemic, and the need for mitigations.[5-7] However, the UK Health and Security Agency's (UKHSA) own research,[8] conducted at a time between waves when attendance and infection prevalence was very low predictably showed few outbreaks within schools, which were interpreted as showing that significant in-school transmission does not occur. Similarly, the ONS School Infections Survey (SIS) which showed infection rates in school children were lower than in the community was interpreted by the UKHSA to mean that schools were not contributing significantly to transmission, when this was almost certainly because many COVID-19 infected children and their contacts were not attending school (due to isolation policies at the time), so were not sampled. Another reason appears to have been increased focus on a systematic review of the evidence base undertaken by a UK team (including members of SAGE)[9,10] that suggested reduced susceptibility to infection in children – with policy makers ignoring that children often have one of highest exposure rates because of contact rates in school environments.*

There were key flaws in the primary evidence included in the review, as has been highlighted before[11]— in particular the failure of many studies to take account of the fact that infected children are often asymptomatic or have atypical symptoms.[1,12-15] If case ascertainment is based on symptoms or symptom-based testing (which it was in many studies), many infections in children will be missed, making it difficult to identify networks of transmission. The vast majority of studies either did not test all contacts, or tested contacts only if/when they developed symptoms. Furthermore, studies that focus on seroprevalence data[16] and also underestimate infection and transmission in children. This is because seroconversion is known to occur at a lower rate in children,[17] with waning of antibodies and seroreversion occurring more rapidly than in adults. Attendance data[18] was also interpreted to re-inforce these narratives. Attendance is a function of identifying cases in children via symptom-based testing, thereby also underascertaining infection. Another key flaw of several studies examined was that they were carried out under conditions of lockdowns and/or school closures when adult contacts would be expected to be higher (e.g. due to travel/work) than for children. During such periods a lower prevalence or seroprevalence of infection would not necessarily suggest a lower susceptibility (just lower exposure). Additionally, studies from periods of spread of less transmissible variants would not reflect spread from schools during the delta and omicron waves."

We agree that there is uncertainty around the relative susceptibility of children compared with adults given the same level of exposure, so have now removed this from the list of flawed narratives. Irrespective of the relative susceptibility of children there is little doubt that the high level of contacts children are exposed to has led to high infection rates in children during the pandemic during periods when schools were open.

The authors should balance their discussion of prevention in schools by citing evidence from various PHE and ONS studies of school prevention and transmission that indicates that in the main school preventive measures were well implemented and did appear to reduce transmission in schools. Some of these are published as grey literature.

We have included the reports from the ONS and PHE, as follows:

"Mask use remained low in classrooms in England, with secondary school headteachers reporting only 32% of secondary school children wearing masks in classrooms in December 2021.[19] In January 2022, nearly two years into the pandemic, UKHSA and DfE[20] acknowledged the large and accumulating body of observational evidence showing that masks were effective in reducing transmission, including in school.[21-24] However, their evaluation of risks and benefits of mask wearing continued to be skewed in England, where masks were re-introduced only in secondary schools and for just 3 weeks during the omicron wave (Table 1). Far more weight was given to limited DfE surveys showing that although secondary school age children understood the need for masks, a significant proportion reported difficulty with communication.[20] These negative impacts of masks were presented, without acknowledging or modelling the additional educational benefits a child would have if masking reduced the high number of school days lost as a result of covid-19 infections (including staff absences, and impacts from long COVID)"

And

"*In setting UK policy on masking in schools, a great deal of emphasis was placed on a small, highly flawed and non-peer-reviewed study which the DfE conducted over a two-week period in October 2021.[20] This study was underpowered and had too short a follow-up period to test the effectiveness of masking. It did not distinguish between mask wearing in classrooms and masking only in communal areas, and no participants were masked during lunch breaks. The negative finding (no statistically significant difference between masked and unmasked arms) was interpreted as evidence that the effectiveness of mask wearing was limited or inconclusive. [20,25,26] The report failed to fully acknowledge the limitations of the study design and largely ignored the breadth of global evidence which had demonstrated a significant positive impact of masking on school-based transmission*.[22,23,27]
"

And

"Above 90% of schools reported opening windows periodically to ventilate or even for most of the day, but the adequacy of these measures is hard to quantify without data on monitoring of air quality.[19] Even after promises for provision of CO_2 monitors to all schools were made,[28] delivery to schools was considerably delayed,[29] and their utility limited by inadequate supply of monitors and barriers to ventilation (e.g. temperature, limited window opening)[19,29] and a much higher cut-off (CO2 above 1,500pm) compared to international standards applied by the DfE. It is unclear why the English DfE and Public Health Scotland[30] recommended a much higher cutoff of 1500 ppm, especially given the negative impact of high CO_2 levels on concentration[31] and learning. To date, only 3% of

schools have been considered eligible for air purifiers.[32] Many English schools are still unable to use CO_2 monitors,[29] and a significant number report consistently high values of CO_2 despite actions taken to improve ventilation.[29] There has been no policy introduced to require ventilation standards in new school buildings."

The paper suggests that the evidence is clear that schools were major sites of transmission. While of course transmission did and does occur in schools it is quite a mixed picture as to how important schools were/are in overall transmission. For example, ONS community prevalence studies identified that teachers were not at increased risk of infection compared to other occupational groups and the ONS school infection study found that school prevalence was generally not higher than background community prevalence.

We disagree that this was a grey area. Indeed, the ONS study on teachers showed that teachers were ranked to be among the professions with the highest infection rates. At the time, due to small sample sizes, the error bars were quite large, and no occupation (including most healthcare workers) showed a statistically significantly higher risk, because error bars were overlapping. Larger studies such as REACT[33] (February 2021), and ONS studies of long COVID suggest exposure in this group has consistently been higher than that in other occupations, and comparable to health and social care workers. Research studies from Scotland also show the same pattern of teachers being at higher risk of infection than other workers during periods when school was open.[34]

The ONS school infection study, as has been discussed widely, has been flawed in its design to study infection risk of children, and widely misinterpreted. First, the study was carried out in schools, where by definition school cases and contacts (at higher risk of infection) were isolating. Second, it also relied on seroprevalence, despite extensive evidence that seroconversion is lower than adults and seroreversion and waning of antibodies occurs rapidly in school age children. [35,36,16,17,37] Indeed, comparisons with the ONS data on community prevalence (which does not suffer from the same biases) make this clear.[38] These data was however, repeatedly used to suggest that schools were not contributing much to transmission, despite these key limitations. Indeed, the Office for Statistics Regulation raised the issue with study investigators to clarify this publicly following a complaint, when incorrect claims were made.[39]

There is also observational evidence: Dept for Education data showed large increases in absence of both students and teachers during term time;[40] ONS data showed that increases in children in recent waves preceded that in adults of parent age groups when waves coincided with children being in school[41] (Figure 1); Since September 2021, peak ONS prevalence has been higher in school aged children than in adults, and increased and reduced in line with school openings and closures for school breaks, which is hard to explain if children are not catching it in school.

Furthermore, a systematic review of observational studies internationally found quite mixed evidence of the impact of school closures and school reopening on community transmission of COVID-19, and some evidence for a lack of impact when community prevalence was low.(2)

We thank the reviewer for pointing out this additional review. However, we have concerns about the methodology followed in that review, and do not believe its conclusions are supported by evidence (see Box Panel and Figures below).

The large and rigorous multi-country studies[42,43] (some post-dating the search date) carried out in this area have all shown very consistently that school opening and closures had one of the highest impacts on community transmission. In conclusion, we believe there are multiple flaws in this systematic review, including a misreporting of what authors found, and therefore cannot include this

as robust evidence in our paper. It is worth noting that even without the overwhelming multi-country evidence that has repeatedly showed this association, including in England, even just looking at the ONS data shows consistent repeated evidence of reduction in community transmission (reduction in school age groups preceding reduction in other age groups) at each half term, and school break (see Figure 1).

Indeed it is telling that SPI-M-O, the modelling group advising government consistently considered that school closures and openings had a fairly large impact on pandemic growth in their modelling.[44]

Box Panel: Limitations of Walsh et al. review on impact of school closures and reopening on community transmission

Limitations of review	Study	What study showed	How it was presented in the review	
Large-scale peer-reviewed global study on ranking of interventions by effectiveness excluded	Haug, N.*, et al* [45]	The study, published in Nature Human Behaviour showed that closure of education settings was one of the most effective interventions in reducing pandemic growth during the 1st wave	Not included. Reason for exclusion not stated.	
Misinterpretation of study results	Garchitorena et al.[46] (ref 24 in the systematic review)	The authors state "*We found that bans on mass gatherings had the largest effect among NPIs, followed by school closures, teleworking, and stay home orders*" "*Recent evidence from South Korea(14) and the United States(15, 16) suggests that children may be as susceptible and transmissible as other age groups. Our results support this hypothesis, showing that closing schools to reduce contact rates among children and adolescents can*	The authors refer to this study in the statement below: "*Of the four school reopening studies at lowest risk of bias, three (including Garchitorena et al.) reported no association between school reopenings and transmission."*	The impact of school closures on transmission is shown in Figure 4 (see below)[46] which show a statistically significant increase in public health response efficiency with school closures being added to other interventions, with partial relaxation leading to loss of this effect. The authors of the systematic review seem to erroneously interpret this as evidence that partial school re-opening made no difference, when it clearly does, as shown below, resulting in loss of efficiency of the NPI (school closures) and as stated by the authors.

		be an effective way to reduce transmission."		
	Brauner et al. (ref 18 in the BMJ systematic review, subsequently published in Science[42])	The authors state: "*There was significant heterogeneity in the study findings (table 3): 17 studies[14 24 31 32 34–38 40 42–44 48–51] reported that closing schools was associated with a reduction in transmission rates; 9[15 18 20 23 26 29 30 39 47] found no association between school closures and transmission;"* And "*Of these studies, 11[14 24 32 34–36 40 42 48–50] reported that school closures were associated with significantly reduced community transmission of SARS-CoV-2, 7[15 18 20 26 30 39 47] reported no association*"	The published article states: *" Closing both schools and universities was consistently highly effective at reducing transmission at the advent of the pandemic."* And "*We found a large effect for closing both schools and universities in conjunction, which was remarkably robust across different model structures, variations in the data, and epidemiological assumptions."*	The figure in the paper (Figure 3, see below) referred to by the authors clearly shows that school closures were among the most effective interventions, while the authors of the systematic review have stated that the paper showed the opposite.
Similar weight given to single country and multi-country studies even though these were considered	NA	NA	NA	Studies that examine a limited number of countries will find it difficult to unravel the different impacts of interventions that tended to occur together. Indeed, the Brauner et al.[42]

separately as well in the review				study shows that the impact is often not additive, may depend on the combination and order of interventions and studies must take this into account. This is entirely expected given pandemic spread is a result of complex system dynamics rather than linear, non-interactive effects, as assumed in many of the studies examined. This is likely to explain at least some of the heterogeneity in findings. This is why it is vital to include multi-country analyses accounting for these factors, and why single country analyses must be treated with caution unless the analyses show repeated patterns over long periods of time. Even then, the generalisability to other contexts must be considered.
Limited generalisability	Isphording et al.[47]	Some single country studies included in the review (e.g. Isphording et al.[47]) occurred in the context of low community transmission and strong mitigations in schools.	Such studies were interpreted as school openings and closures not contributing significantly to community transmission. Although the authors appear to recognise that this is in the context of robust mitigations, the role of these in heterogeneity of study results, and the impact on generalisability is not adequately considered.	Rather than bringing into question the role of schools in community transmission, these studies provide evidence that in contexts where mitigations were in place and/or low community transmission was maintained,[47] schools were less likely to lead to superspreading, and transmission back into the community. These studies are not generalisable to the UK context where it is clear that schools did contribute substantially to transmission (see Figure 1), and mitigations were very limited compared to other European countries at the same time. It is

				important that studies examining the role of schools in transmission take the context into account, which the review does not appear to have adequately, reaching flawed conclusions.
Assessment of bias in the review, and sensitivity of results to this		"*The studies at the highest risk of bias generally reported large reductions in transmission associated with school closures, while studies at lower levels of bias reported more variable findings (figure 2)*"	NA	There is little transparency around how bias was considered in the review. This suggests that if bias was incorrectly or subjectively assigned by reviewers, this would likely change the entire outcome of the review. This is even more concerning given high-quality multi-country studies were not included in the review at all, despite having been published prior to the stated date of the review (7th January 2021).

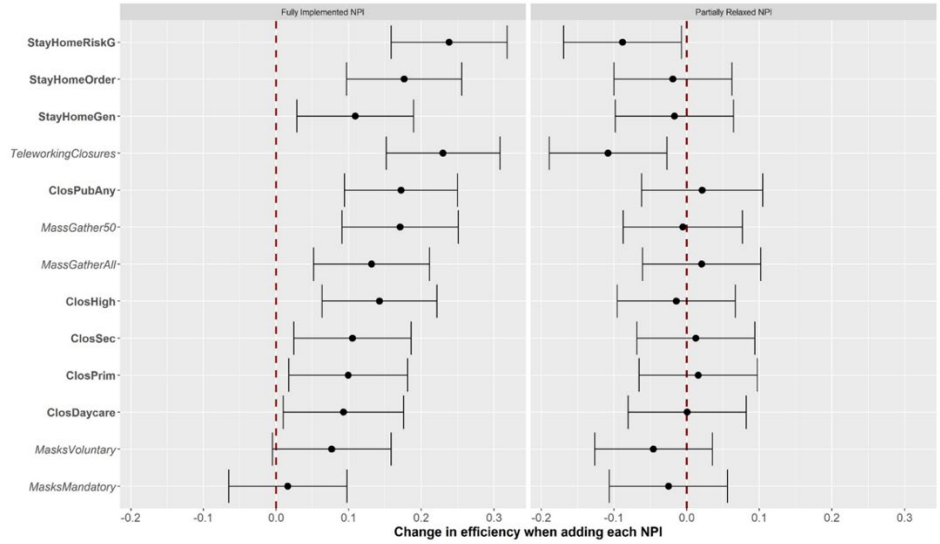

Figure 4: Additional PHR efficiency gained with NPIs implemented against COVID-19 in Europe. Results show the change in PHR efficiency over time when adding each of the 13 NPIs (mean adjusted effect and 95% confidence intervals in multivariate models). Results are disaggregated by level of implementation. A full description for each NPI is available in Table 1. Labels in X axis alternate between bold and italics to reflect different groups of NPIs.

Figure 4, Garchitorena et al.[46]

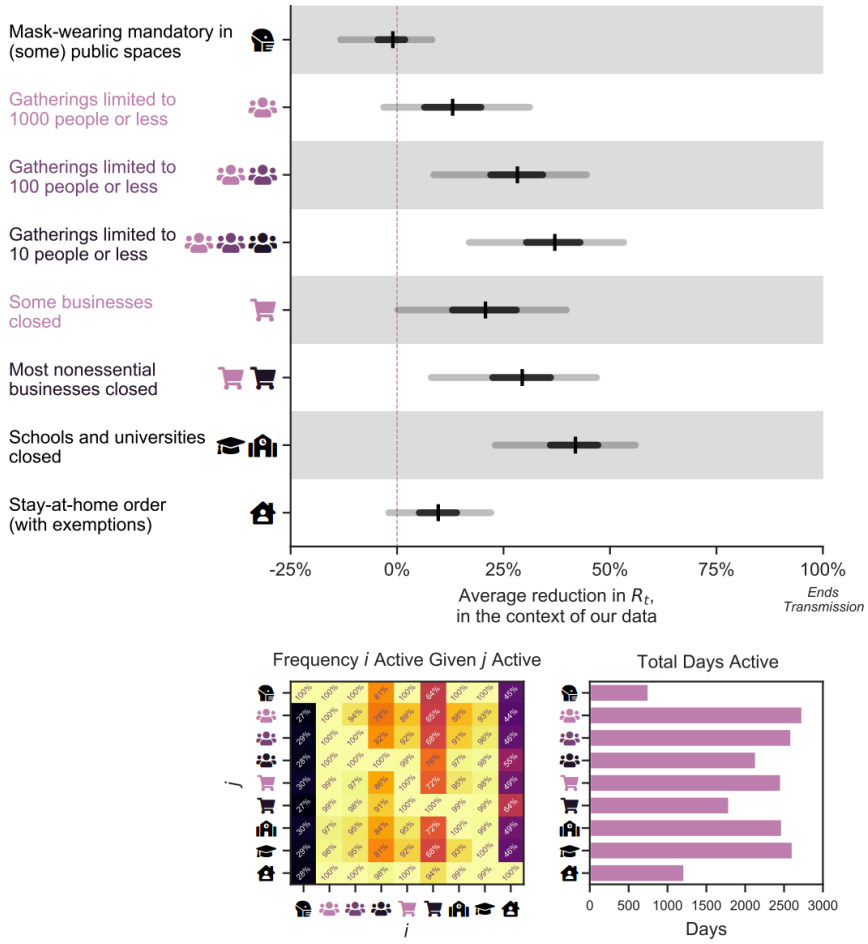

Figure 3, Brauner et al. (ref 18 in the BMJ systematic review, subsequently published in Science[42])

The paper would also benefit from highlighting the adverse impact that school closures have on

young people's mental and physical health, which needs to be factored in to judgements about their closure.

We have now added a section on this in Box Panel 1, with relevant references.

I cannot comment on the evidence about childhood vaccinations as this is outside my area of expertise.

References

1. 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 Pediatrics. 2020.
2. Walsh S, Chowdhury A, Braithwaite V, Russell S, Birch JM, Ward JL, et al. Do school closures and school reopenings affect community transmission of COVID-19? A systematic review of observational studies. BMJ Open. 2021;11(8):e053371.

References

1. Li H, L.H., Chen X, Li H, Li H, Ln S, Huang L, CHen G, Zheng G, Wang S. A need of COVID19 vaccination for children aged <12 years: Comparative evidence from the clinical characteristics in patients during a recent Delta surge. *MedRxiv* (2021).
2. Lorthe A, B.M., Michielin G, Berthelot J, Zaballa M, Penacchio F. Epidemiological, virological and serological investigation into a SARS-CoV-2 outbreak (Alpha variant) in a primary school: a prospective longitudinal study. *MedRxiv* (2021).
3. Meuris, C*., et al.* Transmission of SARS-CoV-2 After COVID-19 Screening and Mitigation Measures for Primary School Children Attending School in Liege, Belgium. *JAMA Netw Open* **4**, e2128757 (2021).
4. Willeit, P*., et al.* Prevalence of RT-qPCR-detected SARS-CoV-2 infection at schools: First results from the Austrian School-SARS-CoV-2 prospective cohort study. *Lancet Reg Health Eur* **5**, 100086 (2021).
5. SAGE. Children's Task and Finish Group: update to 4 November 2020 paper on children, schools and transmission - 17 December 2020. (2020).
6. SPI-M-O. Expert narratives for potential Autumn and Winter Events, 29th July 2020. (2020).
7. SPI-M-O. SPI-M-O: Consensus statement on COVID-19 - 10 February 2021. (2021).
8. Ismail, S.A., Saliba, V., Lopez Bernal, J., Ramsay, M.E. & Ladhani, S.N. SARS-CoV-2 infection and transmission in educational settings: a prospective, cross-sectional analysis of infection clusters and outbreaks in England. *Lancet Infect Dis* **21**, 344-353 (2021).
9. Viner RM, M.O., Bonell C, Melendez-Torrez GJ, Ward J. Susceptibility to SARS-CoV-2 infection amongst children and adolescents compared
with adults: a systematic review and meta-analysis. (2020).
10. Viner, R.M*., et al.* Susceptibility to SARS-CoV-2 Infection Among Children and Adolescents Compared With Adults: A Systematic Review and Meta-analysis. *JAMA Pediatr* **175**, 143-156 (2021).
11. Hyde, Z. COVID-19, children and schools: overlooked and at risk. *Med J Aust* **214**, 190-191 e191 (2021).

12. Poletti, P.*, et al.* Association of Age With Likelihood of Developing Symptoms and Critical Disease Among Close Contacts Exposed to Patients With Confirmed SARS-CoV-2 Infection in Italy. *JAMA Netw Open* **4**, e211085 (2021).
13. Brotons, P.*, et al.* Susceptibility to Severe Acute Respiratory Syndrome Coronavirus 2 Infection Among Children and Adults: A Seroprevalence Study of Family Households in the Barcelona Metropolitan Region, Spain. *Clin Infect Dis* **72**, e970-e977 (2021).
14. Hippich, M.*, et al.* A Public Health Antibody Screening Indicates a 6-Fold Higher SARS-CoV-2 Exposure Rate than Reported Cases in Children. *Med (N Y)* **2**, 149-163 e144 (2021).
15. SAGE. SAGE Subgroup: The role of children in transmission SAGE 26: 16 April 2020. (2020).
16. Ladhani, S.N.*, et al.* SARS-CoV-2 infection, antibody positivity and seroconversion rates in staff and students following full reopening of secondary schools in England: A prospective cohort study, September-December 2020. *EClinicalMedicine* **37**, 100948 (2021).
17. Toh, Z.Q.*, et al.* Comparison of Seroconversion in Children and Adults With Mild COVID-19. *JAMA Netw Open* **5**, e221313 (2022).
18. Southall, E.*, et al.* An analysis of school absences in England during the COVID-19 pandemic. *BMC Med* **19**, 137 (2021).
19. ONS. COVID-19 Schools Infection Survey, England: attitudes to vaccines and preventative measures, November to December 2021. (2021).
20. DfE. Evidence Summary: Coronavirus (COVID-19) and the use of face coverings in education settings. (2022).
21. Zimmerman, K.O.*, et al.* Incidence and Secondary Transmission of SARS-CoV-2 Infections in Schools. *Pediatrics* **147**(2021).
22. Jehn, M.*, et al.* Association Between K-12 School Mask Policies and School-Associated COVID-19 Outbreaks - Maricopa and Pima Counties, Arizona, July-August 2021. *MMWR Morb Mortal Wkly Rep* **70**, 1372-1373 (2021).
23. Budzyn, S.E.*, et al.* Pediatric COVID-19 Cases in Counties With and Without School Mask Requirements - United States, July 1-September 4, 2021. *MMWR Morb Mortal Wkly Rep* **70**, 1377-1378 (2021).
24. Donovan, C.V.*, et al.* SARS-CoV-2 Incidence in K-12 School Districts with Mask-Required Versus Mask-Optional Policies - Arkansas, August-October 2021. *MMWR Morb Mortal Wkly Rep* **71**, 384-389 (2022).
25. Masks in schools: how convincing is the government's evidence? in *The Spectator* (2022).
26. Covid: Evidence on face masks in schools 'inconclusive'. in *BBC* (2022).
27. Lessler, J.*, et al.* Household COVID-19 risk and in-person schooling. *Science* (2021).
28. Gov.uk. All schools to receive carbon dioxide monitors. (2021).
29. NASUWT. Survey shows Government failing on classroom ventilation. (2022).
30. Scotland, P.H. Coronavirus (COVID-19): Guidance on reducing the risks from COVID19 in schools. (2021).
31. Laurent, J.G.C.*, et al.* Associations between Acute Exposures to PM2.5 and Carbon Dioxide Indoors and Cognitive Function in Office Workers: A Multicountry Longitudinal Prospective Observational Study. *Environ Res Lett* **16**(2021).
32. DfE. CO2 monitors evaluation survey and applications for DfE-funded air cleaning units (2022).
33. Ward H., C., G., Whitaker M., Redd R., Eales O., Brown JC., Collet K. REACT-2 Round 5: increasing prevalence of SARS-CoV-2 antibodies demonstrate impact of the second wave and of vaccine roll-out in England. *MedRxiv* (2021).
34. Fenton, L.*, et al.* Risk of hospital admission with covid-19 among teachers compared with healthcare workers and other adults of working age in Scotland, March 2020 to July 2021: population based case-control study. *BMJ* **374**, n2060 (2021).
35. Szepfalusi, Z.*, et al.* Lessons from low seroprevalence of SARS-CoV-2 antibodies in schoolchildren: A cross-sectional study. *Pediatr Allergy Immunol* **32**, 762-770 (2021).

36. UKHSA. SARS-CoV-2 variants of concern and variants under investigation in England: Technical briefing 36. (2022).
37. Weisberg, S.P.*, et al.* Distinct antibody responses to SARS-CoV-2 in children and adults across the COVID-19 clinical spectrum. *Nat Immunol* **22**, 25-31 (2021).
38. ONS. Coronavirus (COVID-19) Infection Survey, UK. (2021).
39. Gurdasani, D.D. (ed. @dgurdasani1) (2021).
40. Gov.uk. Attendance in education and early years settings during the coronavirus (COVID-19) pandemic. (2022).
41. Mainwood, P. (ed. @PaulMainwood) (2022).
42. Brauner, J.M.*, et al.* Inferring the effectiveness of government interventions against COVID-19. *Science* **371**(2021).
43. Liu, Y.*, et al.* The impact of non-pharmaceutical interventions on SARS-CoV-2 transmission across 130 countries and territories. *BMC Med* **19**, 40 (2021).
44. Munday, J.D., Jarvis C. I., Gimma A., Wong K. L. M., Zandvoort K. V., Funk S., Edmunds J. W. . Estimating the impact of reopening schools on the reproduction number of SARS-CoV-2 in England, using weekly contact survey data. *MedRxiv* (2021).
45. Haug, N.*, et al.* Ranking the effectiveness of worldwide COVID-19 government interventions. *Nat Hum Behav* **4**, 1303-1312 (2020).
46. Garchitorena A, G.H., Cazelles B. Quantifying the efficiency of non-pharmaceutical interventions against SARS-COV-2 transmission in Europe. *MedRxiv* (2020).
47. Isphording IE, L.M., Pestel N. School Re-Openings after Summer Breaks in Germany Did Not Increase SARS-CoV-2 Cases. (IZA Institute of Labour Economics, 2020).