The return to school is welcome, but we must minimise shared air

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There is an insufficient emphasis on airborne spread of covid-19 in government guidelines for schools, says these authors

With high hopes, parents in the UK are sending their children back to school this week. Lockdown has been prolonged and dispiriting. Depending on families' capacity to support remote learning, many pupils have lost up to a year of formal education. Significant concerns around children's mental health are also emerging. [1]

But while vaccination rates are rising impressively and case numbers of covid-19 are falling, the pandemic is not yet over. New variants—more contagious, more deadly, and potentially less likely to spare the young—are becoming the dominant strains in the UK. [2] "Long covid" once thought to be rare in children, is now being described as a potential risk. [3] Cases of children who have died of covid-19 are still extremely rare, but these are only "anecdotal" until that story is your own child. The role of school-acquired cases in igniting community outbreaks is controversial, but it may be substantial. [4] Regardless, cases in teachers or pupils will quickly lead to classes and year groups being quarantined, resulting in stress, uncertainty, and further loss of peer support and education.

The goal of returning to school is therefore twofold: to address the urgent educational and wellbeing needs of the nation's children, while also minimising the spread of covid-19. We believe that recommendations from both the UK Department of Education and Education Scotland, while helpful up to a point, currently place too much emphasis on physical distancing, contact, and fomite transmission—measures that are based on a predominantly large droplet mode of spread. [5,6]

Although there is still some debate about how the virus spreads through air (inhalation), increasingly the evidence suggests that airborne spread is the dominant mode of transmission even at close range. [7-13] Against this background, it is time to revisit our analysis in *The BMJ* last year, where we

discussed how physical distancing, masks, ventilation, and type of activity combine in shaping the relative risk of SARS-CoV-2 transmission. [7,8]

If a live virus spreads exclusively through large ballistic droplets (which fall quickly onto surfaces and objects), integrated *people, surface, and space* management is required to *minimize direct touching or spraying,* with a focus on cleaning surfaces, installing physical barriers (e.g. screens), practising physical distancing (e.g. 2 metres apart), and wearing any type of mask.

But if a live virus is airborne, it can be transmitted whenever someone inhales air that another has exhaled. Preventing airborne spread then additionally requires integrated measures of *people, air, and space* management designed to *minimise air-sharing* including universal, well-fitted, and higher grade masking, particularly indoors, adequate ventilation and air filtration, reducing crowding and time spent indoors, and managing patterns of air flow (see recent fluid dynamics review for more detailed arguments [8-14]).

The risk of airborne spread increases with the number of people in an indoor space, with crowding when it leads to overlap of breathing zones of the occupants (order of 2 metres), and with the duration of time they breathe the same air.

In the UK, the typical state-school classroom contains 31 people, and teaching periods last up to two hours before the children leave for a break. Classrooms are, therefore, a high-risk environment. Ventilation of classrooms in particular should align with expert guidance on air ventilation. This can be done, for example, by increasing fresh intake of airflow, removing air that is recirculated without filtration, and making sure that any filters installed do not reduce the total air changes in the space. A carbon dioxide monitor can give an indication of whether the room is minimally adequately ventilated. Windows should be as widely open as possible to maximise fresh air turnover, with the goal of ensuring fresh or filtered air. [14,15] Portable high-efficiency particulate air (HEPA) filters are viable solutions to reach such levels in indoor spaces. [16]

However, it is also important to optimise detailed patterns of flow: caution is needed when using *localised* airflow controls that can amplify/extend the breathing zone of an occupant or concentrate exposure on another. The former occurs if an individual sits right at the entrance path of a localised fresh/filtered air source (e.g. window, door, or local HEPA filter device) and the latter if an individual sits downstream of others in the direct exit path of the air. [8-14] In the longer-term, there are strong arguments for upgrading and

maintaining classroom ventilation to achieve the highest levels of desired fresh or filtered air flow. [16]

Well-fitting double-layer masks that are kept on while indoors provide good (though not 100%) protection against transmitting the virus to others. [17] Masks may also protect the wearer from infection and reduce the risk of severe disease if infected (because of reduced viral load). [13,18,19] Masks do not cause harm, though some children may find them uncomfortable, and they may cause communication challenges for people with hearing impairments. [17] The World Health Organisation now recommends masks in individuals over the age of 12 and UK government advice is that children in Year 7 and above should wear them at school. [20,21]

Certain activities, including speaking, singing, shouting, playing brass and woodwind instruments, and doing strenuous physical activity indoors are known to emit more extensive respiratory clouds with potential to greatly increase the transmission of airborne virus. [7,22,23] Such activities should therefore be minimised indoors. The evidence strongly supports conducting physical education lessons outdoors and avoiding common music practice indoors. Outdoor lunch would be safer than eating indoors, although this is clearly weather dependent. Staggering of seating indoors and outdoors are important to minimise exposure to respiratory zones. [6,12]

In our view, there is currently an insufficient emphasis on ventilation and localised air management, masking, and avoidance of specific activities known to increase airborne spread in government guidelines for schools. We remind readers of our previously published diagram, which highlights how a combination of poor ventilation, prolonged contact, lack of masks, and vocalisation can lead to high risk of transmission.

See also: Two metres or one: what is the evidence for physical distancing in covid-19?

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References:

1. Royal College of Paediatricians and Child Health. Role of paediatriciansin supporting children and young people's mental health – position statement. London: RCPCH. Accessed 8th March 2021 at https://www.rcpch.ac.uk/resources/role-paediatricians-supporting-children-young-peoples-mental-health-position-statement 2021.
2. European Centre for Disease Control. SARS-CoV-2: increased circulation of variants of concern and vaccine rollout in the EU/EEA, 14th update. Stockholm: ECDC. Accessed 8th March 2021 at https://areasaludbadajoz.com/docencia_investigacion/biblioteca/Te_puede_interesar/RRA-covid-19-14th-update-15-feb-2021.pdf 2021.
3. Hu YJ, Wake M, Saffery R. Clarifying the Sweeping Consequences of COVID-19 in Pregnant Women, Newborns, and Children With Existing Cohorts. *JAMA pediatrics* 2021;175(2):117-18.
4. Flasche S, Edmunds WJ. The role of schools and school-aged children in SARS-CoV-2 transmission. *The Lancet Infectious Diseases* 2020
5. Department for Education. Face Coverings in Education. London: DFE. Accessed 1st March 2021 at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/965446/Face_coverings_in_education_-_March_2021.pdf 2021.
6. Scottish Government. COVID-19: Return to educational establishments. Physical Education Guidelines. Edinburgh: Education Scotland. Accessed 4th March 2021 at https://education.gov.scot/media/5s2p23zp/pe-guidelines-22-02-2021.pdf 2021.
7. Jones NR, Qureshi ZU, Temple RJ, et al. Two metres or one: what is the evidence for physical distancing in covid-19? *bmj* 2020;370
8. Bourouiba L. The fluid dynamics of disease transmission. *Annual Review of Fluid Mechanics* 2021;53:473-508.
9. Zuo YY, Uspal WE, Wei T. Airborne Transmission of COVID-19: Aerosol Dispersion, Lung Deposition, and Virus-Receptor Interactions. *ACS Nano* 2020
10. Prather KA, Marr LC, Schooley RT, et al. Airborne transmission of SARS-CoV-2. *Science* 2020;370(6514):303-04.

11. Azimi P, Keshavarz Z, Cedeno Laurent JG, et al. MechanisticTransmission Modeling of COVID-19 on the Diamond Princess Cruise Ship Demonstrates the Importance of Aerosol Transmission. *medRxiv* 2020:2020.07.13.20153049. doi: 10.1101/2020.07.13.20153049
12. Tang JW, Bahnfleth WP, Bluyssen PM, et al. Dismantling myths on the airborne transmission of severe acute respiratory syndrome coronavirus (SARS-CoV-2). *Journal of Hospital Infection* 2021
13. Bourouiba L. Turbulent gas clouds and respiratory pathogen emissions: potential implications for reducing transmission of COVID-19. *Jama* 2020;323(18):1837-38.
14. Bourouiba L. The fluid dynamics of respiratory disease transmission. *Annual Review of Biomedical Engineering* 2021;in press
15. Somsen GA, van Rijn C, Kooij S, et al. Small droplet aerosols in poorly ventilated spaces and SARS-CoV-2 transmission. *The Lancet Respiratory Medicine* 2020;8(7):658-59.
16. Asanati K, Voden L, Majeed A. Healthier schools during the COVID-19 pandemic: ventilation, testing and vaccination. *Journal of the Royal Society of Medicine* 2021:0141076821992449.
17. Czypionka T, Greenhalgh T, Bassler D, et al. Masks and face coverings for preventing the spread of Covid-19: a narrative review. *Annals of Internal Medicine* 2020:doi.org/10.7326/M20-6625.
18. Gandhi M, Beyrer C, Goosby E. Masks do more than protect othersduring COVID-19: reducing the inoculum of SARS-CoV-2 to protect the wearer. *Journal of general internal medicine* 2020;35(10):3063-66.
19. Bahl P, Doolan C, de Silva C, et al. Airborne or droplet precautions for health workers treating COVID-19? *The Journal of infectious diseases* 2020
20. World Health Organisation. Advice on the use of masks in the context of COVID-19. Geneva: WHO. Accessed 8th July 2020 at https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjottfJnr3qAhU6UhUIHbVaByYQFjAAegQIBBAB&url=https%3A%2F%2Fapps.who.int%2Firis%2Frest%2Fbitstreams%2F1279750%2Fretrieve&usg=AOvVaw3OEk7GblHnLXwd5oEzXFJ1. 2020 (updated 5th June).
21. Miller SL, Nazaroff WW, Jimenez JL, et al. Transmission of SARS-CoV-2 by inhalation of respiratory aerosol in the Skagit Valley Chorale superspreading event. *Indoor Air* 2021;31:314-23.
22. Vance D, Shah P, Sataloff RT. COVID-19: Impact on the Musician and Returning to Singing; A Literature Review. *Journal of Voice* 2021