

Healthier schools during the COVID-19 pandemic: ventilation, testing and vaccination

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The role of children's schools in COVID-19 transmission

COVID-19 in children and the role of school settings in COVID-19 transmission have been reviewed by the European Centre for Disease Prevention and Control (ECDC).¹ Only a small proportion (<5%) of COVID-19 cases reported in the European Union, European Economic Area and the United Kingdom have been in children.¹ Children with COVID-19 are also much less likely to be admitted to hospital because of severe disease or die than adults.¹

Children are more likely than adults to have a mild or asymptomatic infection; hence, COVID-19 infection often goes undetected in children. When symptomatic, children shed the virus in similar quantities to adults and can infect others but it is unclear how infectious children with asymptomatic infections are.¹ Large outbreaks of COVID-19 in schools have not been frequently reported but this may be because school outbreaks are rarely investigated in detail; for example, through the use of mass testing when after a case has been detected in a child, to determine the true infection rate among children in the school.

Route of transmission

Larger respiratory particles, droplets, are the primary means of transmission of COVID-19 and generally require close range contact.² They typically fall to the ground within 2 m of the source after a short time.³ Thus, physical distancing reduces exposure to these larger respiratory particles. In addition, SARS-CoV-2 can also be transmitted through aerosols, particles smaller than droplets that remain in the air over time and distance, especially in a poorly ventilated room⁴ with the potential to lead to superspreading events.⁵

The role of ventilation

What does the current evidence suggest?

It takes about 4 min for the number of small droplets in the air to be halved with no ventilation; whereas with only mechanical ventilation turned on in a room, the number of respiratory particles is halved in 1.4 min. In a room that also has a door and window open, the number is halved after 30 s; substantially faster than in poorly ventilated and unventilated rooms.⁶

Therefore, an important approach to lowering the concentrations of indoor air pollutants or contaminants, including any viruses that may be in the air, is to increase ventilation. Increasing air flow by ventilation, whether by window and door opening or mechanical systems – which could mix outdoor air with indoor air or air filtration and cleaning devices, reduces the risk of infection by diluting concentrations of respiratory particles and removing them in the ambient air.

Ventilation in classrooms

Good ventilation in classrooms is crucial to dilute and filter out respiratory particles to reduce the risk of infection. This is due to the large amount of respiratory particles that are produced and concentrated in an enclosed environment by activities such as breathing, talking, singing, coughing and sneezing.^{3,7–9}

Improving indoor air quality in classroom spaces should be followed at the same level as government advice regarding social distancing, mask wearing and hand washing to lower the risk (e.g. using natural and/or mechanical ventilation, if possible, with filtration).

Natural or mechanical ventilation?

While it would be beneficial and cost-effective to have windows and doors open for natural ventilation,⁹ achieving this in winter periods is more difficult due to colder outdoor temperatures and would require an extensive amount of new additional heating power. In order to address this, ideally a mixture of fresh and re-circulated air could be used.

Lessons from the airline industry

The risk of contracting COVID-19 on a flight is currently lower than from an office building or a classroom.¹⁰ The International Air Transport Association (IATA) reports that there have been millions of flights since the start of the COVID-19 pandemic, resulting in less than 50 confirmed cases of transmission in-flight.¹¹ Hence, the multi-layer risk reduction strategy used in the aviation industry seems to have been working efficiently.

The strategy includes testing passengers, the use of face coverings or masks, hygiene measures and, more importantly, maintaining clean air by circulating a mix of fresh air and recycled air through High-Efficiency Particulate Air (HEPA) filters.¹⁰ HEPA is an efficiency standard of air filters.¹²

The main difference between control measures in an airplane and other enclosed environments seems to be in the efficient airplane ventilation system (HEPA-filtration recirculation system and the high air-exchange rate).¹³

A proposed model of ventilation and filtration in schools

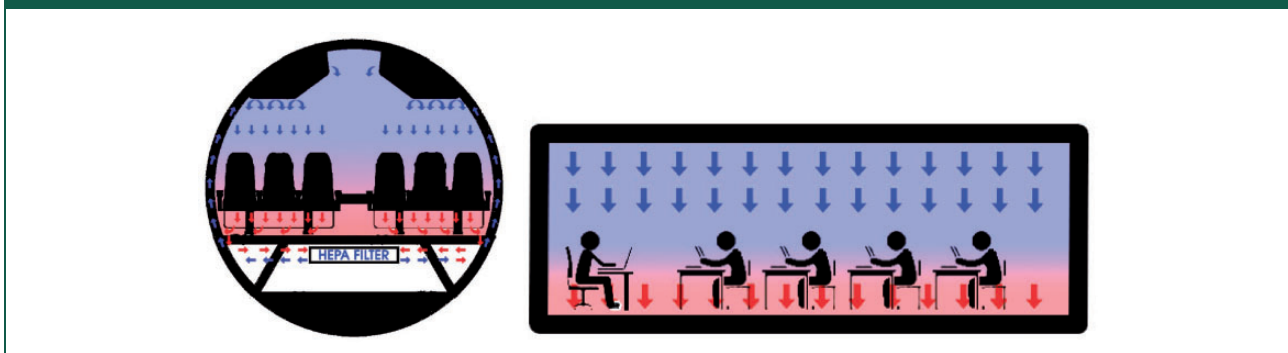
To maintain the building temperature, ideally a mixture of fresh and re-circulated air is commonly

used in more modern buildings with good heating and ventilation systems. However, the position of the inlet and outlets are located for more natural air circulation such as bottom to top or sideways rather than top to bottom as they are done in airplanes. Neither do many of them have HEPA filtration; hence, if they need to be used to effectively dilute and clean the re-circulated air, they will need to be modified as in Figure 1 so that:

- Air outlets are extended to reach clean air above the sitting areas
- Air suction is re-designed to take the air from the floor by means of a suspended floor or via ducts distributed near the floor level of the sitting areas

While implementing air ducts seems to be the most effective method of reducing transmission in a school environment, the practicality of this measure will certainly be problematic because many schools are located in older buildings. The installation process can potentially be long, and due to safeguarding issues, cannot happen when children are present in school and would have to be postponed to a time such as a school holiday. The U.S. Centers for Disease Control and Prevention recommends for healthcare workers during the COVID-19 pandemic to consider the addition of portable solutions such as portable HEPA-filtration units to augment air quality in areas when permanent air-handling systems are not a feasible option.¹⁴ This could be a potential practical option for schools too. In one study performed in the hospital room of COVID-19 patients, the researchers were able to detect SARS-CoV-2 in aerosols, only when they used the air samplers without a HEPA filter on the inlet tube.⁴

Figure 1. Left: schematic illustration of the ventilation air flow in a typical airplane cabin, where the majority of the air is circulated via a HEPA filter. The clean air outlet ducts are located above head and the air suction is located on the bottom. Right: ideal air flow direction in a classroom with modified air ventilation system with added HEPA filter and duct location if the same concept of the airplane cabin is to be achieved.



The need for a guideline on ventilation and filtration in schools

This installation time could be minimised if a school has already implemented HVAC units in classrooms by adding the HEPA filters to the existing units. If not, portable units with HEPA filters suitable for classrooms can be used, after developing appropriate relevant guidelines for schools. Spanish researchers together with technicians have developed a handbook with guidelines on how to use ventilation to reduce the contagion risk by COVID-19.¹⁵ The document establishes the recommendations for effective ventilation and air filtration according to the room volume, the number and age of people inside, and the type of activity. It also provides the tools to determine if ventilation conditions achieved are adequate. There is an urgent need for a similar guideline for British schools.

COVID-19 testing

The recent developments in sensitive, rapid tests are promising,¹⁶ as they could be used to work towards effective COVID-19 elimination strategies by regularly testing students and staff.¹⁷ Other testing methods include 'batch testing' whereby samples from individuals are tested in batches.¹⁸ If the batch test is positive, then the individuals can be tested separately. As most COVID-19 tests are negative, this could considerably reduce the cost of testing. Hence, in addition to considering and implementing adequate ventilation, batch testing could help support a more effective and timely system of test, trace, isolate and support; along with measures to minimise the risk of virus transmission. Batch testing works best for populations with a low expected prevalence, as frequent retesting for pooled samples that test positive may not save time and resources in high-prevalence settings.

Temperature test kiosks at the school entrance

While most children are asymptomatic with COVID-19, a small percentage of children go to school with a fever and are sent home later in the day, and followed up by COVID-19 testing if indicated. Most secondary schools are implementing a bubble within each year group, which in some larger schools is up to 320 children. Detecting those single cases with a fever using the temperature test kiosks before they get in touch with their year group bubble could potentially decrease the risk of transmission in the wider school community.

Vaccination

It is vital that the UK COVID-19 vaccination programme should be implemented well as this offers the best method of controlling the COVID-19 pandemic.¹⁹ In that context, in order to keep schools open, it is essential that teachers and other school staff should be protected. The most promising way of protection is COVID-19 vaccination and therefore, teachers and school staff should be added to the priority list for vaccination.

Conclusions

To keep schools open, there is an urgent need to implement more effective on-site mitigation strategies – with particular attention to ventilation and testing. In addition, it is essential that teachers and other school staff should be added to the priority list for vaccination. As far as ventilation is concerned, we suggest undertaking a feasibility study of implementing better ventilation and filtration systems in schools as well as some pilot work and research involving indoor air quality and HVAC experts. Until then, keeping doors and windows open – for as much as is reasonably practicable – seems to be the best way forward.

Regarding COVID-19 tests, there is an urgent need to develop an appropriate guideline for schools on how staff and students should be tested regularly to work towards COVID-mitigated environment in schools. The recommendations on ventilation, testing and vaccination need to be combined with other infection control measures, such as wearing face masks or face coverings for staff and older students, regular cleaning of surfaces and frequent handwashing.

A failure to implement adequate control measures could result in COVID-19 outbreaks in schools then extending to the wider community, which would be a threat to public health, particularly for more vulnerable people such as the elderly, as well as leading to harm to children and families from school closures.

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