CENTER FOR CITIES+SCHOOLS
UNIVERSITY OF CALIFORNIA BERKELEY

COVID-19 BRIEF #1
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Reopening Schools Safely and Equitably Amidst the COVID-19 Pandemic:

School Facilities are Frontline Defense in Reducing Risk

In this first brief of our series, *Reopening Schools Safely and Equitably Amidst the COVID-19 Pandemic*, CC+S's cofounder Jeff Vincent, PhD, describes how the SARS-CoV-2 virus spreads and why mitigation measures are recommended for schools. He highlights the important role school facilities play in effectively implementing health mitigation measures inside schools.

Dr. Vincent has nearly 20 years of experience working with school districts and states on school facilities issues and is advising local and state school COVID-19 reopening plans, including serving as an ad-hoc working group member for the National Academies of Sciences, Engineering, and Medicine report, "Reopening K-12 Schools During the COVID-19 Pandemic: Prioritizing Health, Equity, and Communities."

In these efforts, he observed that as school leaders work to operationalize public health guidance, the essential bridge between public health and school facilities was missing. Following months reviewing national and state reopening guidance and careful study of the emerging epidemiological knowledge, Dr. Vincent provides the bridge in this brief.

ABSTRACT. As the novel coronavirus, SARS-CoV-2, rapidly spread across the globe in Spring 2020, one of the most widely implemented risk reduction measures utilized was to physically close all school buildings. Reopening America's public schools for site-based instruction safely amidst the ongoing COVID-19 pandemic (without a vaccine) is remarkably complicated and hotly debated. Operating healthy school buildings is a necessity for doing so. However, the important urgency of having school facilities in good repair is missing from the national debate on school reopening. This brief describes how the SARS-CoV-2 virus spreads and why mitigation measures are recommended for schools. It argues that it will be more difficult for schools with poor condition facilities to effectively implement the SARS-CoV-2 mitigation measures. As a result, students and staff attending these schools will face greater health risks.

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Public School Facilities are Frontline Defense in a Pandemic

As the novel coronavirus, SARS-CoV-2, rapidly spread across the globe in Spring 2020, one of the most widely implemented COVID-19 risk reduction measures utilized by governments was to physically close all school buildings. By April 2020, nearly 200 countries closed their schools affecting more than 1.5 billion students.[1] Physically closing schools was used as swift tool for implementing extreme physical distancing to combat COVID-19.

Reopening America's public schools for site-based instruction safely amidst the ongoing COVID-19 pandemic (without a vaccine) is remarkably complicated. For starters, the scale of the challenge is staggering: nearly 50 million students and 6 million adults attend public school each day in 100,000+ buildings.[2] With each individual school campus being entirely unique in design, configuration, and physical condition, reopen plans must also be uniquely tailored. Surrounding community and environmental issues also contribute to the unique situation of each school and factors that need to be mitigated. By mid-April 2020, 26 U.S. states closed schools for the academic year, affecting half of the nation's students.[3] When and how to reopen school buildings for students and staff remain hotly debated.

A plethora of school reopening guidance has been developed, much of it stemming from the U.S. Centers for Disease Control and Prevention (CDC) recommendations: initial school and childcare center guidance for reopening was released on April 10, 2020; revised guidance was released on July 23, 2020 and August 21, 2020.[4] The CDC recommendations focus in particular on establishing extensive cleaning protocols and achieving social (e.g., physical) distancing as key mitigation measures. While these measures make sense on paper, making them work in a real school with real children and adult staff is riddled with complexity.

Fundamental to operationalizing the health and safety guidance to reduce the spread of SARS-CoV-2 inside schools requires using school facilities differently. Operating healthy school buildings is a foundational necessity for battling the COVID-19 pandemic.[5]

School facilities were designed to support dense communities of children, managed by adults – all in close proximity to support learning and growing through relationships, sharing, and communication. Public school facilities are, by and large, designed to group students to maximum class sizes; utilize large spaces for eating, facilitate outdoor play and hold assemblies for large groups; and share labs, art, music, computers, and physical education spaces to reduce the costs.

Pandemic conditions turn all this on its head. School districts are being advised – by the CDC, states, and local health officials – to employ mitigation measures that are extremely challenging to implement in their existing spaces. These include increasing levels of surface cleaning, ensuring frequent hand washing for students and staff, conducting daily symptom screening, requiring mask wearing, employing space utilization to physically distance students and staff, and ensuring high levels of indoor air ventilation and filtration. Each of these mitigation measures offers unique operational challenges that every local school district leader across the country is grappling with. *How do we reopen schools safely and still offer meaningful learning experiences?*

The reality is, the physical conditions and qualities of local school facilities greatly shape each schools' ability to effectively implement COVID-19 mitigation measures.[6] However, the fundamental importance of having school facilities in good repair is missing from the national debate on school reopening.

SARS-CoV-2 mitigation requires school facilities in good repair. It is more difficult to effectively implement SARS-CoV-2 mitigation measures in schools that have poor condition facilities. As a result, students and staff attending these schools will face greater risk of contracting COVID-19.

In this brief, we describe the important public health role public school facilities play in the COVID-19 pandemic. To do so, we reviewed official government guidance to public school districts in the U.S. as well as the emerging scientific evidence on the SARS-CoV-2 virus. We reviewed the CDC health guidance and school reopening guidance from the states.[7] We explain how the SARS-CoV-2 virus spreads in order to make sense of the recommended mitigation measures for schools.[8]

Minimizing Risk and Maximizing Safety Inside Schools During the COVID-19 Pandemic

The SARS-CoV-2 coronavirus reproduces in our upper and lower respiratory tracts. It is emitted when we breathe, talk, sing, sneeze, and cough. Scientific understanding of the SARS-CoV-2 virus continues to rapidly evolve, but we know that COVID-19 infection occurs when virus particles from an infected person come into contact with another person's mucus membranes such as the eyes, nose, mouth, or respiratory tract.

A key reason the SARS-CoV-2 virus is difficult to control is because not everyone shows symptoms when they are infected. On average, infected individuals do not experience symptoms for 2-5 days after becoming infected.[9] Further complicating matters is that some individuals are asymptomatic or only show very mild symptoms.[10] Asymptomatic, presymptomatic, and mildly symptomatic individuals are all contagious.

The recommended mitigation measures for school reopening have two main purposes: 1) to keep the virus out of the school entirely; and 2) to create an environment that will limit its spread when someone with COVID-19 enters the school building.

Keeping the Virus Out of Schools

Once school buildings reopen to students, there are three primary tools to keep COVID-19 virus out: symptom screening, testing, and tracing. Each tool involves knowing who already has the virus or has a high probability of having it.

- **Symptom Screening.** A commonly used symptom screening tool is recording body temperature prior to allowing an individual to enter the school. However, temperature screening is believed to have a low efficacy rate.[11]

  Testing. Regular testing is an essential tool for stopping the spread of COVID-19. With regular testing, people testing positive can be quarantined until they test negative, thereby preventing them from spreading the virus. However, recent studies find that false negative rates are high *prior* to showing symptoms.[12]

- **Contact Tracing.** Contact tracing involves a set of techniques to identify, notify, and advise people who have been in close contact with someone how has tested positive or has also been exposed. This technique enables those that have potentially been exposed to COVID-19 to quarantine to avoid exposing others.[13]

The main challenge for schools is that the vast majority simply do not have the capacity to assume duties for screening, testing, or tracing. [As of this writing, schools in the U.S. rarely, if ever, have timely access to all three tools. Daily temperature taking appears to be the most widely used among these, despite its minimal effectiveness.] Yet, these three tools are frontline defenses to keeping the virus out of schools when students and staff return to the buildings.

Minimizing Virus Spread in Schools

As long as COVID-19 is in the community and there is no vaccine, there will never be *zero* risk for the virus in schools. Mitigation measures reduce – but do not eliminate – the likelihood of virus spread. In its guidance to schools, the CDC calls for a "collective practice of preventive behaviors" as the most critical measures to support a safe reopening for schools. These include: practicing social/physical distancing among students and staff, practicing good hand hygiene, using face coverings, engaging in "cohorting" of students, and maintaining a healthy environment by cleaning and disinfecting frequently touched surfaces and ensuring fresh air ventilation indoors.[14] Every state has released school reopening guidance and while they do vary in their content somewhat, they all adapt and reference the CDC guidance.[15] Much of this guidance outlines practices designed to minimize risk and contain virus spread.

Understanding How the SARS-CoV-2 Virus Spreads and What It Means for Risk Mitigation In Schools

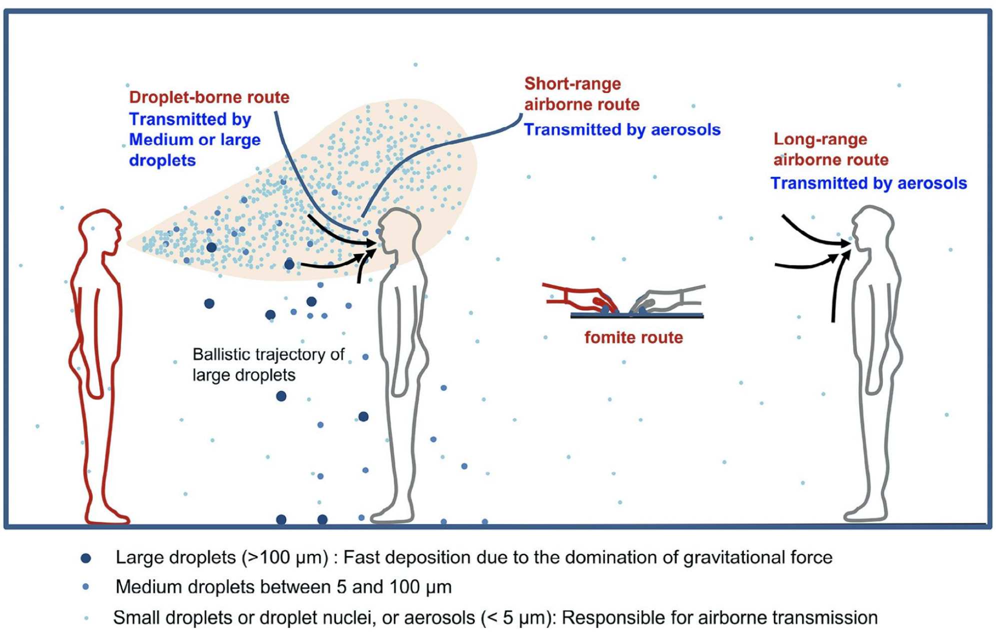
According to the World Health Organization (WHO), there are multiple modes of transmission, including human contact, droplet, airborne, surfaces, fecal-oral, bloodborne, mother-to-child, and animal-to-human transmission.[16,17]

The recommended mitigation measures for school reopening focus on preventing three primary methods of transmission:[18]

- ***Surface (fomite) transmission***: contact with virus-containing respiratory secretions surviving on the surfaces of objects. Contaminated surfaces are known as *fomites*.
- ***Direct human contact and droplet transmission***: close human-to-human physical contact with infected respiratory secretions such as saliva or droplets from sneezing, coughing, talking, or singing.
- ***Aerosol particle transmission***: contact with virus-containing respiratory secretions in the form of small droplets that suspend in the air for longer distances and times, known as *aerosol droplets*.

Figure 1 below illustrates these three main virus transmission routes.

Figure 1. Illustration of fomite, large droplet, and aerosol transmission routes



Source: Wei, LJ and Y Li. 2016. Airborne spread of infectious agents in the indoor environment. American Journal of Infection Control 44 (2016) S102-S108.
https://www.ajicjournal.org/article/S0196-6553(16)30531-4/pdf

Table 1 below shows what virus transmission mode is being mitigated by the recommendations.

Table 1: Key School Reopening Mitigation Measures and SARS-CoV-2 Transmission Pathways

		Three Main SARS-CoV-2 Transmission Pathways		
		Surface/ Fomite Transmission	**Direct Contact/ Droplet**	**Aerosol Particles**
Key School Reopening Mitigation Measures	**Frequent Handwashing**		X	
	Facility/Surface Cleaning/Disinfecting	X	X	
	Physical/Social Distancing		X	
	Indoor Air Ventilation/Filtration		X	X
	Mask Wearing	X	X	X

Local school leaders are devising protocols and operations plans for each of these mitigation measures to their best of their ability. The author of a July 2020 *Atlantic* article noted, “As the virologist Ryan McNamara of the University of North Carolina told me, all these protections stack on top of one another: The more tools we have to deploy against COVID-19, the better off we are.”[19] Similarly, researchers in the healthy buildings program at Harvard note in their risk mitigation guidance to schools, “Although it is unlikely that any given school will be able to incorporate every recommendation, we want to emphasize that these strategies work *together* as part of a multi-layered plan to reduce exposure and limit transmission of COVID-19 in schools.”[20]

Next, we briefly describe the three dominant modes of transmission (surface/fomite transmission, contact and droplet transmission, and airborne (aerosol) transmission), based on current scientific understanding. Of course, scientists around the world are working diligently to better understand how the virus spreads and how different environmental conditions affect likelihood of transmission. Close, direct person-to-person contact is clearly a strong transmitter, especially when an infected person is unaware they are infected. This is why local and state governments across the country have mandated the closure of many businesses as well as requiring 6 foot social distancing requirements for residents - to reduce close contact of individuals not in the same household. It is also why face coverings (masks) have been mandated in many communities across the country. Still, better understanding is key to making sure the right mitigation measures are being used and prioritized inside schools.

As of this writing, there is highly active scientific examination on how dominant each of the main transmission routes is. As we will discuss below, there is growing evidence that aerosol transmission of SARS-CoV-2 is much great than originally thought. For example:

- A July 2020 study of transmission among healthcare personnel caring for infected patients in hospital settings found that aerosol (57%) and droplet (35%) routes predominate over fomite routes (8%), without use of personal protective equipment.[21]
- In early August 2020, Jose-Luis Jimenez, a prominent aerosol specialist at the University of Colorado-Boulder, looked at the recent studies and estimated the relative contributions of transmission routes to be:
    - ~75% aerosols
    - ~20% surfaces / fomite / direct contact between people
    - ~5% ballistic droplets from accidental sneezing and coughing.[22]
- In a late August 2020 presentation to the National Academies of Sciences, Engineering, and Medicine, Linsey Marr, an expert on airborne transmission of viruses at Virginia Tech, stated that new research finds that breathing, talking, coughing, and other activities produce ~100 times more aerosols than they do large droplets.[23]

Additional research will help better understand the relative dominance of different transmission routes and how those routes might differ in different settings, such as in a restaurant, in a hospital, at the grocery store, or in a school.[24]

In response, when schools reopen for site-based instruction, school facility managers will need to recalibrate their mitigation plans accordingly as evidence reveals new knowledge about the virus or about which mitigation measures in schools have better results. For example, CDC and state guidance to schools place strong emphasis on cleaning and disinfecting surfaces to mitigate SARS-CoV-2 while placing comparatively little emphasis on filtration and ventilating indoor air. However, a July 3, 2020 letter in *The Lancet Infectious Diseases* argues that there is a greatly *exaggerated* risk of fomite transmission.[25] Similarly, a July 6, 2020 letter in *Clinical Infectious Diseases* argues that aerosol transmission is greatly *under* estimated.[26] As the science on SARS-CoV-2 continues to rapidly evolve, schools will need to adjust accordingly. But we need to better understand the different transmission routes in order to better guide local schools on how to prioritize and implement mitigation measures in different school settings.

Surface (Fomite) Transmission of SARS-CoV-2

Virus-containing respiratory secretions can accumulate on and contaminate surfaces and objects. Contaminated surfaces are known as *fomites*. Numerous studies have found that viable virus particles can survive on surfaces for numerous hours and potentially for multiple days.[27] The length of time virus particles persist depends on the ambient environment (especially its temperature and humidity) and the material of the surface. Fomite transmission of the coronavirus may be possible – for example if a person touches a contaminated surface such as a doorknob and then touches their eyes, nose, or mouth. However, the WHO noted that as of early July 2020, "there are no specific reports which have directly demonstrated fomite transmission."[28] This may be due to the fact that discerning the distinction between respiratory droplet transmission and fomite transmission in a given setting (such as a hospital or a school) is difficult. Still, fomite transmission is considered a likely mode of transmission for SARS-CoV-2.[29]

Mitigating fomite transmission at schools is a major focus of attention in CDC and state guidance on school reopening. The CDC and many states' guidance documents strongly recommend frequent surface cleaning and disinfecting to avoid fomite transmission. Because schools have many people in them when open, there are a multitude of "high-touch" surfaces throughout the building. These include desks, computers, doorknobs, faucets, toilet handles, water fountains, and any educational material (e.g., pencils, computers, books, etc.) that are frequently shared or used by numerous people throughout any given school day. Preventing children and adults from touching surfaces and sharing materials is a tremendous challenge. For one, children frequently touch surfaces and materials. Second, most schools simply do not have the resources to provide each student with their own set of materials – these are frequently shared among students. The CDC states that schools should clean and disinfect "frequently touched surfaces within the school and on school buses at least daily or between uses as much as possible. Use of shared objects should be limited when possible. Develop a schedule for increased, routine cleaning and disinfection."[30]

Direct Human Contact and Droplet Transmission of SARS-CoV-2

The SARS-CoV-2 coronavirus is in saliva and emitted in large and small water droplets when we breathe, talk, sing, sneeze, or cough. Therefore, it is risky being very near to an infected person, because they can emit virus particles in large and small water droplets into the air around them, which can be inhaled by another person. There is intense and ongoing research to better understand contact and droplet emission. Droplet transmission has been thought to be especially prevalent within about 6 feet from an infected individual. The 6 foot rule comes from previous research on droplets and their typical travel distance from the person emitting them.[31]

Social (e.g., physical) distancing among students and staff at school is a key SARS-CoV-2 mitigation measure recommended by the CDC, most states, and many public health authorities. Social distancing is meant both to limit direct contact as well as reduce droplet transmission. The CDC school guidance says that "social distancing should be practiced in combination with other everyday preventive actions to reduce the spread of COVID-19."[32] Most sources recommended a distance of at least 6 feet from one another at all times. To accomplish this, schools are looking at a variety of activities that space students out and greatly reduce points of contact, including eliminating use of drinking fountains, reducing class sizes into “cohorts” or “pods” that have little-to-no direct contact with other pods, minimizing or eliminating teacher rotations between pods, changing lunch schedules to avoid large groups in the cafeteria, and other scheduling arrangements that similarly reduce close person-to-person contact inside schools. Achieving recommended physical distancing during site-based instruction will likely need to include reducing/limiting the occupancy of any given room/space in a school at any given time.

Frequent handwashing by children and adults in schools is another major contact risk mitigation measure. Because people (and especially children) often touch their face and may cough or sneeze into their hands, active virus particles can remain on hands and be transmitted to another person with direct contact. The CDC notes that washing hands with soap removes germs more effectively than other methods and individuals should “[avoid] touching your face with unwashed hands, and frequently washing your hands with soap and water for at least 20 seconds.”[33] The SARS-CoV-2 virus breaks down when washed with soap and water for about 20 seconds. Thus, the CDC and all state guidance strongly recommend frequent handwashing throughout the school day, including immediately upon arrival to campus. The virus is also killed when an alcohol-based (at or above 60%) hand sanitizer is applied, although hand sanitizer is less effective than 20 seconds of handwashing. CDC and state guidance from California and other states only recommends using alcohol-based sanitizer when soap and water are not available.[34]

Airborne Transmission of SARS-CoV-2

The third main route of transmission for SARS-CoV-2 is through small microdroplets known as aerosol particles that can linger and accumulate in the air near an infected person for longer periods of time.[35] Early in the spread of SARS-CoV-2, the focus was on direct contact and large droplets as described above. However, growing evidence indicates that very small droplets (“aerosol particles”) emitted from an infected person when talking, singing, sneezing, and coughing do contain enough virus to infect others. This has led to shifting mitigation recommendations to include prevention of airborne as well. In a July 2020 open letter to the WHO, 239 scientists from around the world noted that mounting evidence supports high transmission through aerosol particles.[36] The letter called on the WHO and other leading health entities to take airborne transmission more seriously and to adjust their recommendations accordingly. The scientists wrote,

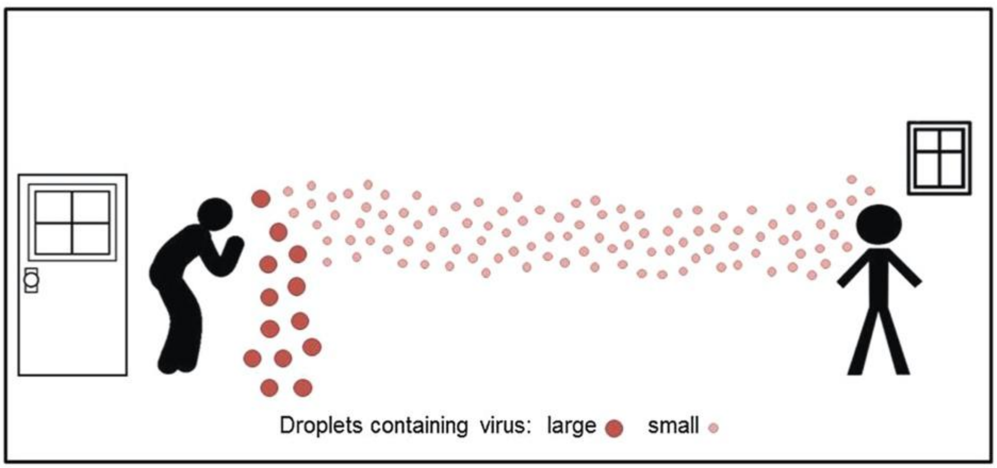
> Studies by the signatories and other scientists have demonstrated beyond any reasonable doubt that viruses are released during exhalation, talking, and coughing in microdroplets small enough to remain aloft in air and pose a risk of exposure at distances beyond 1 to 2 m from an infected individual (pg 2)…Many studies conducted on the spread of other viruses…show that viable airborne viruses can be exhaled and/or detected in the indoor environment of infected patients. This poses the risk that people sharing such environments can potentially inhale these viruses, resulting in infection and disease (pg 2).[37]

Prior to this, the WHO had held that SARS-CoV-2 is transmitted mostly by large respiratory droplets that fall to the floor within about 6 feet of being discharged via talking, sneezing, coughing, and the like. The scientists wrote,

> The current guidance from numerous international and national bodies focuses on hand washing, maintaining social distancing, and droplet precautions. Most public health organizations, including the World Health Organization (WHO), do not recognize airborne transmission except for aerosol-generating procedures performed in healthcare settings. Hand washing and social distancing are appropriate, but in our view, insufficient to provide protection from virus-carrying respiratory microdroplets released into the air by infected people. This problem is especially acute in indoor or enclosed environments, particularly those that are crowded and have inadequate ventilation relative to the number of occupants and extended exposure periods. For example, airborne transmission appears to be the only plausible explanation for several superspreading events investigated which occurred under such conditions, and others where recommended precautions related to direct droplet transmissions were followed.[38]

Figure 2 below illustrates the indoor air travel difference between large and small droplets containing the virus.

Figure 2: Illustration of large and small (aerosol) droplet emissions in indoor air



Source: Morawska and Cao (2020)

The mitigation for aerosol particles in schools is to ensure all indoor spaces are frequently ventilated with fresh air and that return air is filtered. Doing so dilutes or removes potentially infectious aerosols.[39] Initial guidance documents to school districts made only brief mention of indoor air quality. However, as scientific consensus has coalesced regarding the risk of airborne transmission, the CDC has updated its guidance accordingly: “Ensure ventilation systems operate properly and increase circulation of outdoor air as much as possible, for example opening windows and doors. [Avoid opening] windows and doors if doing so poses a safety or health risk to children using the facility.”[40] State guidance documents largely mirror the CDC. For example, the California Department of Education’s Stronger Together guidance document recommends that schools, “Maximize central air filtration for heating, ventilation, and air conditioning (HVAC) systems (targeted filter rating of at least MERV 13).”[41] The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) notes, “Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled. Changes to building operations, including the operation of heating, ventilating, and air-conditioning [HVAC] systems, can reduce airborne exposures.”[42]

Figure 3 below illustrates the key indoor air quality mitigation recommendations for schools.

Figure 3: Engineering controls for reducing indoor airborne virus transmission

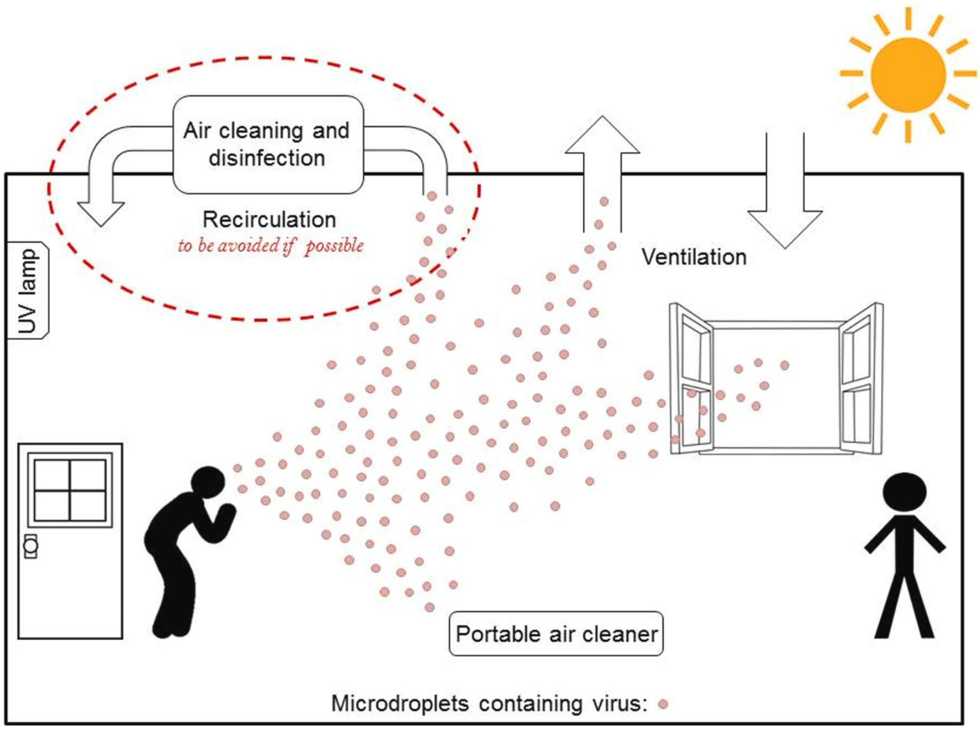
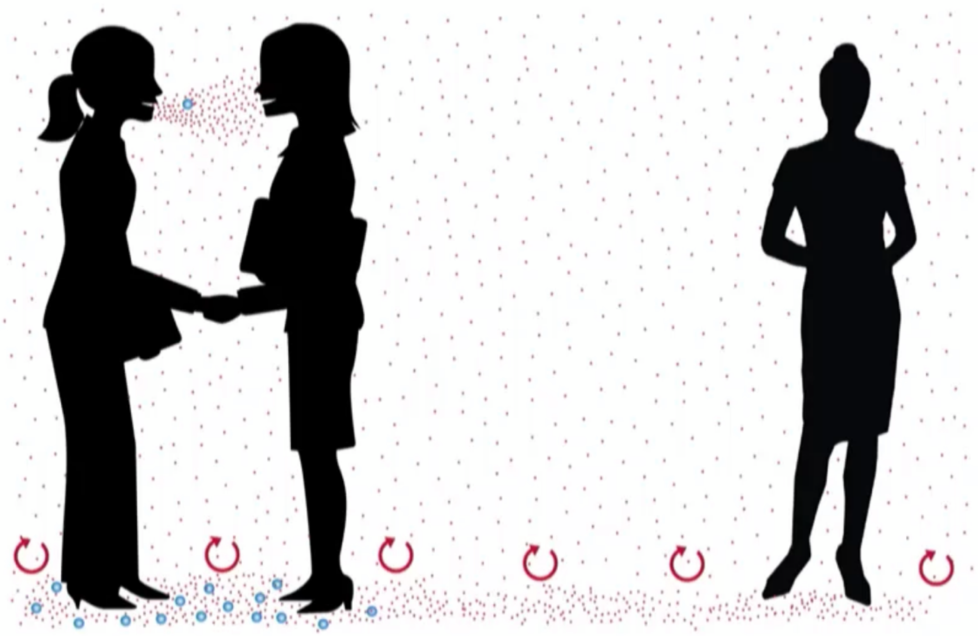


Fig. 2. Engineering level controls to reduce the environmental risks for airborne transmission.

Source: Morawska, L et al. 2020. How can airborne transmission of COVID-19 indoors be minimised? *Environment International* 142 (2020) 105832. https://doi.org/10.1016/j.envint.2020.105832

Lastly, it is also important to understand that these three transmission routes can be interconnected. For example, droplets and aerosol particles may end up setting on surfaces and creating fomites (i.e., contaminated surfaces). Therefore, adequate ventilation will likely reduce fomites created by settling aerosols, for example. Also, there is emerging evidence that droplets and aerosols can settle on surfaces, such as floors, and then be “kicked up” and resuspended into the air (e.g., “aerosolized fomites”) by sweeping or walking, as illustrated in Figure 4.

Figure 4: Spread, Dilution, and Resuspension of Virus Particles



Source: Graphic by Linsey Marr, August 26, 2020. Aerosols and Transmission of Respiratory Viruses 101. Presentation to the Airborne Transmission of SARS-CoV-2: A Virtual Workshop of the Environmental Health Matters Initiative at the National Academies of Sciences, Engineering, and Medicine. https://www.nationalacademies.org/event/08-26-2020/airborne-transmission-of-sars-cov-2-a-virtual-workshop. See also: Khare, P. and Marr, L.C. (2015), Simulation of vertical concentration gradient of influenza viruses in dust resuspended by walking. *Indoor Air*, 25: 428-440. doi:10.1111/ina.12156; Asadi, S., Gaaloul ben Hnia, N., Barre, R.S. et al. 2020. Influenza A virus is transmissible via aerosolized fomites. *Nature Communications* 11, 4062. https://doi.org/10.1038/s41467-020-17888-w

SARS-CoV-2 Mitigation Requires School Facilities in Good Repair

It is more difficult to effectively implement SARS-CoV-2 mitigation measures in schools that have poor condition facilities. As a result, students and staff attending these schools will face greater risk of contracting COVID-19.

Fundamentally, the effective implementation of the hygiene, distancing, and ventilation mitigation measures noted above is dependent on the physical condition and adaptability of school facilities. For example:

- School buildings that are cluttered and/or in disrepair are more difficult to clean
- School buildings with fewer (or broken) bathrooms and sinks cannot support frequent handwashing
- School buildings with non-operable windows or other heating, ventilation, and air conditioning (HVAC) system deficiencies will make mitigating aerosol transmission nearly impossible

To effectively and equitably reduce risk of the spread of COVID-19 when schools physically reopen for site-based instruction, states and local school districts must:

- Assess the physical conditions of all schools in relation to COVID-19 mitigation measures
- Determine each schools' ability to physically implement recommended COVID-19 mitigation measures
- Direct resources to rapidly remedy identified facility deficiencies that hinder implementing the mitigation measures

Lastly, the federal government, states, and the research community must work diligently together to provide clear, detailed, regularly updated guidance to schools on how to *prioritize* the various recommended mitigation measures as the scientific evidence of SARS-CoV-2 transmission routes advances. This is crucial. Schools have limited budgets, which must be used wisely and strategically to reduce risk amidst a pandemic.

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In follow up briefs, we will look at conditions of public school facilities in the U.S. and identify policies and tools to assist local school districts and states in mitigating risk associated with their facilities.

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SCHOOL REOPENING FACILITY RESOURCES
https://citiesandschools.berkeley.edu/covid-school-facilities

[1] UNESCO Institute for Statistics (UIS). https://en.unesco.org/covid19/educationresponse

[2] Filardo, M. (2016). State of our schools: America's K–12 facilities 2016. Washington, DC: 21st Century School Fund and Center for Green Schools. https://eric.ed.gov/?id=ED581630

[3] https://www.npr.org/sections/coronavirus-live-updates/2020/04/16/835941050/nearly-half-of-u-s-public-school-students-are-home-for-the-school-year

[4] CDC guidance April 10, 2020: https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/guidance-for-schools.html. Updated CDC guidance July 23, 2020: https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/prepare-safe-return.html; Updates August 21, 2020: https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/schools.html

[5] Jones, E, Young A, Clevenger K, Salimifard P, Wu E, Lahaie Luna M, Lahvis M, Lang J, Bliss M, Azimi P, Cedeno-Laurent J, Wilson C, Allen J. Healthy Schools: Risk Reduction Strategies for Reopening Schools. Harvard T.H. Chan School of Public Health Healthy Buildings program. June, 2020. https://schools.forhealth.org/risk-reduction-strategies-for-reopening-schools/

[6] National Academies of Sciences, Engineering, and Medicine. 2020. "Reopening K-12 Schools During the COVID-19 Pandemic: Prioritizing Health, Equity, and Communities." Washington, DC: The National Academies Press. https://doi.org/10.17226/25858

[7] For the research, we partnered with the National Council on School Facilities to review and compare state guidance on COVID-19 school reopening: https://www.facilitiescouncil.org/covid19-stateguidance

[8] Scientific knowledge of SARS-COV-2 is evolving almost daily. Our summaries here draw on the latest evidence as of August 21, 2020.

[9] According to the CDC, "The incubation period for COVID-19 is thought to extend to 14 days, with a median time of 4-5 days from exposure to symptoms onset.1-3 One study reported that 97.5% of persons with COVID-19 who develop symptoms will do so within 11.5 days of SARS-CoV-2 infection." https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-guidance-management-patients.html

[10] In July 2020, the CDC estimated that 40% of individuals infected with COVID-19 may be asymptomatic. https://www.cdc.gov/coronavirus/2019-ncov/hcp/planning-scenarios.html

[11] https://www.sciencemag.org/news/2020/03/why-airport-screening-wont-stop-spread-coronavirus.

[12] Lauren M. Kucirka, Stephen A. Lauer, Oliver Laeyendecker, Denali Boon, and Justin Lessler. 2020. Variation in False-Negative Rate of Reverse Transcriptase Polymerase Chain Reaction–Based SARS-CoV-2 Tests by Time Since Exposure. Annals of Internal Medicine 2020 173:4, 262-267. https://www.acpjournals.org/doi/10.7326/M20-1495

[13] CDC guidance on contract tracing: https://www.cdc.gov/coronavirus/2019-ncov/php/contact-tracing/contact-tracing-plan/contact-tracing.html

[14] The CDC has an extensive set of guidance information to schools for reopening amidst the COVID-19 pandemic, including a school reopening decision tree and a Readiness and Planning Tool, a checklist guidance document to assist in conducting general readiness assessments, prior to reopening (i.e. ensuring school have plans in place, secures enough supplies, offers proper training, among other things) in addition to conducting daily and weekly assessments, preparing for if someone gets sick when schools reopen and are in session. See: https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/k-12-testing.html; https://www.cdc.gov/coronavirus/2019-ncov/downloads/community/School-Admin-K12-readiness-and-planning-tool.pdf

[15] See: https://www.facilitiescouncil.org/covid19-stateguidance for comparison on state by state guidance to COVID-19 school reopening.

[16] World Health Organization. Transmission of SARS-CoV-2: implications for infection prevention precautions. Scientific Brief. 9 July 2020. | COVID-19: Infection prevention and control / WASH.

https://www.who.int/publications/i/item/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations

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