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COVID-19 and School Air Quality

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The goal of COVID-19 programming in schools should be viewed as empowering the immune systems that naturally protect facility occupants. This is the governing consideration in maintaining wholesome air within the school facility.

In a way every COVID-19 preventive action, from the attempt to create a safe vaccine to social distancing and masks is based on empowering an individual's immune system to better do its job. That concept is important to keep in mind in facility maintenance efforts to protect individuals from COVID-19.

Attached to this paper is a brief description of the immune system and its relationship to SARS-CoV-2, the virus that causes COVID-19—**know your enemy and your allies**!

The spread of the COVID-19 is not like "playing tag," where one person simply touches or breathes near another. The real risk relates to **heavy burdens of exposures** of the SARS-CoV-2 virus. It is typically the heavy burden of virus washing over an immune system that creates disease. Consequently, any effort reducing the thresholds of exposure is protective. This manifests itself in personal protection, distancing policies, isolation protocols, surface hygiene, and especially securing wholesome ambient air in breathing zones.

Air Exchange

Simply upgrading the amounts or velocity of air exchange is not necessarily going to reduce exposure thresholds, or breathing zone burdens of the SRAS-Co-2 virus. Often greater acceleration of air movement creates dead air space. That occurred in some South Korean schools where dead space in the classrooms, created in part by unwise use of Plexiglas dividers, frustrated increased air exchange. The shared breathing zones combined with dense occupancy accelerated COVID-19 among students. That reliance on dividers, which impaired air exchange impacted the prevalence of SARS-CoV-2 in the classroom breathing zones and consequently COVID-19 disease within South Korea.

COVID-19 sensitive schools require a focus upon air exchange, balancing, and the nature of return and introduced fresh air.

It is important to accept the public health concept of **universal precautions**, meaning we need to operate as if every individual could "spread disease through exhaling." Unlike most viruses, including six previously identified strains of SARS, asymptomatic transfer of the virus from an apparently healthy non-symptomatic person is the primary cause of the world-wide pandemic.

A standardized review of CO_2 thresholds in a room is likely the best indicator of breathing zone safety. Although this process cannot identify the burden of SARS-CoV-2 virus CO_2

burdens indicate the probability of inhaling another person's expelled breath.

Research conducted by the Lawrence Berkeley National Laboratories, prior to the COVID-19 pandemic, established thresholds and protocols for CO_2 health-related guidelines regarding virus exposure. The research complements the recently upgraded COVID-19 sensitive school facility ASHRAE air exchange standards. The value of a CO_2 exposure benchmark is discussed later in this paper.

In addition to increasing and balancing air exchange some schools are considering or implementing the following:

- More restrictive air filtration including medical grade MERV filters and high-efficiency air purifiers (HEPAs) placed in a room to filter out virus size particulates.
- Virus neutralizing ultraviolet (UV) radiation, encased in the air handling system which would avoid direct human exposure to UV radiation.
- Needlepoint bipolar ionization, typically incorporated within the air handling system confounding the polarity of the virus and causing it to be removed through standard filtering or gravitation.

Air Filtration

Most school properties utilize air filters at a "minimum efficiency reporting value" or MERV 8 threshold. The higher the MERV rating number the tighter the weave of the fibers in the filter. Eight is typically considered optimal for schoolrooms introducing fresh air while filtering out dust mites, mold, large dust particles, bacteria, some VOCs, and inadvertent bus, car, or art kiln emissions. The MERV 8 filter will not generally filter out virus because of the small size of viruses. If the school air handling systems shift to medically standard systems with tighter weave filtration, such as MERV 13, depending on the HVAC system they may filter out most viruses but the filters may clog up quickly and become restrictive in providing fresh air. The consequence of this suspended virus in "stale air" may increase the risk of exposure as a result of decreased dilution. This air filtering challenge amid concerns for virus exposure is being addressed using several innovative technologies beyond more aggressive filtration. There is limited peer-reviewed research on effectiveness.

UV radiation and ionization, both may be of value, if used correctly, in school air handling systems but both also have limitations as well as concerns about impact.

The most obvious shortcoming is that the emissions that are placing occupants at risk emerge from people within the room, and are not brought in from outside. However, as treated air is introduced into the area it will have been sanitized by UV and/or ionization and will promote safety by diluting the burden of exposures. More aggressive filtration, UV, and ionization will not reduce the absolute necessity of personal protection, controlled hygienic behaviors, and especially distancing, but may contribute to improved ambient air.

Ultraviolet Radiation

One special limitation with UV radiation, is that while it will render any virus inert, the UV itself may be potentially harmful. Both direct contact with human tissue, especially eye tissue, is problematic as is the potential leaching of mercury if the UV placement and maintenance is not carefully managed.

Lower intensity UV systems represent a diminished risk and some UV products have either eliminated or implemented safeguards for mercury exposures. There is often a significant level of maintenance involved with UV systems incorporated within air handling structures. However, most schools maintain sophisticated maintenance personnel who quickly learn how to safely work with UV devices usually placed safely inside air handling systems. It is important to note that a new safer "222NM" UV product is being developed which may be more safely used, even inside an occupied room.

Needlepoint Bipolar Ionization

The use of needlepoint bipolar ionization represents new use of an old and well-established technology for eliminating many particulates. There is limited academically published research regarding ionization impact on viruses in buildings. There is substantial data regarding safe and successful use in airplane cabins and some proprietary industrial research supporting safe and effective use. However, AARP has labeled the use of ionization systems as of unproven value in impacting viruses.

The ionization process involves removing the polarizing charge inherent within the virus and its constituent molecules. This causes the virus and the water molecules in which the virus is typically encased to essentially cluster, becoming enlarged and heavier. Consequently, they either drop out of ambient air or are filtered out of breathing zones through the standard MERV 8 filter. The ionization process enables the standard filtering/air exchange, typical in a school or office building, to capture and neutralize viruses while maintaining quality air exchange.

Some hybrid air handling systems provide a combination of UV radiation and bipolar ionization.

There is limited published data on how these systems ultimately safeguard occupants, but it seems obvious that introducing virus free air would decrease the inhaled burden of SARS-CoV-2 virus through dilution. Emissions from area occupants would continue, so protective safeguards and behaviors must remain in place.

Perhaps the most important aspect of air handling within the school is thoughtful and well-informed facility maintenance leadership. They must remain sensitive to rapidly emerging research and consequently best practices for securing safe ambient air.

COVID-19 Procedures and Products

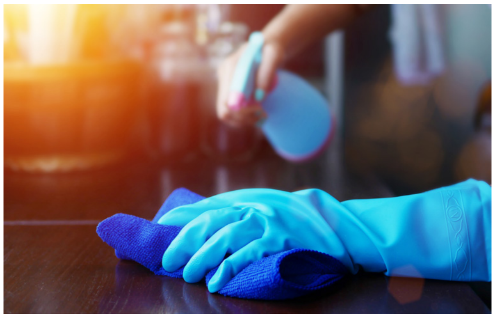
Understandably, with the destabilizing pandemic different, and sometimes unproven and ultimately unwise, procedures and products are being introduced. The following describes the value and potential risk of several safeguards, as we currently understand them.

Cloth Facemasks and Distancing

Some individuals have concerns regarding facemasks providing only limited value because the physical dimensions of the SARS-CoV-2 virus could technically penetrate most commercial facemasks. There is solid research substantiating that responsibly produced non-N95 facemasks will filter and limit the spread of virus emissions, as well as prevent some exposure through inhalation. The virus may be small relative to mask weave, but in order to represent a serious risk the virus must be surrounded or encased by water molecules. This means the configuration of molecules that most likely represent a risk have a size and dimension likely to be significantly restricted with the use of a mask.

Substantial research makes it absolutely clear that responsibly produced and correctly worn commercial facemasks filter and reduce burdens of SARS-CoV-2 being both exhaled and inhaled.

The value of distancing has not been seriously questioned. Standards for distancing have typically ranged from a little over 3 feet (one meter) to 6 feet. The general rule is the more distance the better. The population density, activities, and breathing zone dilution would impact guidelines for distancing. This means that in the dimensions of the occupied area, activities related to respiration and quality of the air exchange impact preferable distancing guidelines. Good judgment and common sense are factors in distancing decisions. Obviously outdoors represents an inherently safer environment.



Fomite Transmission of Often Touched Surfaces

It was initially assumed that because the SARS-CoV-2 virus could typically survive on a smooth surface for a period of time, following respiratory secretions through breathing or hand to mouth touching, hygienic cleaning of surfaces would prevent significant transmission. This is termed fomite transmission and inspired an aggressive focus on hygienic scrubbing down and disinfecting smooth surfaces. Today we understand that while often touched surfaces, such as doorknobs or railings should be hygienically cleaned **the virus is not primarily spread through contaminated surfaces**. Fomite transmission should be controlled through general hygiene but the focus for prevention must relate to controlling airborne emissions and inhalation. For reference the following Lancet medical journal can be located online:

Goldman E, Exaggerated risk of transmission of COVID-19 by fomites, Lancet Infect Dis. 2020 (published online), ***https://doi.org/10.1016/S1473-3099(20)30561-2***.

Spraying Disinfectants in Occupant Breathing Zones

This is a universally bad and often dangerous procedure. Disinfectants can be rubbed on smooth surfaces in rooms that are not occupied to reduce potential exposure but they should never be released to essentially disinfect breathing zones. The possibility of inhalation of disinfectant represents an inherent risk.

Plastic Face Shields

The Centers for Disease Control has made it clear that plastic, open bottomed, transparent face shields are of limited value regarding airborne SARS-CoV-2 virus. They are recommended for use only if there are likely bodily fluid exposures, specifically blood splatter. They represent unquestioned value in preventing exposures from blood-borne pathogens but not from airborne virus.

Although not well documented, there is concern among some public health professionals that the negative air pressure created inside the face shield cavity following inhalation may create a negative air vacuum. The result may be enhanced exposures to any virus in surrounding ambient air through the open bottom on the mask. Essentially, under the right conditions the face shield may potentially increase risk of viral exposure. If a plastic face shield is worn, it would be advisable to also wear a facemask.

Adenosine Triphosphate (ATP) Readings

There are available handheld devices which allow cloth wipe samples to be drawn from surface areas, immediately providing readings regarding the “general hygiene” of the surface. These are accurate and valuable devices providing responsible feedback identifying the effectiveness of aggressively wiping down a surface regarding mold, and bacteria. They are unlikely to provide meaningful information regarding viruses and the readings may be misinterpreted.

In some cases, they have been used to provide building occupants with unreliable numerically based assurances of safety regarding COVID-19 prevention.

These ATP devices are properly promoted as rapidly and correctly identifying levels of bacteria and other contaminating properties, but a virus, such as SARS-CoV-2, typically leaves no trace of ATP which is the basis for detection.

Adenosine Triphosphate (ATP) presence is vital for normal life forms, enabling them to convert energy into life functions. By most biochemical definitions a virus is inert and non-living because it does not contain ATP. Consequently, numerical reading of the wipe sample may have no direct relationship to the presence of SARS-CoV-2 and subsequent COVID-19 related risks.

A case could be made that if one detects that surface bacterial contamination has been diminished it is probable that the same surface cleansing chemical and cleaning process eliminated surface virus burden. However, the conditions under which a bacteria thrives—moisture, warmth, and stagnation—are presumably the converse of the conditions under which SARS-Co-V-2 can thrive—cool, dry, and airborne.

Providing reassuring numbers from a wipe sample registering ATP may be dangerously misleading.

Humidification

We presently have limited research regarding the relationship of humidity to COVID-19, although there are indications that comfortably humid ambient air will reduce the possibility of person-to-person exposure.

The more aggressive spreading of viruses in colder temperatures has often been assumed to relate singularly to more indoor person-to-person interaction. However, recently there has been speculation that the spread of viral contamination also may relate to naturally dryer ambient air, consistent with cooler climates. Expelled air from a contaminated person will spread faster and remain suspended for a longer period of time within shared breathing zones under cold and dry conditions.

It seems responsible to recommend that relative humidity in enclosed areas, especially during cooler temperatures, be maintained between 40% and 50%. The simple fix would involve installing a room humidifier or adjusting or upgrading the HVAC systems. Neither option would be expensive nor difficult to maintain.

Monitoring Carbon Dioxide Thresholds

In 2002 the Lawrence Berkeley National laboratory completed a public health and academically well regarded analysis of the relationship between the carbon dioxide (CO_2) burdens in buildings and the prevalence of certain viral based mucous membrane and lower respiratory illnesses among building occupants. Essentially, they measured the average burdens inside buildings versus outdoor CO_2 concentrations using 1000 ppm as a base. In their analysis of 41 buildings they found there was a consistent increase in incidents of viral disease calibrated at higher thresholds per 100 ppm CO_2. In other words, reduced CO_2 levels equated with proportionally reduced viral disease.

This research finding was pre-COVID-19 and no specific calibration has been published to date on SARS-CoV-2. However, based on the well-documented increase in influenza (a virus) in high human density properties, school facility managers should consider monitoring CO_2 thresholds within potentially higher risk school areas.

If one assumes applying the medical definition of universal precautions, in which every individual is assumed to place another individual in close proximity at risk, monitoring and controlling the CO_2 thresholds makes sense. Technically a dCO_2 reading, meaning the variation between outside and inside CO_2 burdens, would be of significant value in calibrating the potential risk within a room.

A paper describing this process, *Benchmarking School COVID-19 Risk through Differential Carbon Dioxide* is located on our website.

Conclusion

Since the initial detection of COVID-19 we have learned a great deal in identification, treatment and prevention. We remain on an accelerating and vital learning curve. These papers attempt to provide guidance to those managing school policy and property, taking into consideration what we presently understand and suspect. It is critical that lines of communication regarding evolving public health findings and school policy be maintained and contribute to school facility best practices.

