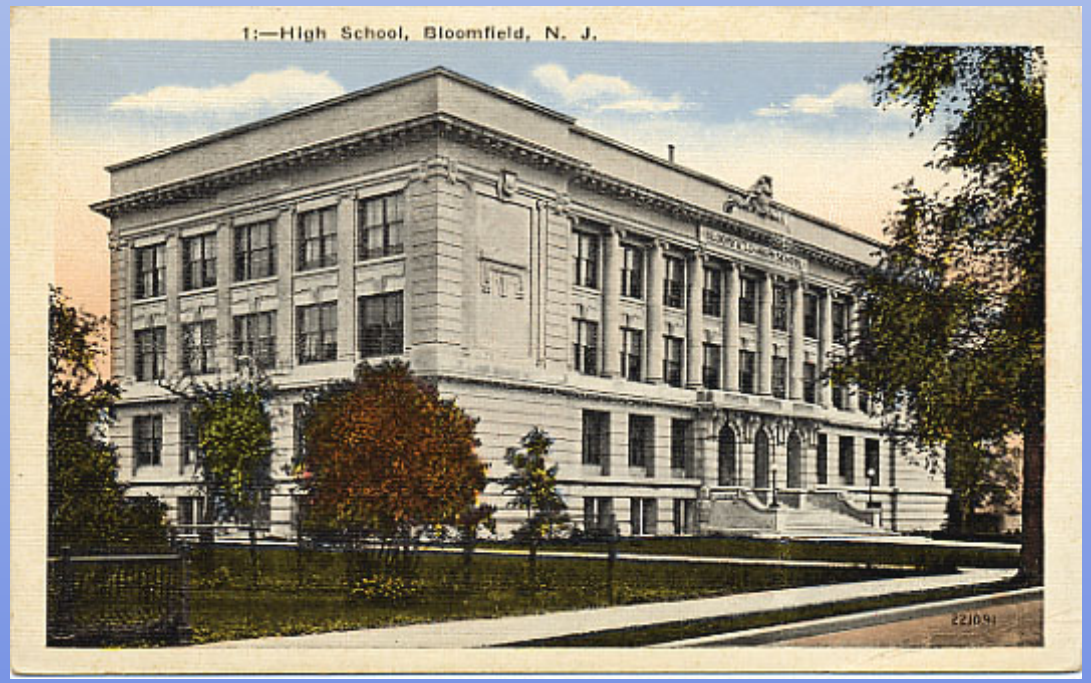
Ventilation for Healthy Buildings



Bloomfield High School, 1911

Allen Barkkume, MS – WEC Industrial Hygienist

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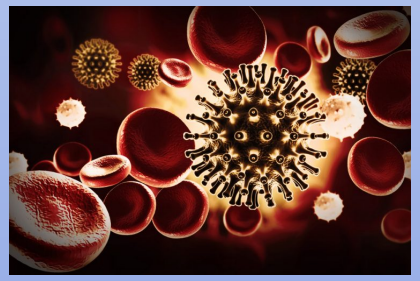
Exposure Science – The Basics



Risk?

Intensity x Duration

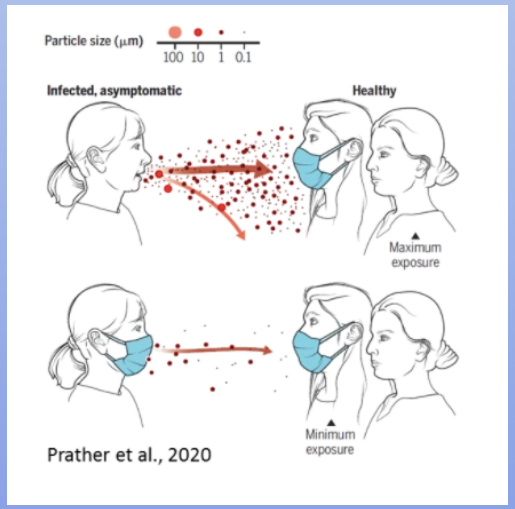
Extended contact (15 minutes or greater) with potentially infectious individuals increases the risk of COVID-19 spread.

-CDC, Close Contact Definition, Dec 3 2020 [link]

Exposure / Transmission

Droplet – larger droplets, settle quickly; social distance
Surface – doorknobs, contaminated surfaces; wash hands
Aerosol – smaller, stays in the air, accumulates over time; ventilate

**Risk increases with age, asthma, obesity, diabetes, other diseases.*
**Risk increases with distance for all routes of transmission.*
**Risk outdoors is low.*



Controls for Risk Reduction

Reduce occupancy, density, intermixing
Wash hands (remove contaminants)
Increase Ventilation (exhaust and dilute contaminants)

**Bathrooms: bioaerosolization via virus shedding in feces, unlikely route of transmission.*

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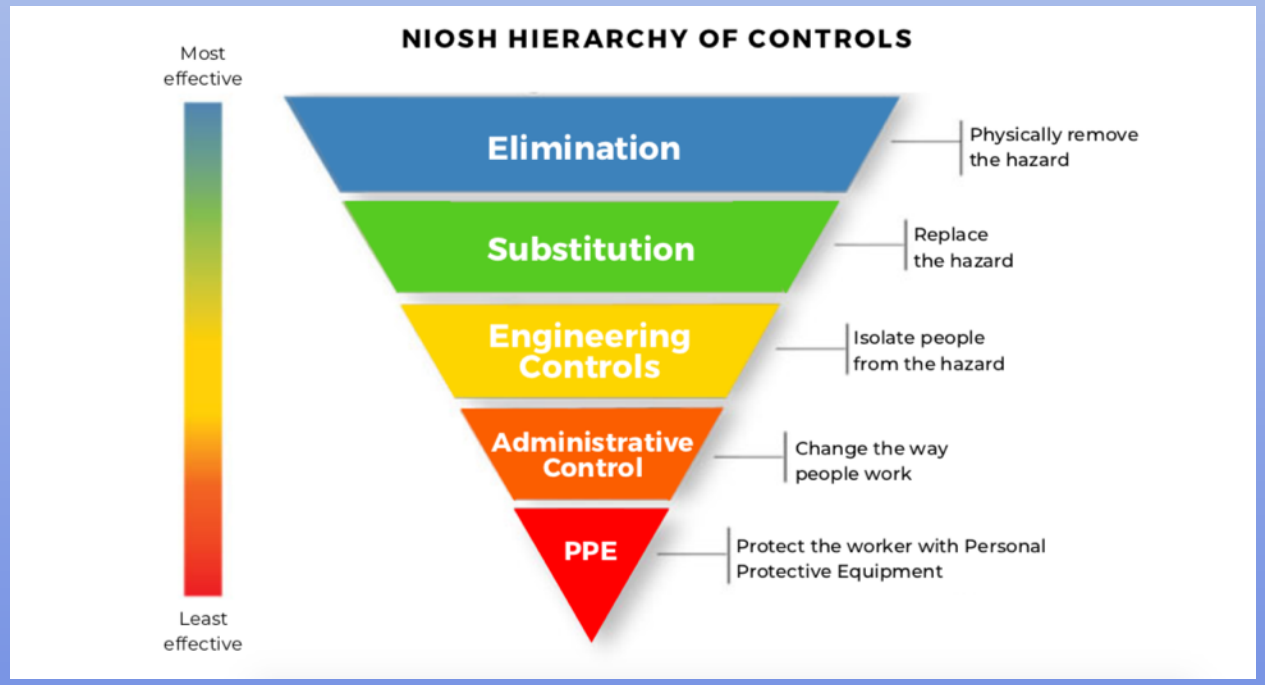
The Hierarchy of Controls

Prioritizing Risk Management

- The National Institute of Occupational Health and Safety hierarchy of controls is a framework for protecting **workers and all building occupants** from recognized hazards.
- The risk of infection by SARS-CoV-2 (the virus that causes COVID-19) can be mitigated **most effectively by eliminating the presence of infected individuals** in the building through stringent security controls.
- The next most effective means of reducing hazards is typically to **replace** the hazard, although in the case of infectious disease, this level of control does not apply.
- An example of using **engineering** controls would be to maximize the introduction of outdoor air for ventilating the building.
- **Administrative** controls could include staffing or scheduling modifications, or clear communications with parents and the community on proper isolation criteria.
- Finally, personal protective equipment (**PPE**) can also be made available, although it should be considered that relying on PPE to reduce the risk is a control method of last resort.



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Surface Transmission vs. Cleaning Products

Know the Rules

- Cleaning staff MUST be trained and provided necessary PPE.
- Children cannot use – registered as pesticides (EPA)
- Staff cannot bring their own – hazard communications right (PEOSH)
- Cleaning with soap and water is NOT the same as applying disinfectant (pesticides).
- Establish written procedures.

Use Targeted Disinfecting Only



- Disinfectants are overused and misused.
- Contains ingredients that can trigger asthma and adverse health effects.
- False sense of security when not used according to instructions.

Safer Disinfectants [link]

- Ethanol (regular alcohol)
- Isopropanol (rubbing alcohol)
- Hydrogen peroxide
- L-Lactic acid
- Citric acid

De-prioritized:

”This isn’t thought to be the main way the virus spreads.”
-*CDC Update, May 22, 2020.* [link]

<u>Ventilate while cleaning!</u>

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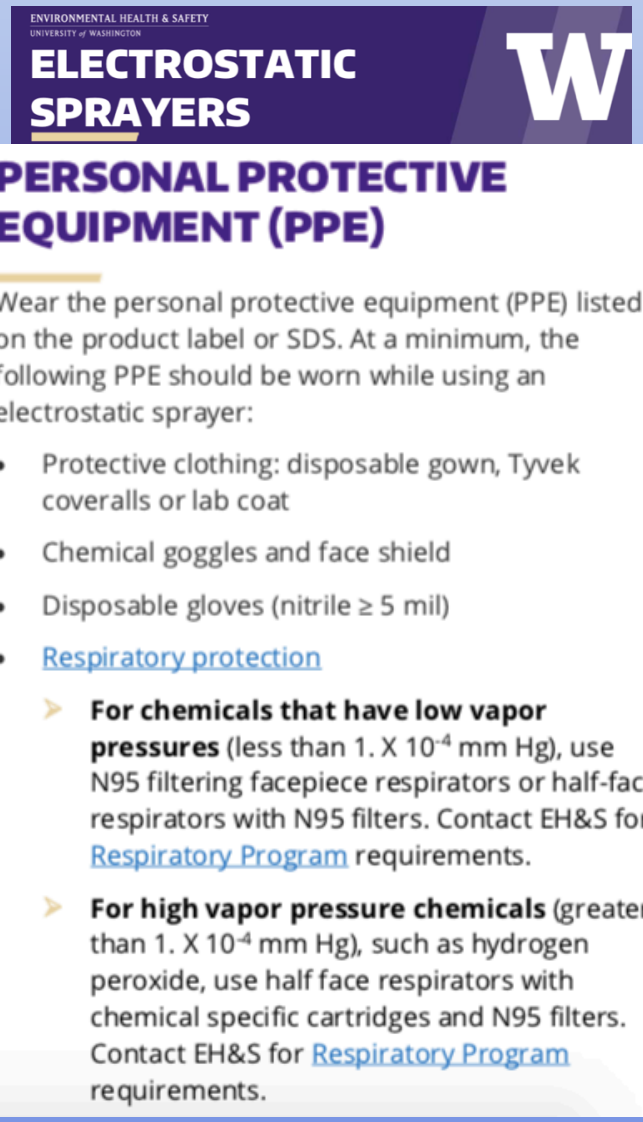
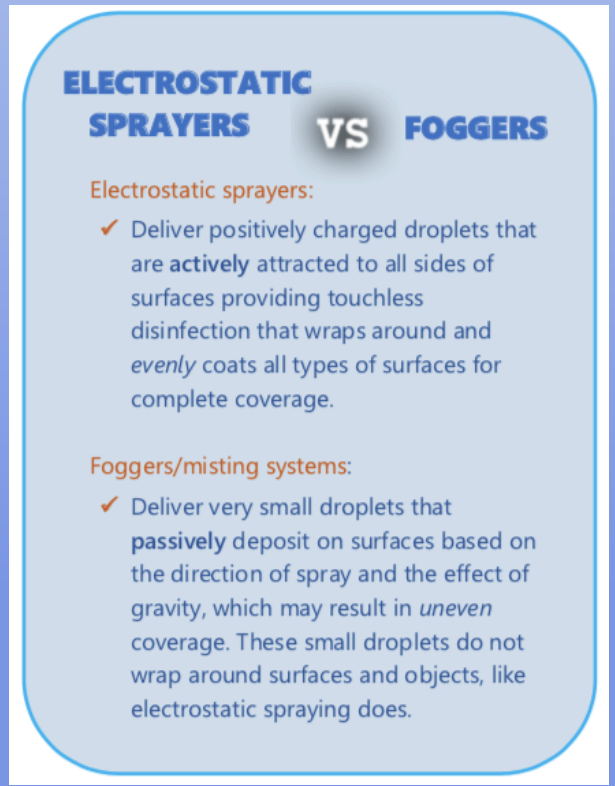
Electrostatic Sprayers vs Foggers



-University of Washington, Electrostatic Sprayer Fact Sheet, Dec 2020 [pdf]

-New Jersey Department of Environmental Protection, Fogging/Misting Systems Using Disinfectants/Sanitizers as a COVID- 19 Treatment Not permissible for Human Exposure, October 5 2020. [pdf]



-New Jersey Department of Health, Disinfectant Use Indoors Fact Sheet, Jan 2021 [pdf]

NJ PEOSH Law:

- Each employee must be trained.
- Provide training on hazardous chemicals.
- Use a technically qualified person.
- Maintain records.

-PEOSH Hazard Communication Standard, N.J.A.C. 12:100-7.8 [link]

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The New York Times

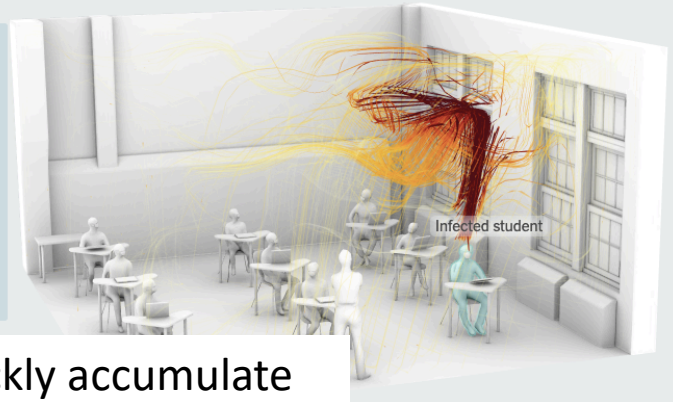
Why Opening Windows Is a Key to Reopening Schools

https://www.nytimes.com/interactive/2021/02/26/science/reopen-schools-safety-ventilation.html

By Nick Bartzokas, Mika Gröndahl, Karthik Patanjali, Miles Peyton, Bedel Saget and Umi Syam Feb. 26, 2021

SCENARIO 1
Window closed

While we still do not know exactly what level of contamination presents the greatest risk of infection, "exposure is a function of concentration and time," said Joseph G. Allen, the director of the Harvard Healthy Buildings program and an environmental health expert.

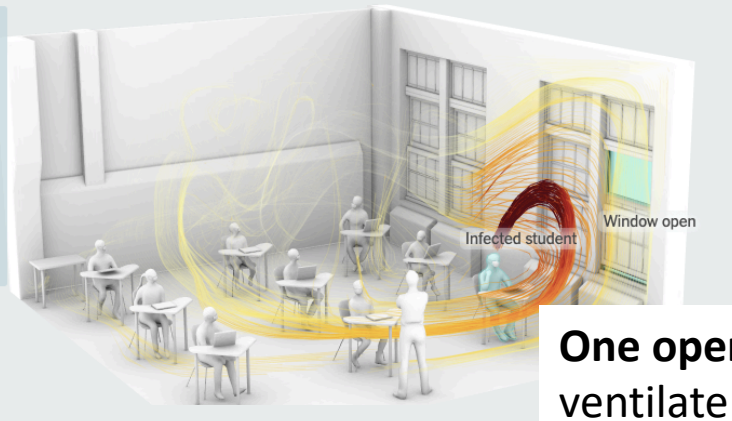


Bad air can quickly accumulate with **no ventilation**.

Within a short time, the room approaches its peak level of contamination. With little fresh air coming into the space, the contaminants continue to circulate throughout the room.

SCENARIO 2
Window open

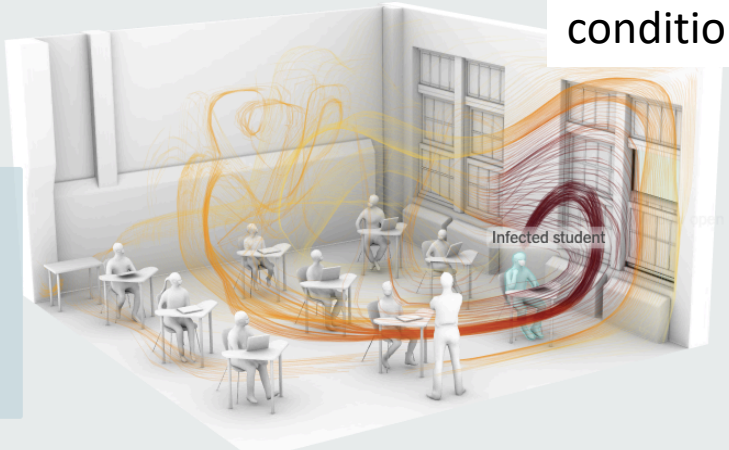
The fresh air dilutes the contaminants as they move around the room. "Simple and inexpensive measures can make schools much safer," said Scott E. Frank, whose engineering firm JB&B assisted with these simulations.



Concentration of contaminants
More

One open window can ventilate a room, but depends on weather conditions

We managed to achieve four total air exchanges by opening just one window in this simulation, which was dependent on specific weather conditions. To get to six air exchanges, we will have to do more.



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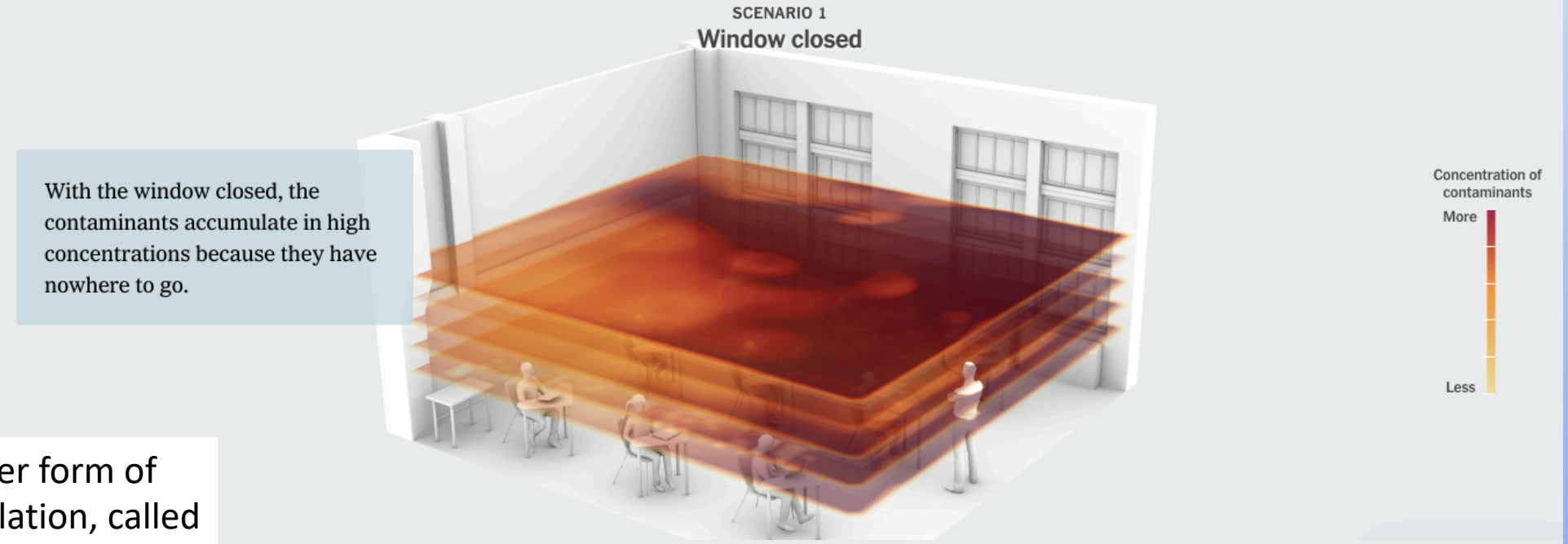
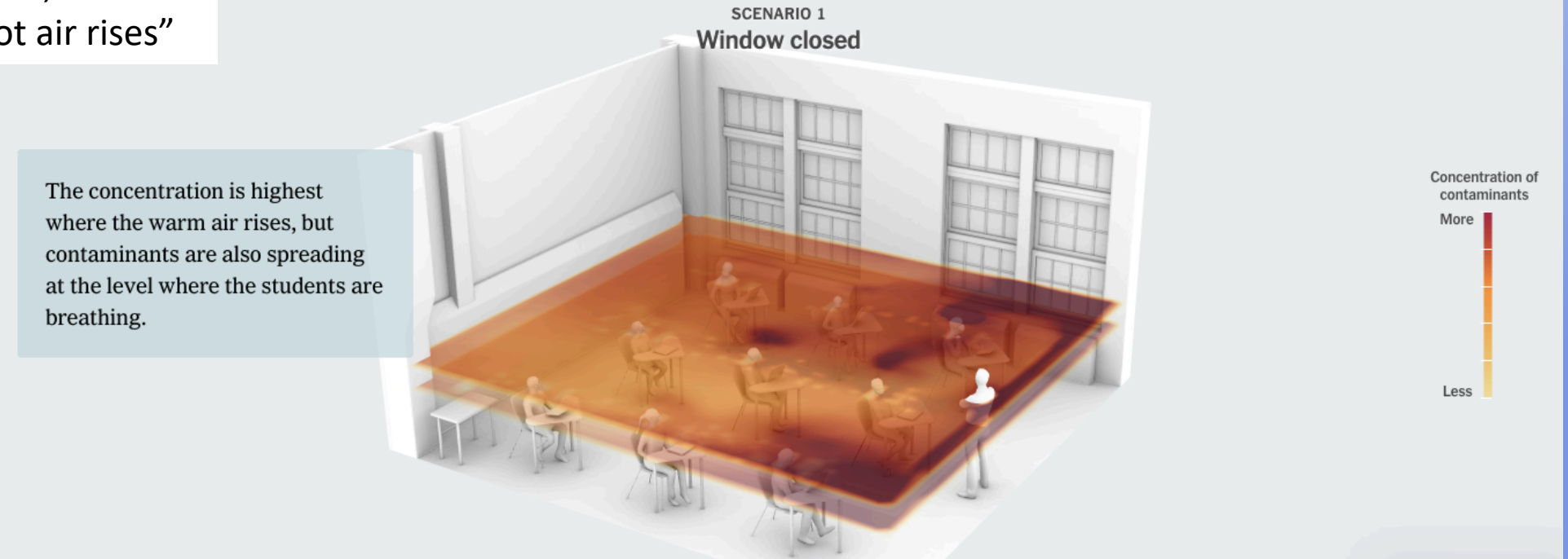
This is another form of natural ventilation, called the **stack effect**, also known as “hot air rises”





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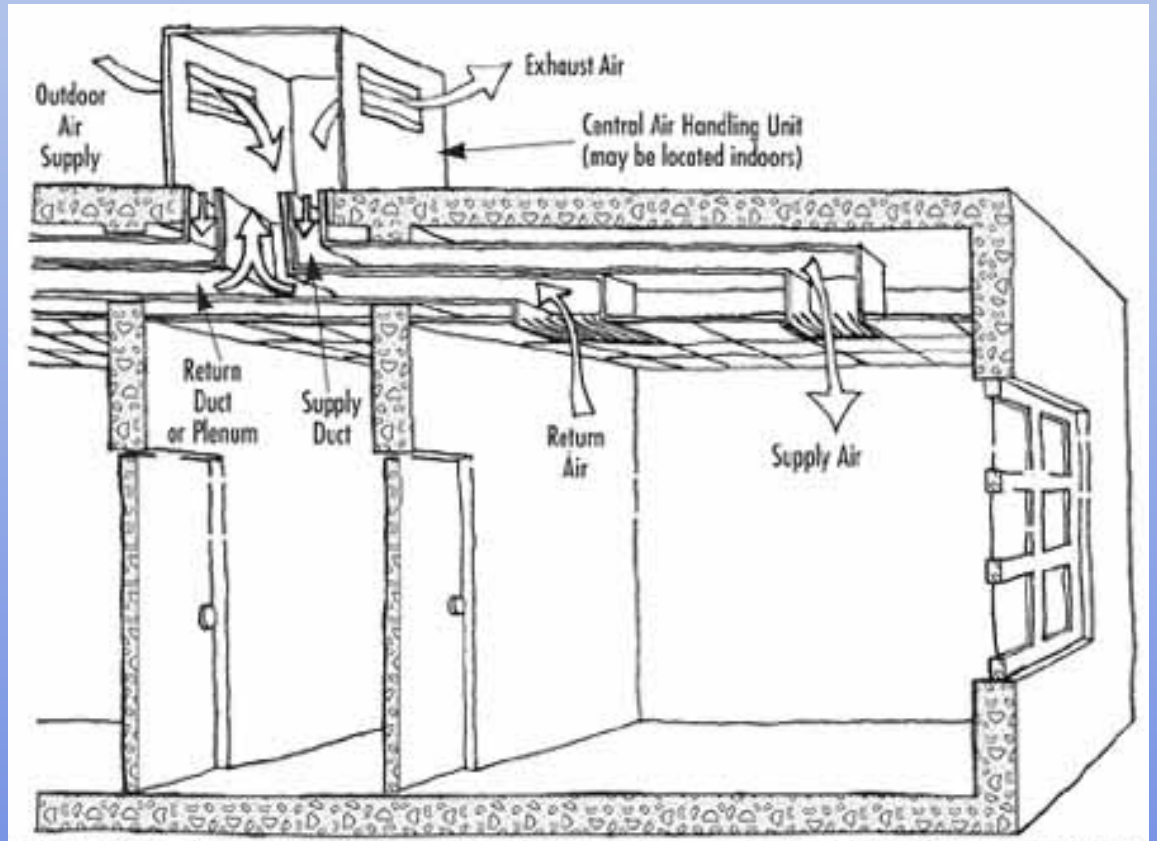
Adequate Ventilation?

- Bring in fresh outdoor air
- Mix this with used indoor air
- Distribute the mixed air
- Exhaust some used air



How Outdoor Air is Supplied in a Central Air Handling System.

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Ventilation Controls for Aerosol Transmission

Ventilation Controls

- Exhaust
- Dilute
- Filter
- (Supplement)

Enforceable Standards

- ASHRAE Standards are the bare minimum and for buildings with existing HVAC systems
- ASHRAE Standards are engineering-based but not health-based
- NJ PEOSH IAQ Standard must have written plan and maintenance log [link]
- California OSHA Aerosol Transmissible Disease Standards for health care workers [link]

New Jersey Department of Health - Tips to Improve Indoor Ventilation [link]

- Increase ventilation through windows, doors and fans
- Improve building-wide filtration
- Optimize HVAC settings
  - Operate continuously and not only according to temperature
  - Operate at least 2 hours before and after occupancy

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Beware of Electronic Air Cleaners

- Bipolar Ionizers, Hydroxyl Generators, etc.
- Does not perform as marketed (when tested independently)
- Produces unintended byproducts (which could be a health concern)

Johns Hopkins, Aug 2021 - "**DO NOT USE unproven technologies** such as ozone generators, ionization, plasma, and air disinfection with chemical foggers and sprays." [link]

NJDOH, Aug 2021 - "It is critical to note **there is no scientific consensus** on the effectiveness of all the electronic technologies that claim to reduce virus concentrations under normal building conditions." [link]

- **Use a HEPA filtration unit instead**

National Institute of Environmental Health Sciences - Selection and Use of Portable Air Cleaners to Protect Workers from Exposure to SARS-CoV-2 - Jun 2021 [link]

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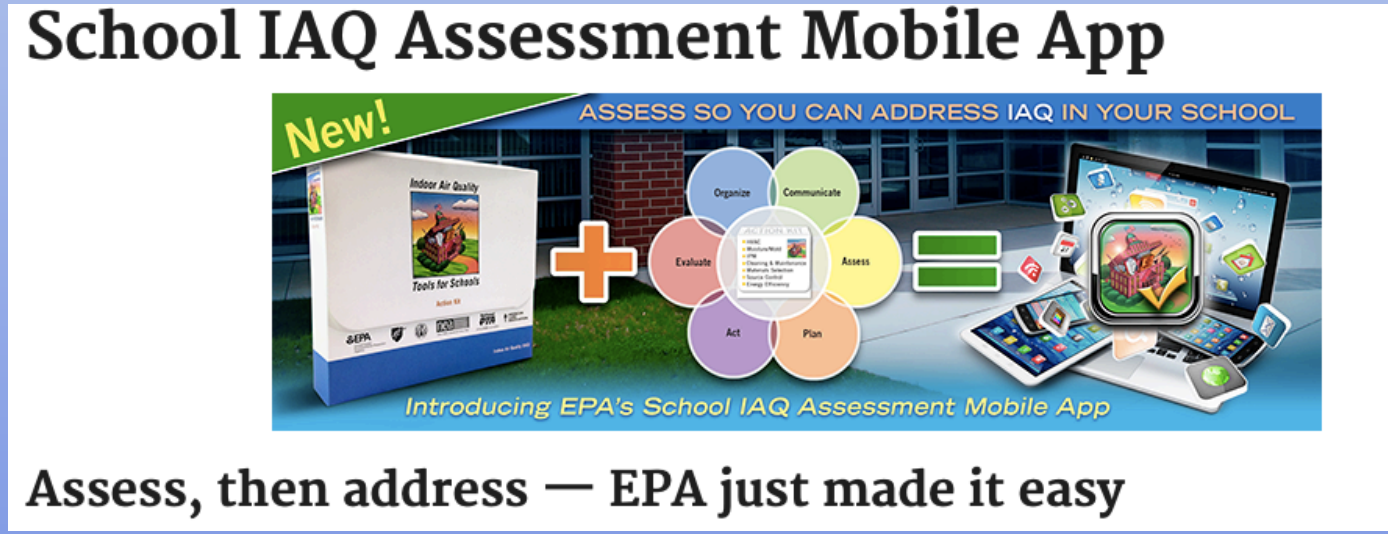
Use EPA Tools for Schools Checklists

1. Teachers
2. Administrators
3. Nurses
4. School officials
5. Building maintenance
6. Food service
7. Waste management
8. Ventilation
9. Renovation and repairs
10. Walkthrough inspections
11. Pest management

[link]



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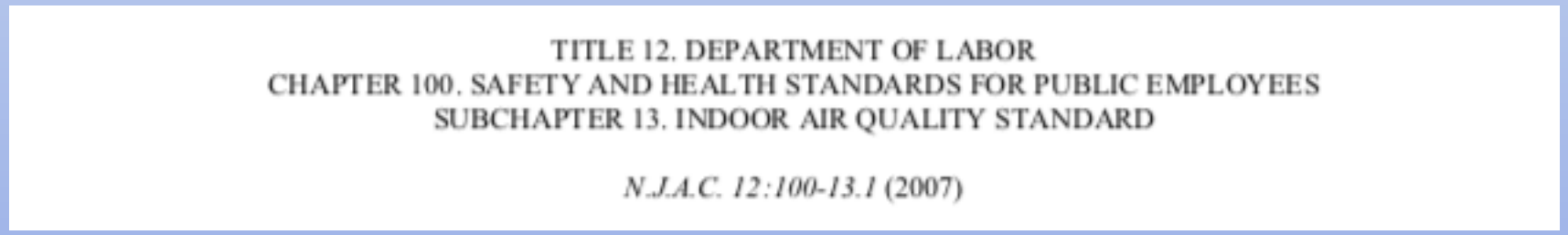
PEOSH 2007 IAQ Standard



TITLE 12. DEPARTMENT OF LABOR
CHAPTER 100. SAFETY AND HEALTH STANDARDS FOR PUBLIC EMPLOYEES
SUBCHAPTER 13. INDOOR AIR QUALITY STANDARD

N.J.A.C. 12:100-13.1 (2007)

- Designated person
- Written IAQ program
- Mold clean-up
- Check HVAC if
  - Carbon dioxide exceeds 1,000 ppm
  - Temperatures out of range of 68 to 79
- HVAC maintenance records
- Isolate renovations

[link]

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Beware the “Clean Bill of Health”

- “No violation of PEOSH Standards were found”
- “All samples were within legal limits”
- Can pull the rug out from under your efforts
- Can make the school look healthy when it isn’t

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Carbon Dioxide in Air

- Meter costs about $120 – $1,200
- Carbon Dioxide levels show whether enough outdoor air is supplied.
- Levels must be measured after 4 hours of continuous occupancy.
- Interpretation of levels
  - Background – 350 to 500
  - No problem – 600
  - Possible problem – 800
  - More outdoor air needed – 1,000
  - *Measured in parts per million parts (ppm)*

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Tissue Test

- Shows “yes” or “no” airflow and direction of flow.
- Tape to a stick for ceiling vents.

Image credit: NJEA Review, “Activism Gets Results”, Jan 2021

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Resources

CDC – Ventilation in Buildings – June 2 2021

https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html

CDC MMWR - Guidance for Implementing COVID-19 Prevention Strategies in the Context of Varying Community Transmission Levels and Vaccination Coverage - July 27 2021

https://www.cdc.gov/mmwr/volumes/70/wr/pdfs/mm7030e2-H.pdf

American Conference of Governmental Industrial Hygienists (ACGIH) - COVID 19 Resources - May 2021

https://www.acgih.org/covid19/

ASHRAE Journal - Guidance for Building Operations During the COVID-19 Pandemic - May 2020

https://www.ashrae.org/file%20library/technical%20resources/ashrae%20journal/2020journaldocuments/72-74_ieq_schoen.pdf

CalOSHA Aerosol Transmissible Disease Standards

https://www.dir.ca.gov/title8/5199.html

New Jersey Department of Health - Tips to Improve Indoor Ventilation - Aug 2021

https://www.state.nj.us/health/ceohs/documents/ceohs%20content/NJDOH_Ventilation_Indoor_Spaces.pdf

New Jersey Public Employee (PEOSH) Indoor Air Quality Standard

https://www.state.nj.us/health/workplacehealthandsafety/documents/peosh/iaqstd.pdf

American Industrial Hygiene Association (AIHA) - AIHA - Joint Consensus Statement on Addressing the Aerosol Transmission of SARS CoV-2 and Recommendations for Preventing Occupational Exposures - Feb 2021

https://aiha-assets.sfo2.digitaloceanspaces.com/AIHA/resources/Fact-Sheets/Joint-Consensus-Statement-on-Addressing-the-Aerosol-Transmission-of-SARS-CoV-2-Fact-Sheet.pdf

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Resources for Electronic Air Cleaners

News Articles:

- Kaiser Health News - Government Oversight of Covid Air Cleaners Leaves Gaping Holes - July 12 2021 [link] https://khn.org/news/article/government-oversight-of-covid-air-cleaners-leaves-gaping-holes/
- Kaiser Health News - Boeing Tested Air Purifiers Like Those Widely Used in Schools and It Decided Not to Use Them in Planes - June 8 2021 [link] https://khn.org/news/article/boeing-tested-air-purifiers-like-those-widely-used-in-schools-it-decided-not-to-use-them-in-planes/
- Kaiser Health News - As Schools Spend Millions on Air Purifiers, Experts Warn of Overblown Claims and Harm to Children - May 3 2021 [link] https://khn.org/news/article/as-schools-spend-millions-on-air-purifiers-experts-warn-of-overblown-claims-and-harm-to-children/
- Medium - Open Letter to address the use of Electronic Air Cleaning Equipment in Buildings - April 12 2021 [link] https://medium.com/open-letter-to-address-the-use-of-electronic-air/no-to-ionizers-plasma-uvpco-bc1570b2fb9b
- Colorado Sun - We Need Safer Air in Colorado's Schools — But Let's Be Careful How We Get There - April 23 2021 [link] https://coloradosun.com/2021/04/23/safer-air-schools-opinion/
- Francis Offermann - Beware The COVID-19 Snake Oil Salesmen Are Here - Nov 2020 [link] http://www.iee-sf.com/pdf/TheCOVID19SnakeOilSalesmenAreHere.pdf.new
- Mother Jones - Are Schools' Fancy New Air-Scrubbing Devices Really Effective and Safe - April 2021 [link] https://www.motherjones.com/coronavirus-updates/2021/03/covid-air-cleaning-filter-delphine-farmer/
- Mother Jones - Hundreds of Schools Are Using This Air Purifier to Fight COVID. A Lawsuit Says It Releases Toxic Chemicals - May 2021 [link] https://www.motherjones.com/coronavirus-updates/2021/05/covid-school-air-purifier-lawsuit-gps-toxic/
- Montclair Local - Parents Tell Montclair District We're Worried New Air Cleaners Aren't Safe - April 22 2021 [link] https://www.montclairlocal.news/2021/04/22/parents-tell-montclair-district-were-worried-new-air-cleaners-arent-safe/

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Resources for Electronic Air Cleaners

Scientific Studies:

- Unintended Consequences of Air Cleaning Chemistry. Douglas B. Collins and Delphine K. Farmer. Environmental Science & Technology Article ASAP. DOI: 10.1021/acs.est.1c02582. https://pubs.acs.org/doi/10.1021/acs.est.1c02582

Environmental scientists have, for many years, worked through case studies where the use of chemicals outpaced a full understanding of their safety, resulting in serious negative ecological and/or health outcomes (e.g., DDT, chlorofluorocarbons, perfluoroalkyl substances). Using the precautionary principle is prudent: unnecessary use of chemical products and reactive processes should be avoided until the broader environmental and health impacts of such interventions are understood.

In the case of air cleaning technologies, decades of fundamental indoor and outdoor atmospheric chemistry knowledge provides a strong footing. The field lacks sufficient scientific information to arrive at a comprehensive, fully quantitative assessment of byproduct formation from many air cleaning technologies.

- Evaluating a commercially available in-duct bipolar ionization device for pollutant removal and potential byproduct formation, Zeng et al, Building and Environment, March 2021. https://www.sciencedirect.com/science/article/pii/S036013232100158X#!

Both the chamber and field tests suggested that the use of the tested bipolar ionization unit led to a decrease in some hydrocarbons (e.g., xylenes) among the lists of compounds we were able to target, but an increase in others, most prominently oxygenated VOCs (e.g., acetone, ethanol) and toluene.

Ionizer operation appeared to minimally impact particle, O3, and NO2 concentrations during normal operating conditions. Particle injection and decay experiments in the chamber suggest that operation of the ionizer unit led to a small increase in loss rates for ultrafine particles (<0.15 µm) and a small decrease in loss rates for larger particles (>0.3 µm), but with negligible net changes in estimated PM2.5 loss rates.

- Negative ions offset cardiorespiratory benefits of PM 2.5 reduction from residential use of negative ion air purifiers. Wei Liu, Jing Huang, Yan Lin, Chaorui Cai, Yan Zhao, Yanbo Teng, Jinhan Mo, Lijun Xue, Li Liu, Wei Xu, Xinbiao Guo, Yinping Zhang, Junfeng Jim Zhang. Indoor Air 2020 August 5. DOI: 10.1111/ina.12728. https://pubmed.ncbi.nlm.nih.gov/32757287/

Our findings suggest that negative ions, possibly along with their reaction products with the room air constituents, adversely affect health. The downsides do not support the use of NIAPs as a health-based mitigation strategy to reduce PM2.5 exposure, especially in residences with PM2.5 concentrations that are not extremely high.

- Taekyu Joo et al, Formation of Oxidized Gases and Secondary Organic Aerosol from a Commercial Oxidant-Generating Electronic Air Cleaner, Environmental Science & Technology Letters (2021). DOI: 10.1021/acs.estlett.1c00416. http://dx.doi.org/10.1021/acs.estlett.1c00416

Ng's study found that in the process of cleaning the air, the hydroxyl radicals generated by the device reacted with volatile organic compounds present in the indoor space. This led to chemical reactions that quickly formed organic acids and secondary organic aerosols that can cause health problems. Secondary organic aerosols is a major component of PM2.5 (particulate matter with a diameter smaller than 2.5 mm), and exposure to PM2.5 has been associated with cardiopulmonary diseases and millions of deaths per year.

Older Studies:

- Jiang S-Y, Ma A, Ramachandran S. Negative Air Ions and Their Effects on Human Health and Air Quality Improvement. International Journal of Molecular Sciences. 2018; 19(10):2966

- Young C, Zhou S, Siegel J, Kahan T. Illuminating the dark side of indoor oxidants. Environ. Sci.: Processes Impacts. 2019;21:1229-1239

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