Ventilation and IAQ in US Schools: Systems, Strategies and Extreme events

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1

US School Ventilation

Minimum air flow requirements
- for classrooms: 5 L/s/person + 0.6 L/s/m^2
- for lecture halls: 3.8 L/s/person + 0.3 L/s/m^2
- for art classrooms: 10 L/s/person + 0.9 L/s/m^2 + 3.5 L/s/m^2 exhaust
- Woodwork shop: 2.5 L/s/m^2 exhaust

Minimum filtration:
- MERV 6
- MERV 11 in locations where outdoor PM2.5 exceeds guidelines:
  - 1 year 9 µg/m^3
  - 24 Hours 35 µg/m^3

ANSI/ASHRAE Standard 62.1-2022
(Supersedes ANSI/ASHRAE Standard 62.1-2019)
Includes ANSI/ASHRAE addenda listed in Appendix Q

Ventilation and Acceptable Indoor Air Quality

See Appendix Q for approval dates by ASHRAE and the American National Standards Institute.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE® website (www.ashrae.org/continuous-maintenance).

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 ISSN 1041-2336

2

US School Ventilation: Typical Systems

3

US School Ventilation: "Temporary" Classrooms

4

US School ventilation

- Recent study (Chan 2020)
  - 104 classrooms in 11 schools with recent retrofitted HVAC
  - Average about 5 L/s* (ASHRAE 62.1 requires about 7 L/s minimum)
  - Majority of systems better than MERV 6 minimum: but mostly past end of service life
  - 74 units ventilation cooling (Economizer in the US) – 25 with CO_2 monitoring and control
  - Underventilation from:
    - Incorrect equipment or installation
    - Incorrect control settings
    - Lack of commissioning
    - Lack of maintenance (overloaded filters)

* estimated from measued CO_2 and assumed emission rates

US School ventilation: CO_2

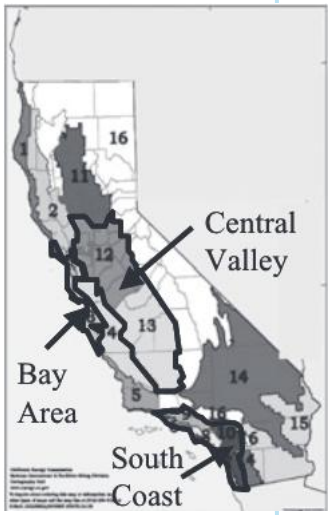
104 classrooms (Chan 2020)
Fraction of Time above 1100 ppm
Each bar one classroom

- Highly variable results….

US School ventilation: CO_2

Mendell 2013: 160 California classrooms:

- Mean CO_2 1350-2490 ppm depending on school district - implied ~ 4 L/s ventilation rate
- 61 – no mechanical systems – open windows only
- Increasing classroom ventilation rates from the California average to the State standard would decrease absence by 3.4%, increase attendance-linked funding* to schools by $33 million annually, and increase costs by only $4 million.



* Because schools are only paid for students that are present

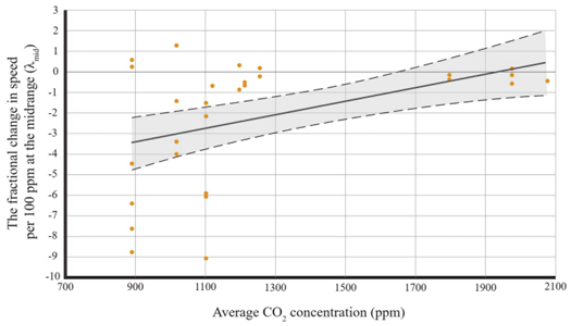
7

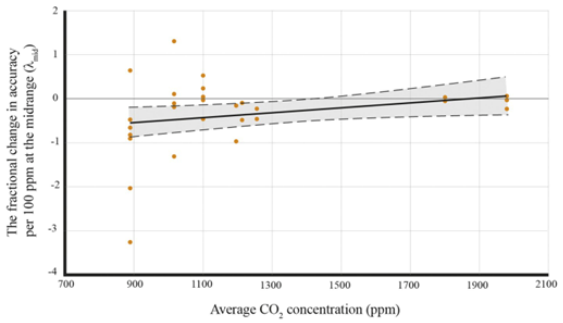
School ventilation: CO_2

More ventilation and lower CO_2 associated with better student performance in some (but not all) studies

Wargocki 2019 summary

>760 schools, >2,000 classrooms, and over 15,000 subjects





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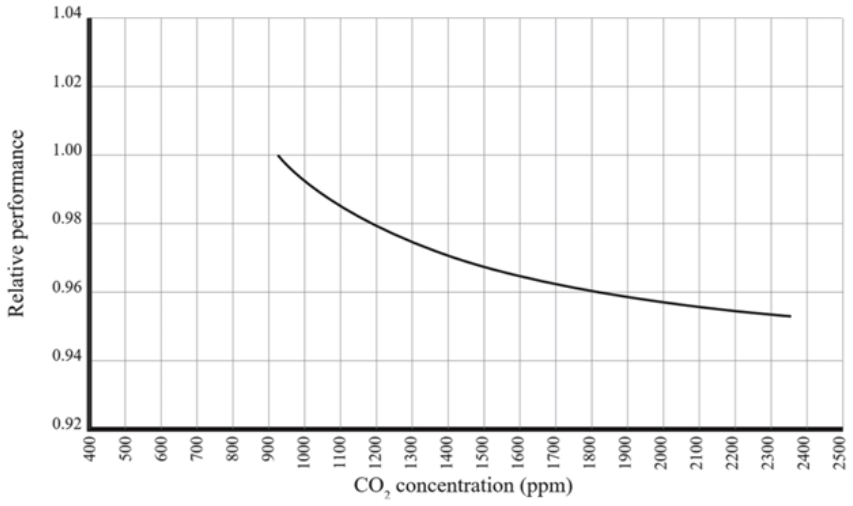
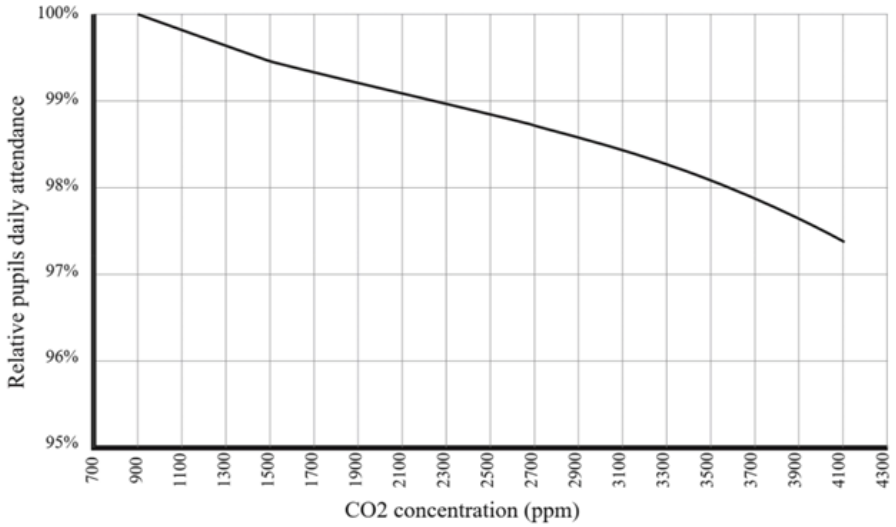
School ventilation: CO_2



Wargocki 2019 summary

School ventilation: CO_2



Wargocki 2019 summary

Other Contaminants are low (below IAQ guideline thresholds)

- VOCs, PM2.5, NOx, Ozone, Formaldehyde, CO, bioaerosols
- Johnson 2018 in 12 Oklahoma city schools
- Madj 2019 in 16 Baltimore Schools
- Godwin 2006 in 64 Michigan classrooms
- Deng 2019 220 Nebraska and Iowa classrooms

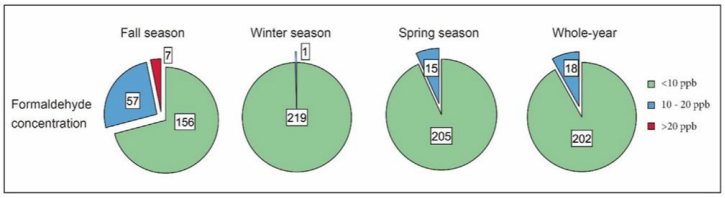


Image from Deng 2019

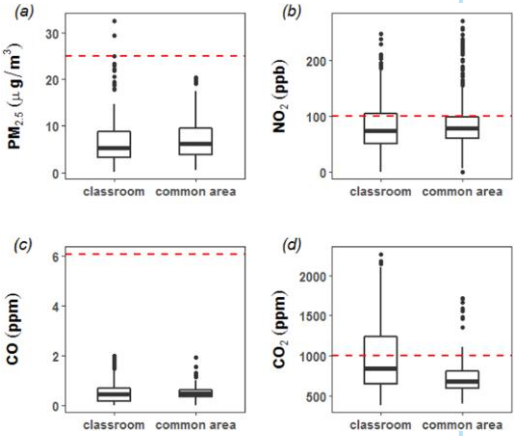
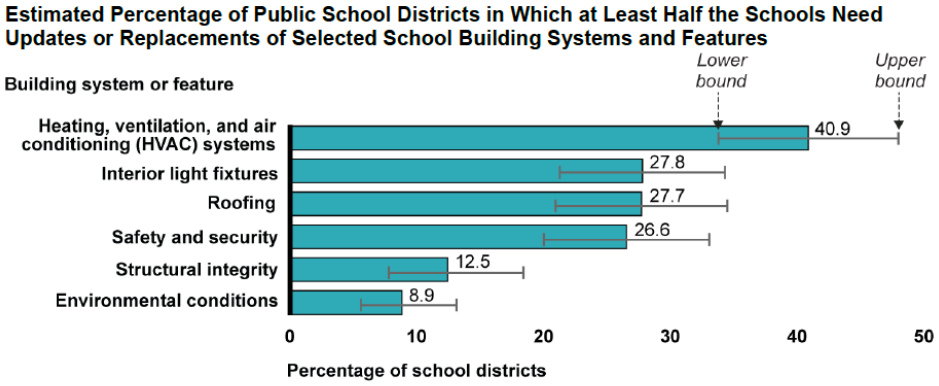


Image from Madj 2019

11

US School Ventilation: US Government Accountability Office Survey



Source: GAO analysis of school district survey data. | GAO-20-494

Note: GAO administered the survey from August to October 2019. Thin bars in the chart display the 95 percent confidence interval for each estimate.

Location matters – schools are locally funded through property taxes so low income areas have much less school budget for IAQ/health (36 of 50 states provide some capital funding)

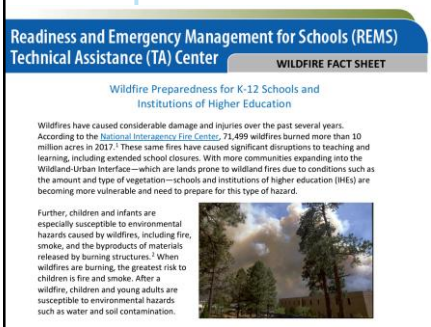
12

Wildfires

- Schools cannot simply close
  - Limited ability to “add more ventilation"
- Recommended Actions
  - Add MERV 13 filters to HVAC systems
  - Use Portable Air Cleaners (certified “ozone-free”)
    - Homemade devices can be cheap and effective.. But can they be used in a regulatory environment where school staff have to meet legal requirements to protect children?
  - Create large “clean air rooms” to shelter in
  - Wear masks*

* Mask mandates have been *banned* in the past by some US States

Wildfires: Fact Sheets & Guidance



Readiness and Emergency Management for Schools (REMS) Technical Assistance (TA) Center

WILDFIRE FACT SHEET

Wildfire Preparedness for K-12 Schools and Institutions of Higher Education

Wildfires have caused considerable damage and injuries over the past several years. According to the National Interagency Fire Center, 71,499 wildfires burned more than 10 million acres in 2017.[1] These same fires have caused significant disruptions to teaching and learning, including extended school closures. With more communities expanding into the Wildland-Urban Interface—which are lands prone to wildland fires due to conditions such as the amount and type of vegetation—schools and institutions of higher education (IHEs) are becoming more vulnerable and need to prepare for this type of hazard.

Further, children and infants are especially susceptible to environmental hazards caused by wildfires, including fire, smoke, and the byproducts of materials released by burning structures.[2] When wildfires are burning, the greatest risk to children is fire and smoke. After a wildfire, children and young adults are susceptible to environmental hazards such as water and soil contamination.

Protecting Kids from Wildfire Smoke:

Actions for California Schools

As smoke and wildfire seasons intensify, schools must take urgent action to protect kids' health. Improvements in indoor air quality and readiness planning are also critical for COVID-19 – and ongoing climate challenges.

Why take action?

Wildfire smoke contains fine, inhalable particles called PM2.5, as well as dangerous levels of heavy metals and other toxins. It may be as much as 10 times more dangerous for kids than other forms of air pollution.

Wildfire smoke can increase emergency room visits for asthma and upper respiratory infections in kids. It can also reduce immune function, lead to cardiovascular and lung diseases later in life, and create long-term cancer risks.

Since air pollution levels are also associated with reduced school performance, improving schools' air quality doesn't just help protect kids' health – it also safeguards their learning. Better air quality infrastructure can also help protect against COVID-19 and other illnesses.

Don't just close.

When schools close due to wildfire smoke, kids – especially from lower-income communities

What can schools do?

KNOW YOUR INDOOR AIR QUALITY

Monitoring indoor air quality is an important way to tailor interventions and keep kids safe. Ideally, this should also be done at home. More information: bit.ly/3wyjJtP

IMPROVE HVAC SYSTEMS

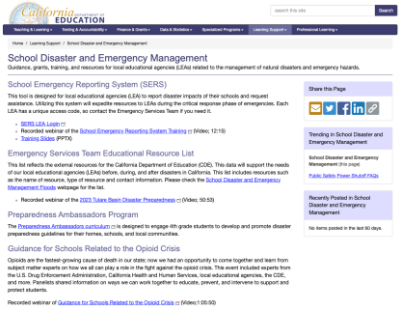
Installing, improving, and maintaining HVAC systems is critical for mitigating exposure to smoke – as well as other emerging challenges, like disease-spreading pathogens and heat. Use MERV13+ filters or highest possible filter compatible with system. More information: bit.ly/3Czx755

GET AIR PURIFIERS

Where HVAC installation isn't an option or additional filtration is needed, classrooms should get portable mechanical air cleaners. Avoid purchasing purifiers that have ionizers, as they can create ozone. More information on devices certified for sale in CA: bit.ly/372wrNJ

CREATE CLEAN AIR ROOMS

Schools should consider creating large clean air rooms, such as cafeterias, gyms, or auditoriums – which can also serve as clean air shelters for community members outside of school hours. Ideally, ALL classrooms should be clean air rooms to keep kids safe. More information: bit.ly/3ykggRt



California Department of Education

School Disaster and Emergency Management

Guidance, grants, training, and resources for local educational agencies (LEAs) related to the management of natural disasters and emergency hazards.

School Emergency Reporting System (SERS)

This tool is designed for local educational agencies (LEA) to report disaster impacts of their schools and request assistance. Utilizing this system will expedite resources to LEAs during the critical response phase of emergencies. Each LEA has a unique access code, so contact the Emergency Services Team if you need it.

- SERS LEA Login
- Recorded webinar of the School Emergency Reporting System Training (Video; 12:15)
- Training Slides (PPTX)

Emergency Services Team Educational Resource List

This list reflects the external resources for the California Department of Education (CDE). This data will support the needs of our local educational agencies (LEAs) before, during, and after disasters in California. This list includes resources such as the name of resource, type of resource and contact information. Please check the School Disaster and Emergency Management Floods webpage for the list.

- Recorded webinar of the 2021 Tulare Basin Disaster Preparedness (Video; 50:53)

Preparedness Ambassadors Program

The Preparedness Ambassadors curriculum is designed to engage 4th grade students to develop and promote disaster preparedness guidelines for their homes, schools, and local communities.

Guidance for Schools Related to the Opioid Crisis

Opioids are the fastest-growing cause of death in our state; now we had an opportunity to come together and learn from subject matter experts on how we all can play a role in the fight against the opioid crisis. This event included experts from the U.S. Drug Enforcement Administration, California Health and Human Services, local educational agencies, the CDE, and more. Panelists shared information on ways we can work together to educate, prevent, and intervene to support and protect students.

Recorded webinar of Guidance for Schools Related to the Opioid Crisis (Video;1:05:50)

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Trending in School Disaster and Emergency Management

School Disaster and Emergency Management (this page)

Public Safety Power Shutoff FAQs

Recently Posted in School Disaster and Emergency Management

No items posted in the last 60 days.

COVID and infectious diseases

Like wildfires: a combination of masking and filtration (upgrading to MERV 13 or better)

Unlike wildfires – strong emphasis on increasing ventilation rates, potentially teaching outdoors

U.S. Department of Education

Search...

Student Loans | Grants | Laws

Improving Ventilation in Schools, Colleges, and Universities to Prevent COVID-19

Did you know? You can use American Rescue Plan (ARP) education funds further described below to improve indoor air quality for in-person instruction, including through:

- Inspection, testing, and maintenance of current ventilation systems and approaches
- Purchasing portable air filtration units, such as HEPA air filters
- Purchasing MERV-13 (or higher) filters for your HVAC system and ACs
- Purchasing fans
- Repairing windows and/or doors so that they can open to let fresh air in
- Servicing or upgrading HVAC systems consistent with industry standards
- Purchasing equipment to run outdoor classes
- Purchasing carbon dioxide (CO_2) monitors, air flow capture hoods, and anemometers for custodians and building personnel to assess ventilation
- Paying for increased heating/cooling costs due to increased use of heating/cooling systems
- Other spending that supports inspection, testing, maintenance, repair, replacement, and upgrade projects to improve the indoor air quality in school facilities, including mechanical and non-mechanical heating, ventilation, and air conditioning systems, filtering, purification and other air cleaning, fans, control systems, and window and door repair.

COVID and ASHRAE Guidance

ASHRAE

STANDARD

ASHRAE Guidance for re-opening of schools:
- ASHRAE 62.1 minimum ventilation per person + pre/post-occupancy purge
- MERV 13 in HVAC systems + consider portable HEPA (not M13!)
- Consider UV systems
- Consider energy implications
- Flush prior to occupancy
- NOTHING ABOUT MASKS!!!

ASHRAE Standard 241 (Control of Infectious Aerosols):
- 20 L/s/person in a classroom
- 25 L/s/person in lecture hall

ASHRAE Standard 241-2023

Control of Infectious Aerosols

Standards Committee on June 24, 2023.

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 ISSN 1041-2336B

Comments and Questions

17

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18

Supplementary Slides

Other Contaminants are low (below IAQ guideline thresholds)

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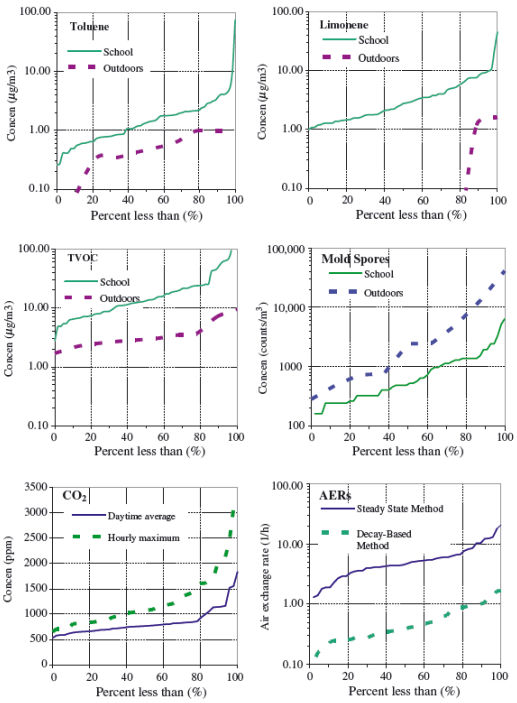
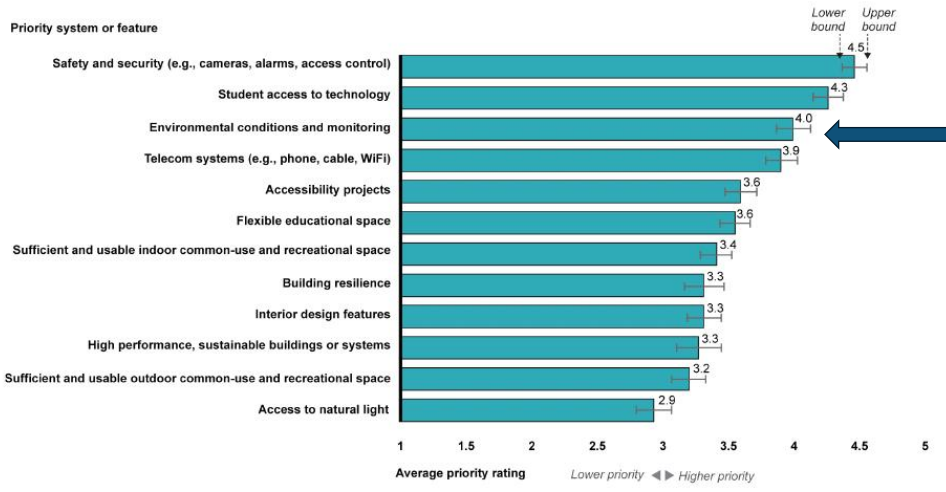


Image from Godwin 2006

Where does IAQ/Ventilation rank as a priority?



Mostly asbestos and lead

Source: GAO analysis of school district survey data. | GAO-20-494

21

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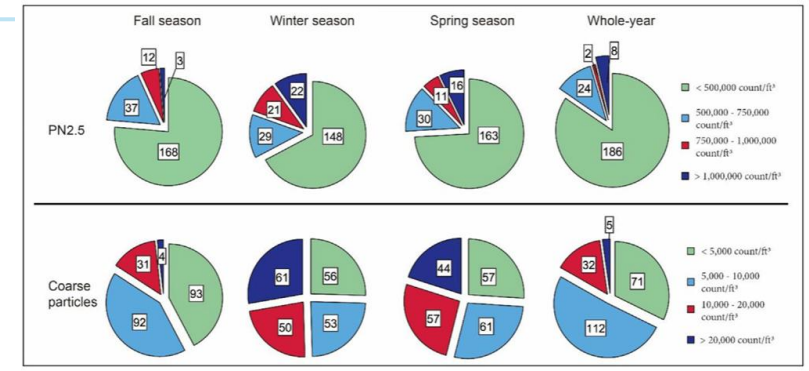

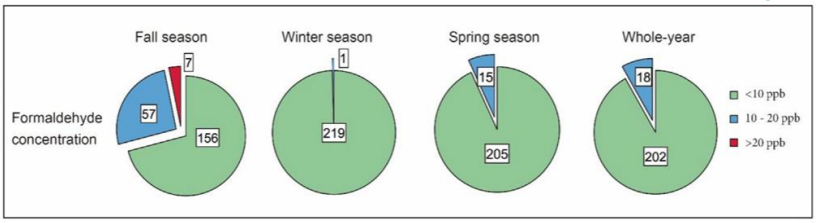

Images from Deng 2019

22