

Thinking about Ventilation for Long Term Care

July 30, 2020



Photojournalist Andrew Lichtenstein, who has been documenting farmworker struggles in California and the Southeast for decades, took this shot of squalid housing conditions 12 years ago.

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Source: Andrew Lichtenstein

Outside of hospitals we have had large COVID outbreaks

- In prisons
- Nursing homes
- Farm workers residential communities
- Dormitories and barracks
- Cruise ships

One thing these may have in common is low rates of air exchange, air that recirculates and is shared by large numbers of people.

We know rates of respiratory infections are lower when:

- Military recruits in barracks “are less crowded” (72 sq. ft./trainee).
- Dorms increase Air Changes per Hour (ACH)
- Taiwanese dorms increase ACH

Military respiratory infections

- Five studies saw lower rates of respiratory infections when military recruits in barracks “are less crowded” (72 sq. ft./trainee).

Sanchez, JL et al. Respiratory Infections in the U.S. Military: Recent Experience and Control. *Clinical Microbiology Reviews* Jun 2015, 28 (3) 743-800; DOI: 10.1128/CMR.00039-14

Also military saw no change with head to toe sleeping arrangements, increasing distance between cots, or hanging cloth between cots.

- No change in ARI rate when 60 person barracks changed air flow, but didn't increase ACH with outside air. Lower ARI rates in 8 person barracks.

White DW, Feigley CE, McKeown RE, Hout JJ, Hebert JR. Association between barracks type and acute respiratory infection in a gender integrated Army basic combat training population. *Mil Med*. 2011;176(8):909-914. doi:10.7205/milmed-d-10-00418

Maryland dorm rooms with more air changes per hour
had 75% fewer lab confirmed infections:

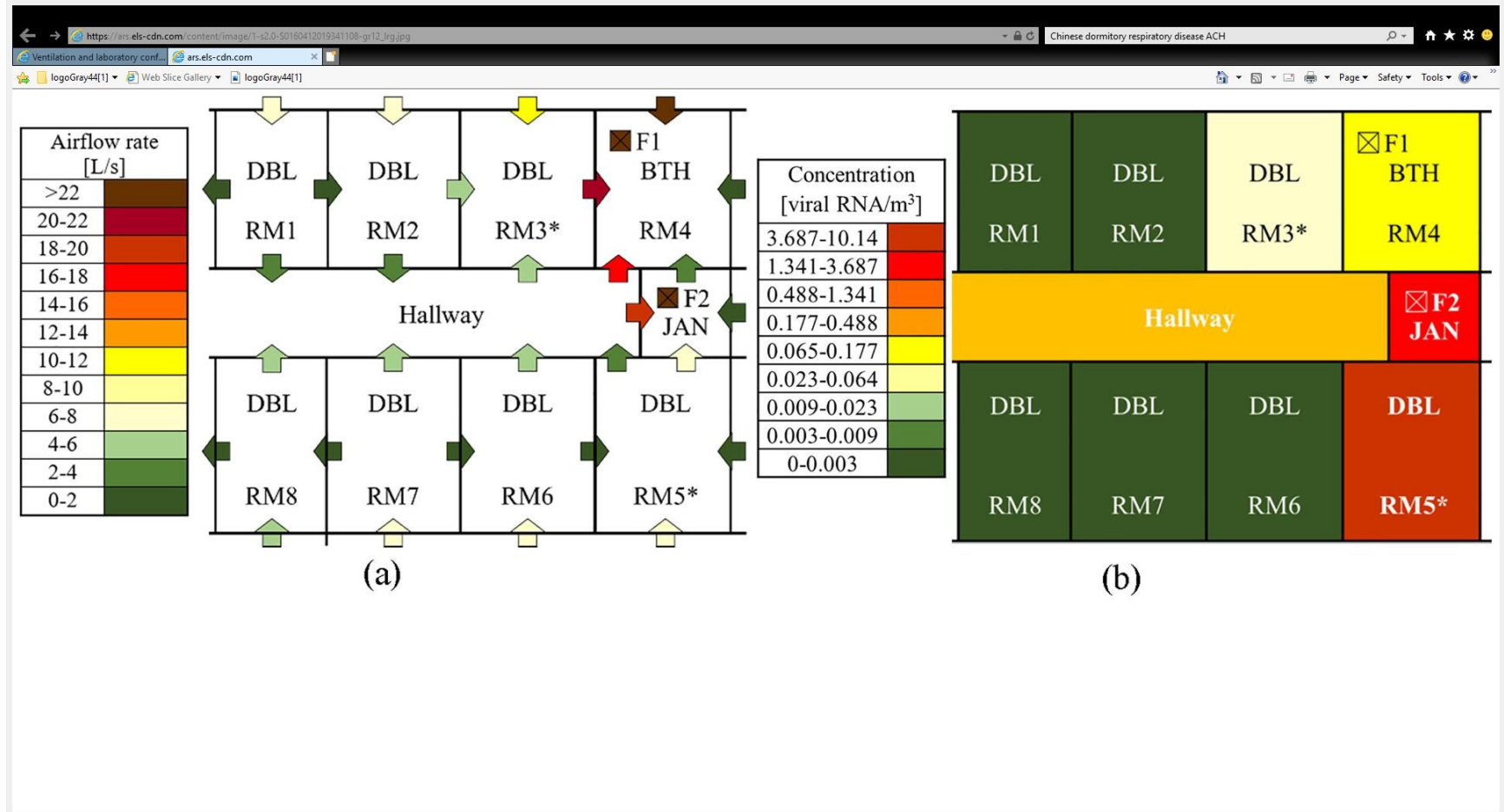
- Low vent (2.3 L/s outside air) = 2.83 infections per person per year
- High vent 6.6 L/s outside air = 0.7 infections per person per year
- Opening

Windows ventilation  2.3- 7.5 L/s

Doors:  3.6 L/s

Windows and doors:  8.8 L/s

Room across from infectious patient developed infection: air flow



Source: "Ventilation and laboratory confirmed acute respiratory infection (ARI) rates in college residence halls in College Park, Maryland": <https://www.sciencedirect.com/science/article/pii/S0160412019341108>

Chinese University, 2712 students in 13 buildings

- Self reported URI ≥ 6 times greater in students with lower ventilation rates (1 L/s/person) compared to higher (5 L/s person)
- Tiny rooms averaged 5 meters per person or $< 180 \text{ f}^3$: (8 X 8 X 3 ft.).
- Is crowding different from poor ventilation?
- Sun Y, Wang Z, Zhang Y, Sundell J. In China, students in crowded dormitories with a low ventilation rate have more common colds: evidence for airborne transmission. *PLoS One*. 2011;6(11):e27140. doi:10.1371/journal.pone.0027140

Shared Air Space, Korean Call Center: 43.5% attack rate



Park S, Kim Y, Yi S, Lee S, Na B, Kim C, et al. Coronavirus Disease Outbreak in Call Center, South Korea. *Emerg Infect Dis.* 2020;26(8):1666-1670. <https://dx.doi.org/10.3201/eid2608.201274>

Princess Cruise Ship

- Preprint: (needs peer review) from Kings College:

Persons who roomed with an symptomatic case did not have higher attack rates than other persons who had recirculated air.

Concluded risk of disease from shared air space, low ACH and recirculating air.

Reference:

<https://www.medrxiv.org/content/10.1101/2020.07.08.20148775v1>

Ventilation and crowding are flip sides of the same coin

- Crowding measured by number of persons per sq foot, and repeated CO₂ concentrations (< 1000 ppm).
- Ventilation is volume of outside air per time. Measure Air Changes/Hour, filtration, direction, rate exhausted to outside.



We know that respiratory infections can occur without touching > 6 feet

- Bus
- Restaurant
- Wards
- Apartments
 - SARS Amoy Garden toilet U traps dry – every time a toilet flushed droplets went into sewage vent pipe and up 8 floors. 1 case spread to 321 cases.

https://www.info.gov.hk/info/sars/pdf/amoy_e.pdf

Transmission on bus to others

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How Covid-19 spread through a Hunan bus

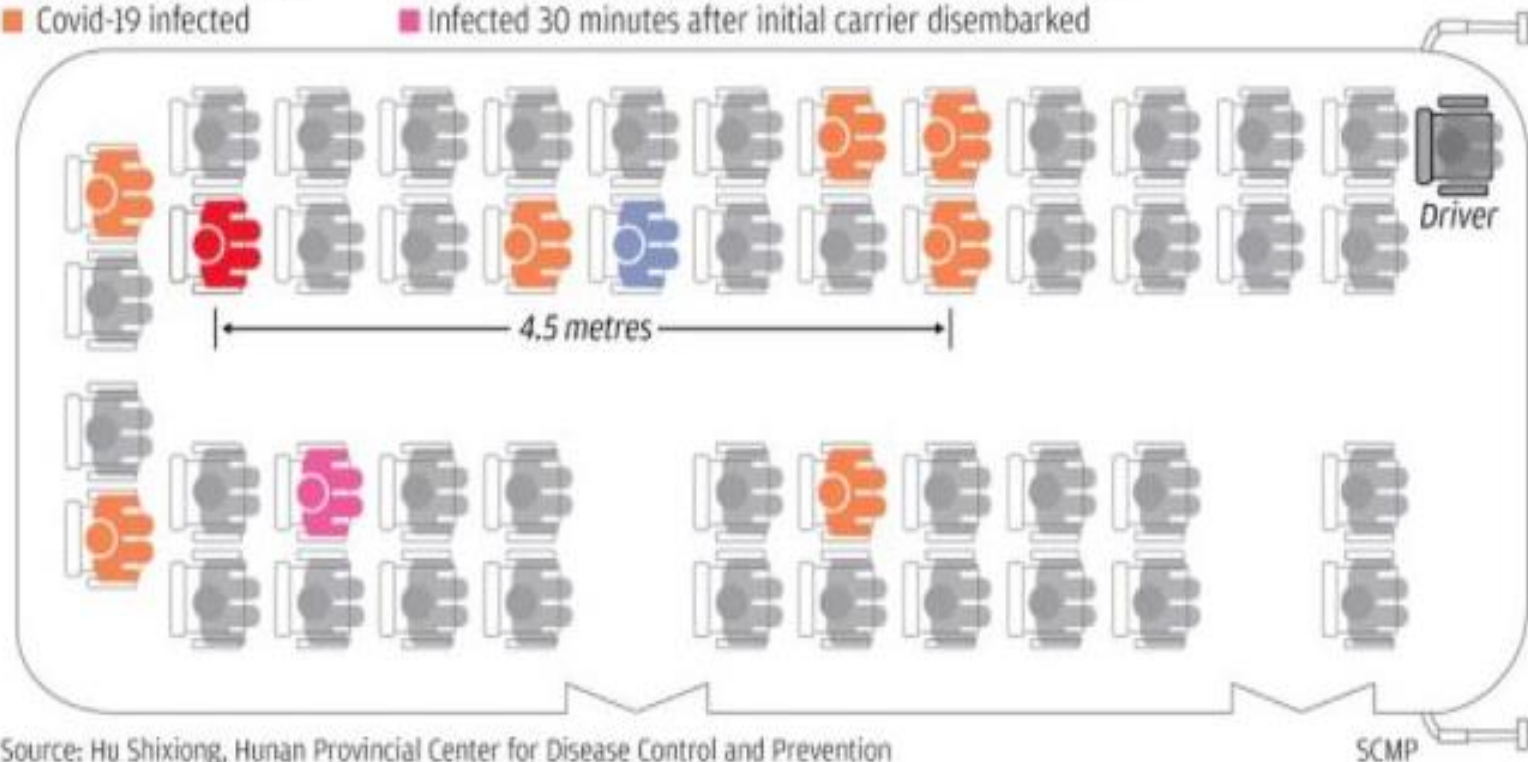
■ Initial Covid-19 carrier

■ Covid-19 infected with no symptoms

■ Uninfected

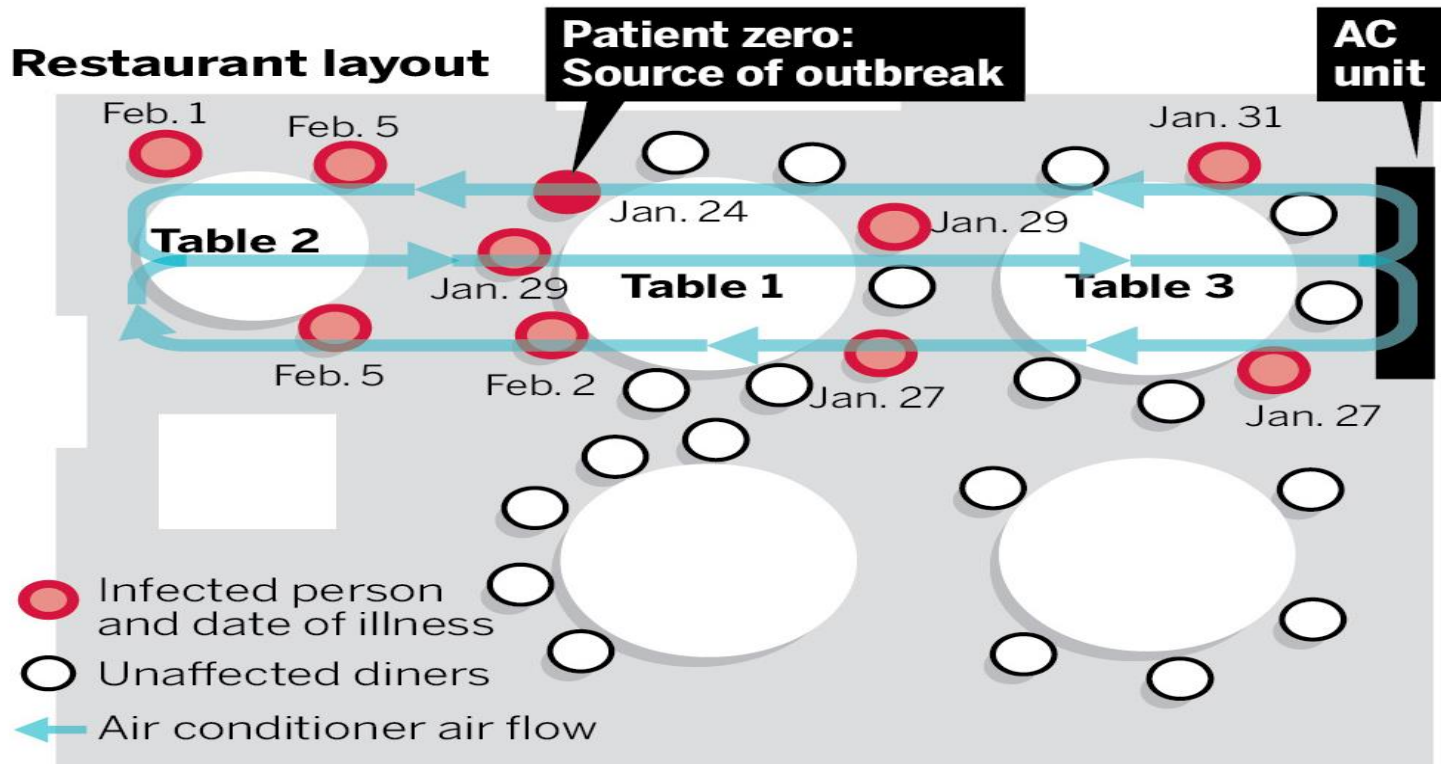
■ Covid-19 infected

■ Infected 30 minutes after initial carrier disembarked



Several passengers became infected during the four-hour bus journey.

Guangzhou, China. AC flow implicated in airborne spread.



Source, CDC and Guangzhou CDC. Bay Area News Group

Letter from 239 scientists documenting airborne transmission

- Provide sufficient and effective **ventilation**
- Avoid **overcrowding**
- Minimize recirculated air at least in hospitals, schools and workplaces
- Use germicidal UV lights in air filtration systems

Lidia Morawska, Donald K Milton, It is Time to Address Airborne Transmission of COVID-19, *Clinical Infectious Diseases*, , ciaa939, <https://doi.org/10.1093/cid/ciaa939>

Lawrence Berkeley National Laboratory for Indoor Air Quality (EPA) 2007

- “There is strong and sufficient evidence” to demonstrate that lower ventilation rates and indoor airflow from infected to uninfected people are associated with increased transmission of infectious diseases.”
- Review supports AIR in hospitals but “**data insufficient to specify minimum ventilation rates**” for other types of buildings.

Industry standards set for energy efficiency not respiratory health

- HVAC industry focuses on reducing energy costs, “comfort”, control of moisture and mold.
- ASHRAE ventilation rates are too low to prevent respiratory infections.
- Older buildings are exempted.

Image source:

<https://www.greenbuildingadvisor.com/article/plugging-air-leaks-would-save-billions>

Green Building News

Plugging Air Leaks Would Save Billions

Researchers say that bringing U.S. homes to a uniform level of airtightness could save \$33 billion in energy costs annually



By Scott Gibson | October 23, 2013



So the question is

Droplet transmission of COVID is primary, but airborne transmission exists,

Can we reduce a portion of respiratory transmission in congregate settings by improving ventilation?

Are there a few easy fixes or things to avoid?

Beginners Guide To HVAC watching



Source: Creative Commons, WikiHow

What to look for

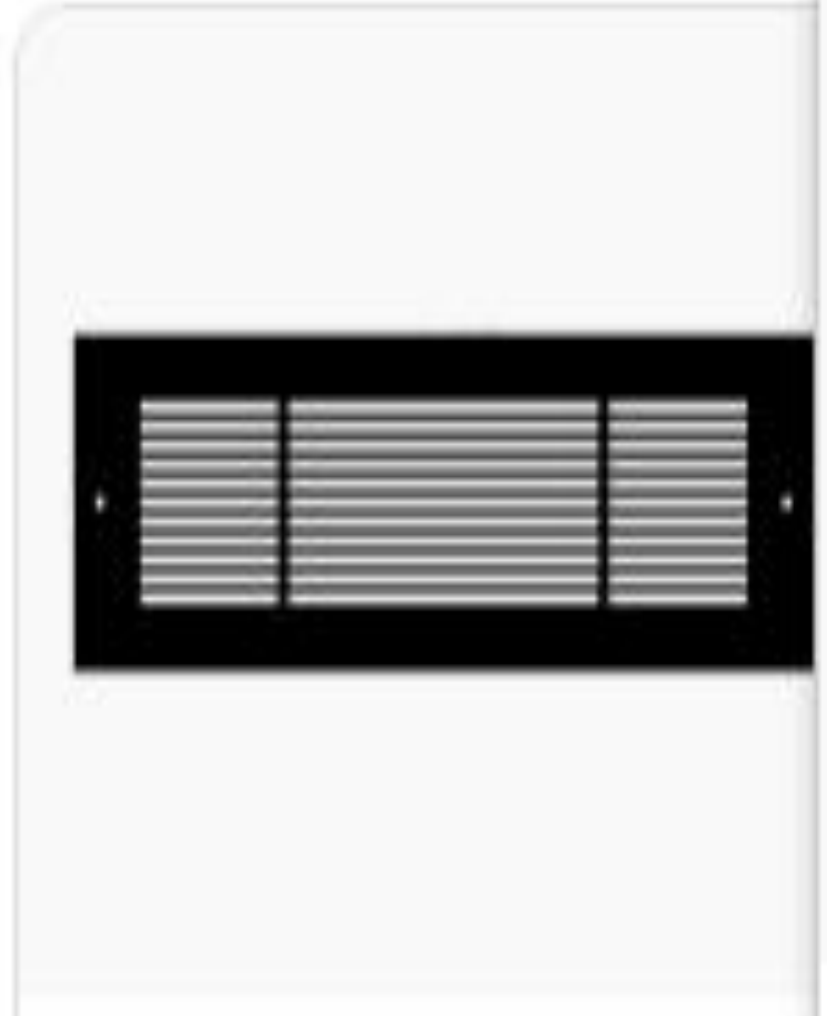
- Where does outside air come in?
- Where does air go out?
- What is the crude direction of air flow?
- Is air recirculating from one area to another?
- Do windows open?
- Have they made any changes to the system?
Fans or filters or new exhaust path?

If COVID-19 enters congregate settings with low ACH...

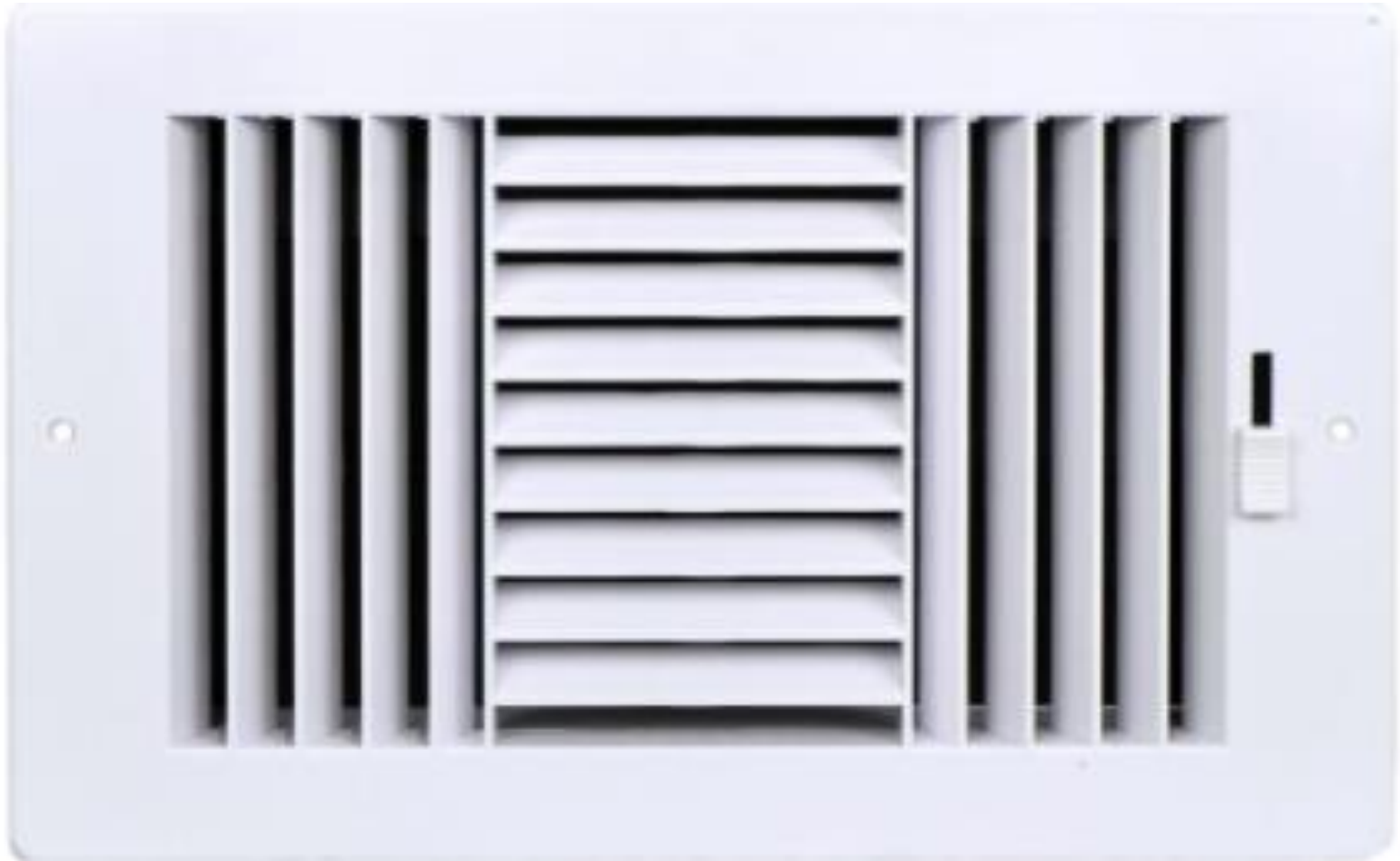


Source: Andrew Lichtenstein

Grills



Registers are grills with adjustable dampers



Source: home depot

Air Diffuser (Air in)

Diffusers change the incoming direction of air flow.

They can reduce the noise of the system, and give more even air supply around the room.

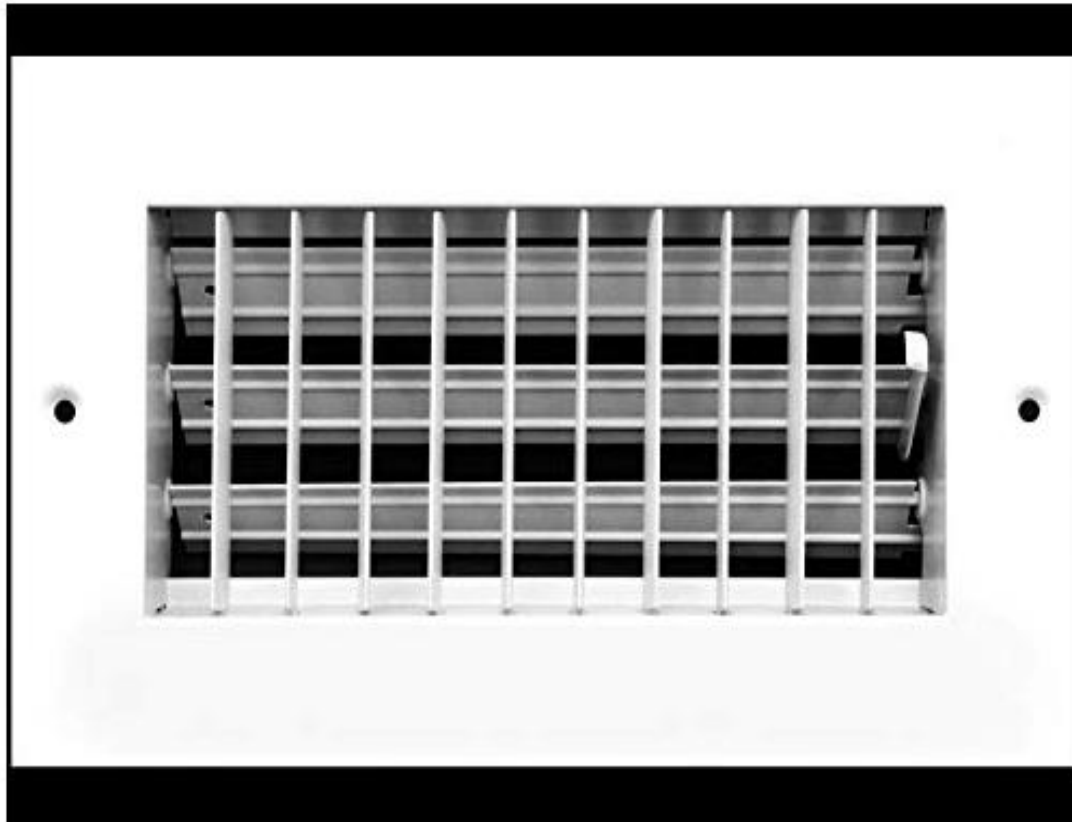
Often in the ceiling.



Source: Accord

Not Mutually Exclusive

Metal-Fab Adjustable Air Supply Diffuser Grille Register



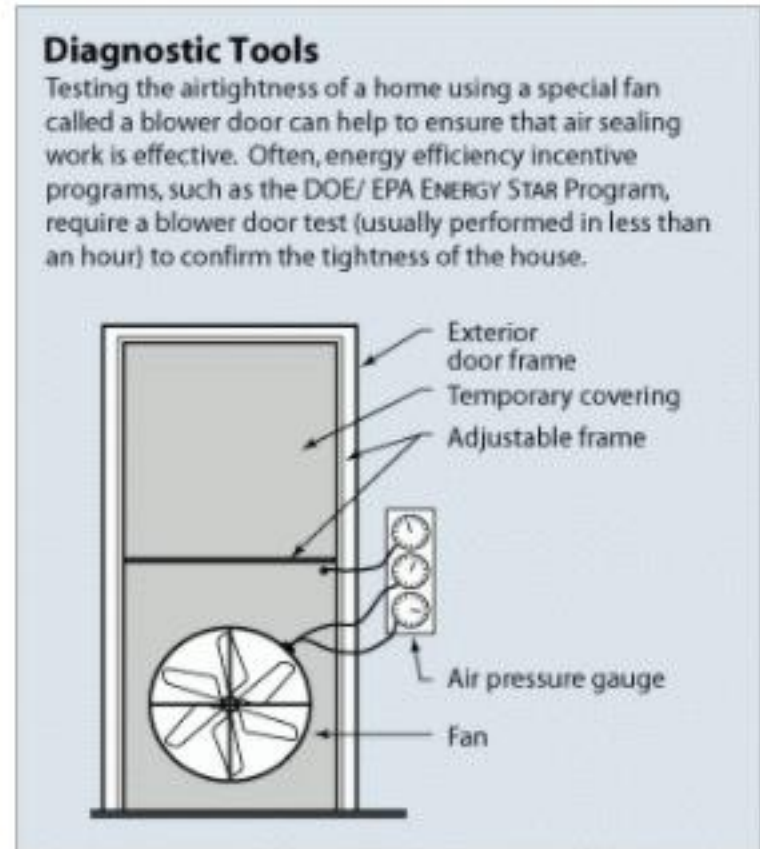
Filters



Source:<https://www.wikihow.com/Change-a-Home-Air-Filter>

Focus on energy efficiency lowered ACH leakage in new homes and businesses (can't exceed 7 ACH)

- Older wood frame homes had 5-12 ACH from leaks
- Insulated concrete homes with concrete roof may be as low as .15 ACH
- Commercial building standard is .35 ACH/hr
- Tight buildings need mechanical ventilation (HVAC)
- Wood houses don't always have central HVAC



door blower <https://www.energy.gov/energysaver/blower-door-tests>

HVAC systems: Gas furnace move air through ducts



Source: Service Champions

Boiler and radiators: Don't supply or exhaust air. Move heated H2O.



Source: Hudsonread.com

Mini-split for heat and air: Don't provide or exhaust Air



Air flow in a wood building

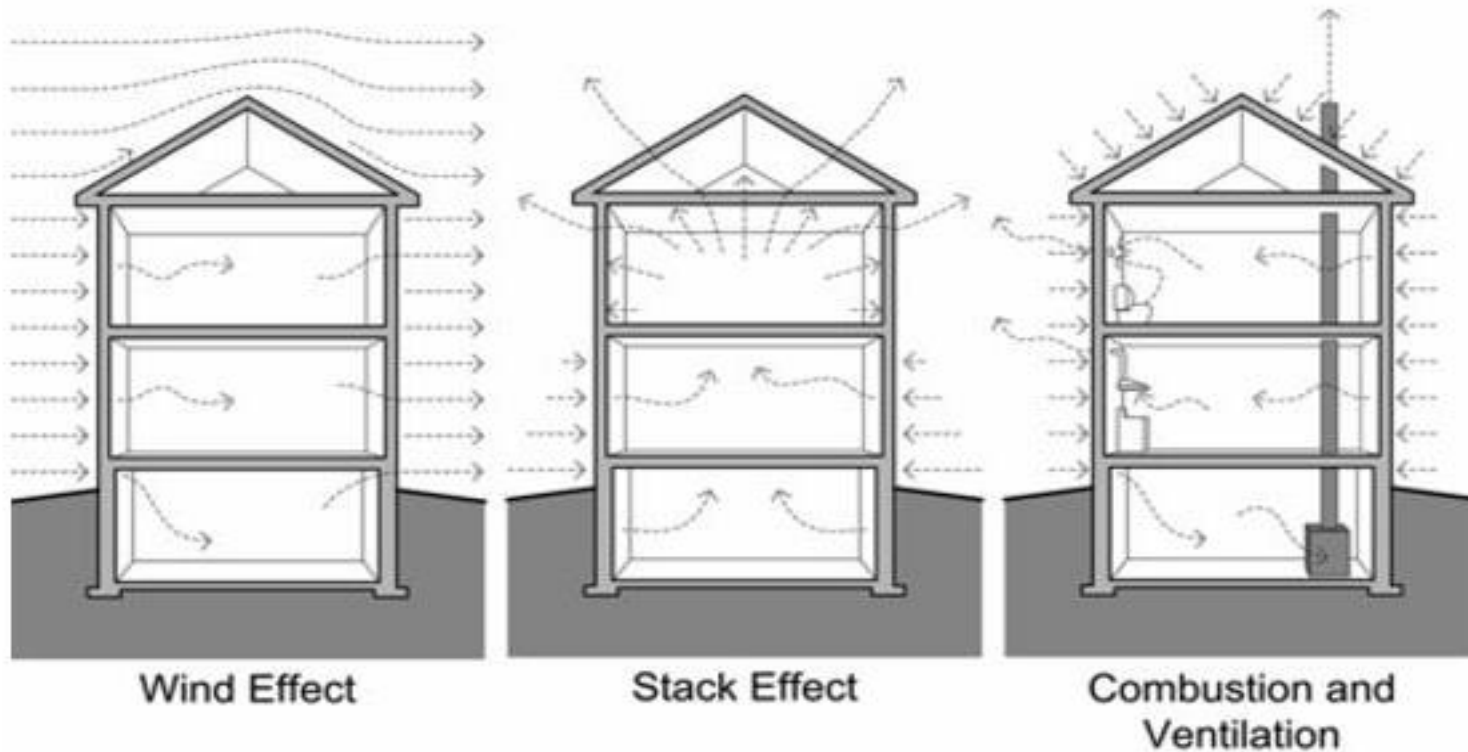


Figure 1: Forces Driving Air Flow through Building Enclosures

Source: John Strab

Where to look for in coming air vent

- In homes, source registers (air in) are often near the floor, so hot air will rise.
- At least 6 inches from corner
- If in the wall, heating is generally across from window.
- Heating and cooling can have separate registers or use the same one.

Location of external residential intakes

- Not on roof
- 10 feet away, and not directly above from exhaust fan, plumbing drain, appliance vent
- Away from idling cars, rodent, pests and rain
- Don't put generators or barbeque grills near intakes.

Cluster of deaths from carbon monoxide poisoning

- After a windstorm in King County in 2006, 250 cases of poisoning when HVAC on generators brought in CO from outside, or exhaust failed to purge houses of CO from charcoal stoves.
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2724456/>

Don't cover exhaust vents, without making a new way for air to leave

- If you have air that recirculates from room to room, place COVID patients in rooms that vent to the outside
- Or use hepa filter and fan to vent to outside.
- Don't exhaust into enclosed courtyards
- Avoid facing into prevailing winds.

Be aware of ventilation flow: in, out, flow

- Actual room air flow is highly turbulent, non-linear, modeled by computational fluid dynamics
- Reality is pockets of dead air, and lack of air mixing. Heat sources, furniture, windows changes flow.

Ideal for COVID: Air moves clean to dirty

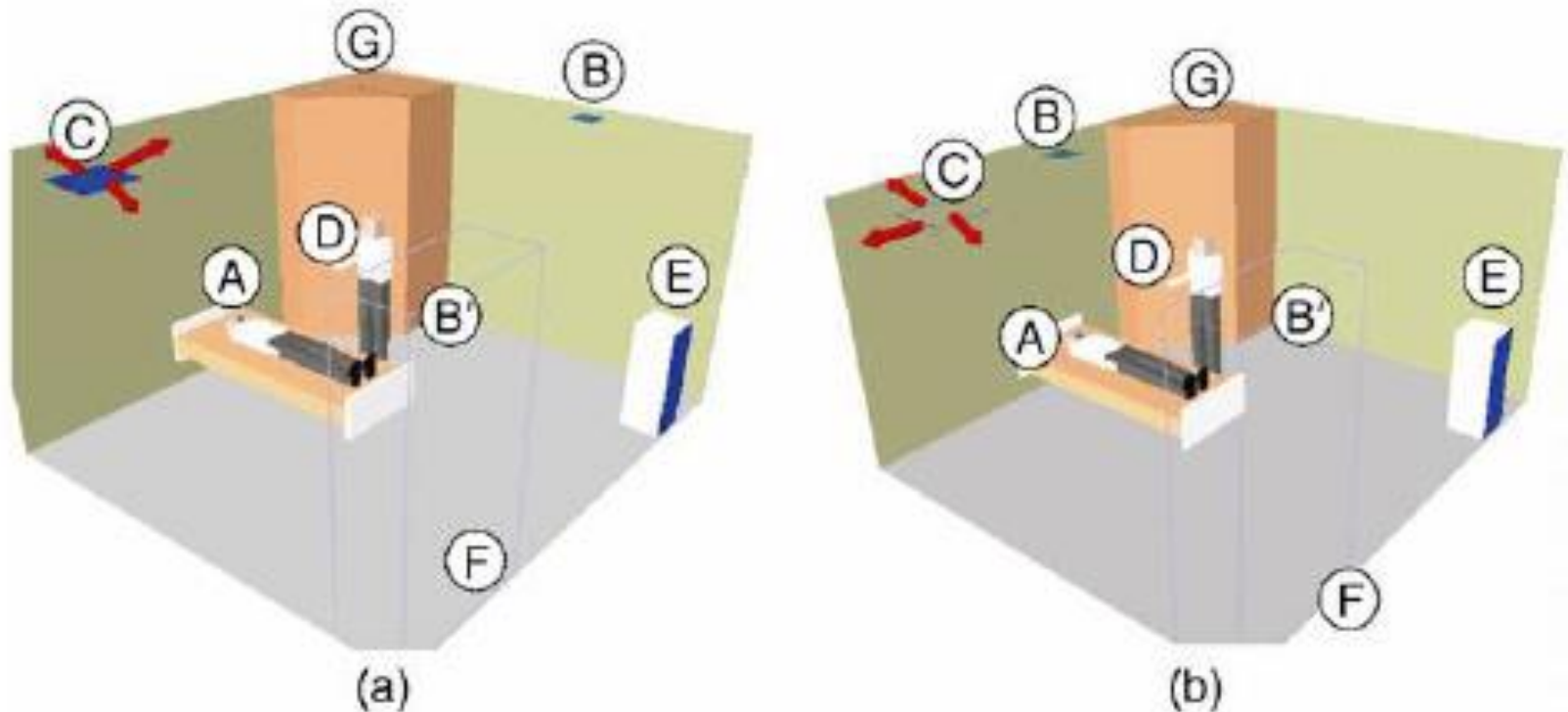


Fig. 3 Case setup (a) Cases 5–10; (b) Cases 11–16. Arrows indicate supply flow directions. A: patient/source; B, B': return; C: supply; D: caregiver; E: equipment; F: cabinet; G: bathroom

Position of supply and exhaust changes air flow

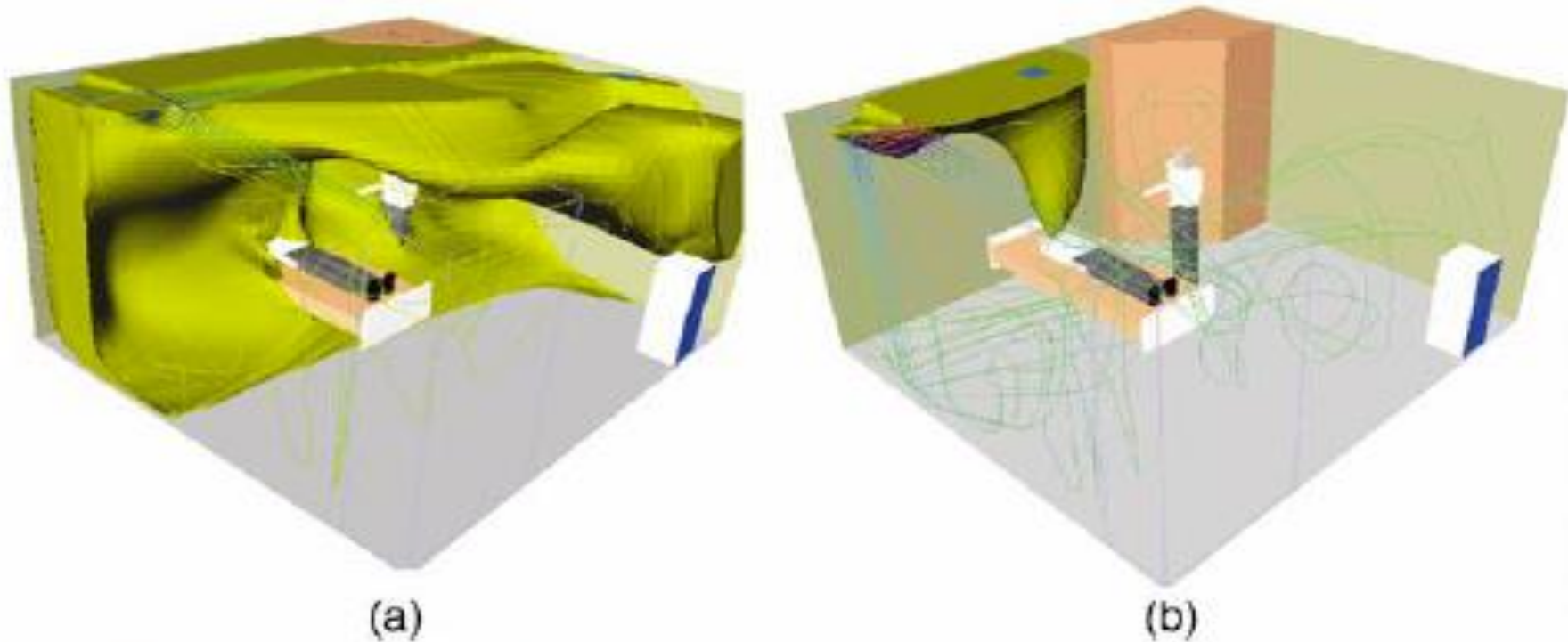
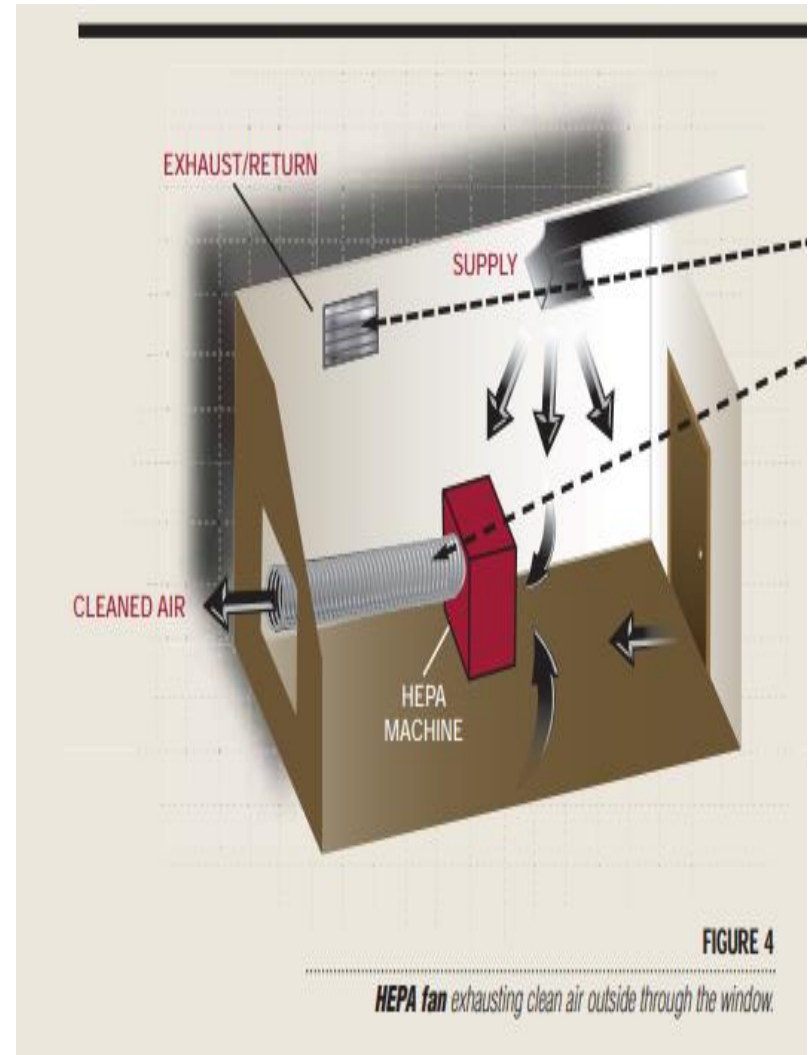


Fig. 7 Comparison of contaminant concentration iso-surface between (a) Case 5 (poor design); (b) Case 11 (good design)

What about HEPA fans?

As an neg. air flow room?

- Select room with door
- Set up window adapter
- Set up HEPA machine
- Seal return air grill
- Turn on HEPA filter and adjust flow



What about fans? Fan + New Air = Yes

- Window, box, tower fans in front of window.
- Fans can to blow air out and/or blow air in.
- If single fan, use in same direction air normally flowing.
- Don't blow from infected person to others
- Don't block window needed for fire escape

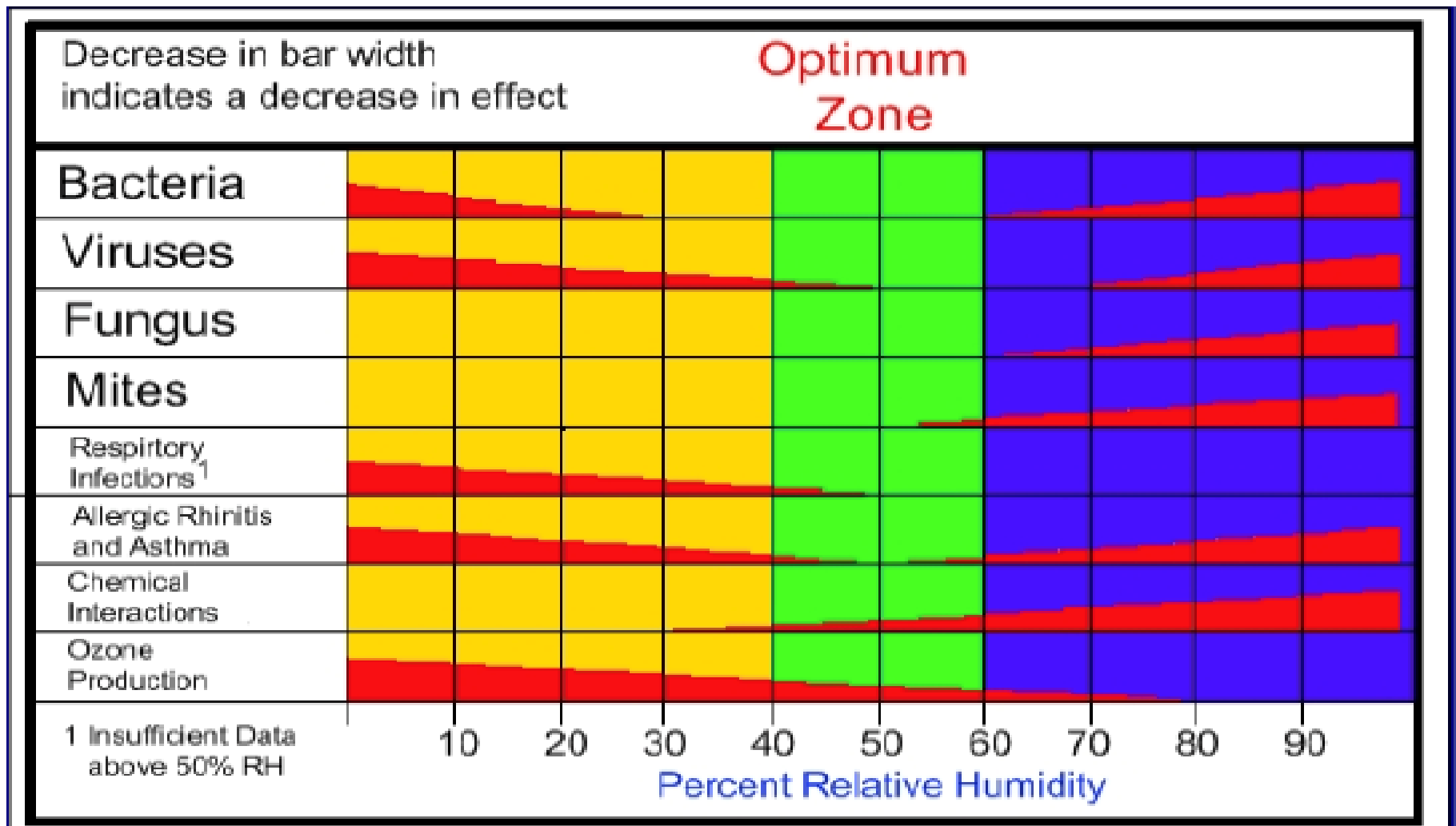
What about “air purifiers”?

- EPA technical guide https://www.epa.gov/sites/production/files/2018-07/documents/residential_air_cleaners_-_a_technical_summary_3rd_edition.pdf
- Filters: yes, but start with routine replacement of furnace filters.
- Size HEPA filter units to room. Close door.
- UVGI: yes, upper vents and upper ceiling in crowded rooms with flow ACH. More info: <http://www.stoptb.org/wg/ett/assets/documents/MaintenanceManual.pdf>
- Generally, say “no” to the exotic untested
 - Ozone generators: none are approved by feds for use in occupied spaces
 - Plasma air cleaners: use high voltage and high current. May form harmful byproducts.
 - Photocatalytic oxidation (PCO) Cleaners. “ ”
 - Electrostatic precipitator: some have high ozone and nitrogen oxide generation, high electric power.
Ionizers and ion generators: generate ozone and low effectiveness

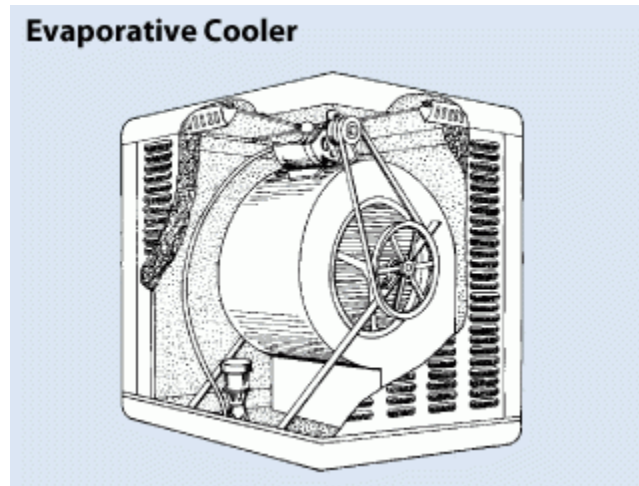
In, Out, Flow: What can make things worse?

- Dampers, windows closed to avoid “drafts”
- Patients placed within air flow path of COVID
- Exhaust vents covered or blocked
- Fans moving air from patient (dirty) to clean, recirculating in multiple rooms.
- Locating crowds in areas with least ACH

Humidity?



Evaporative coolers



<https://www.energy.gov/energysaver/home-cooling-systems/evaporative-coolers>

What CDC recommends for businesses is also appropriate for LTC

- <https://www.cdc.gov/coronavirus/2019-ncov/community/office-buildings.html>
- Open windows and doors and use fans.
- Disable demand control ventilation that reduce air supply based on temperature or occupancy.
- Increase air filtration of recirculated air, if air handling system can manage
- Move air clean to dirty, move workers to clean zones.
- Use exhaust fans in restrooms and operate at full capacity
- Maintain HVAC systems, including filter changes.
- Consider use of UV GI irradiation in upper room air.
- Identify crowded areas and remove furniture.

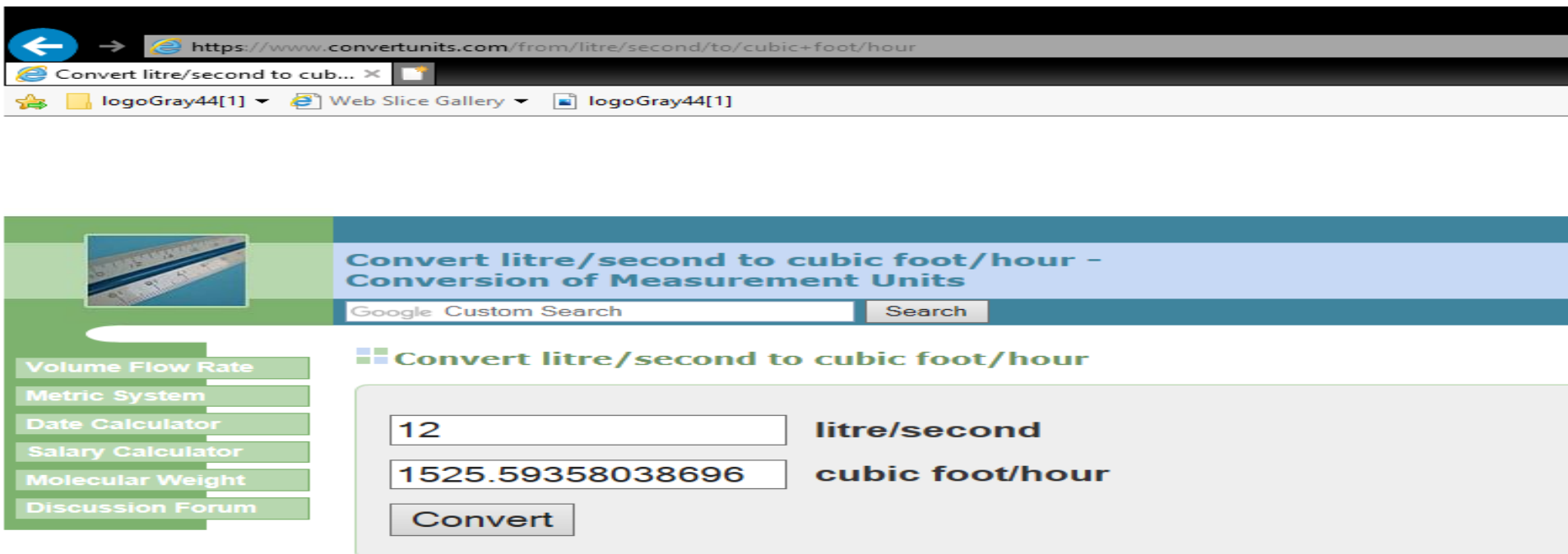
https: www.ashrae.org/technical-resource/commercial offers pandemic advice as well

Take home advice:

- On LTC assessments, do look for air supply, flow, exhaust: IN OUT FLOW
- **Starting points** to discuss with their HVAC expert
- Be aware HVAC staff are be trained to save energy costs and decrease drafts
- When all else is complicated, eliminate crowding and use outside air whenever possible.

Converting L/s to cubic F/hour

- ACH formula uses CFH/room volume
- Find calculator at <https://www.convertunits.com/from/litre/second/to/cubic+foot/hour>



← → <https://www.convertunits.com/from/litre/second/to/cubic+foot/hour>

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