Indoor Air Quality, Ventilation & COVID

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What can you do? 5 Step Plan

- Ensure thermostat is set properly
- Monitor CO2 levels
- Monitor airflow on your HVAC system
- Open windows
- Use a HEPA Filter

1. Your Thermostat

- Should be on “fan” or “on” and not “auto”
- Ensure there is no recirculation mode

2. Monitor CO2

- Use a nondispersive infrared (NDIR) sensor
- What does CO2 tell you?
  - How much air you are rebreathing from others.
  - Outdoor airflow rate per person

What contributes to CO2 levels

- Generation:
  - Sex of occupants
  - Age
  - Activity level
  - Occupant density/number of occupants
  - Non-human sources – e.g. candles
- Removal:
  - Ventilation
  - Sorption-type cleaners

TABLE 4 CO_2 generation rates at 273 K and 101 kPa for ranges of ages and level of physical activity (based on mean body mass in each age group)

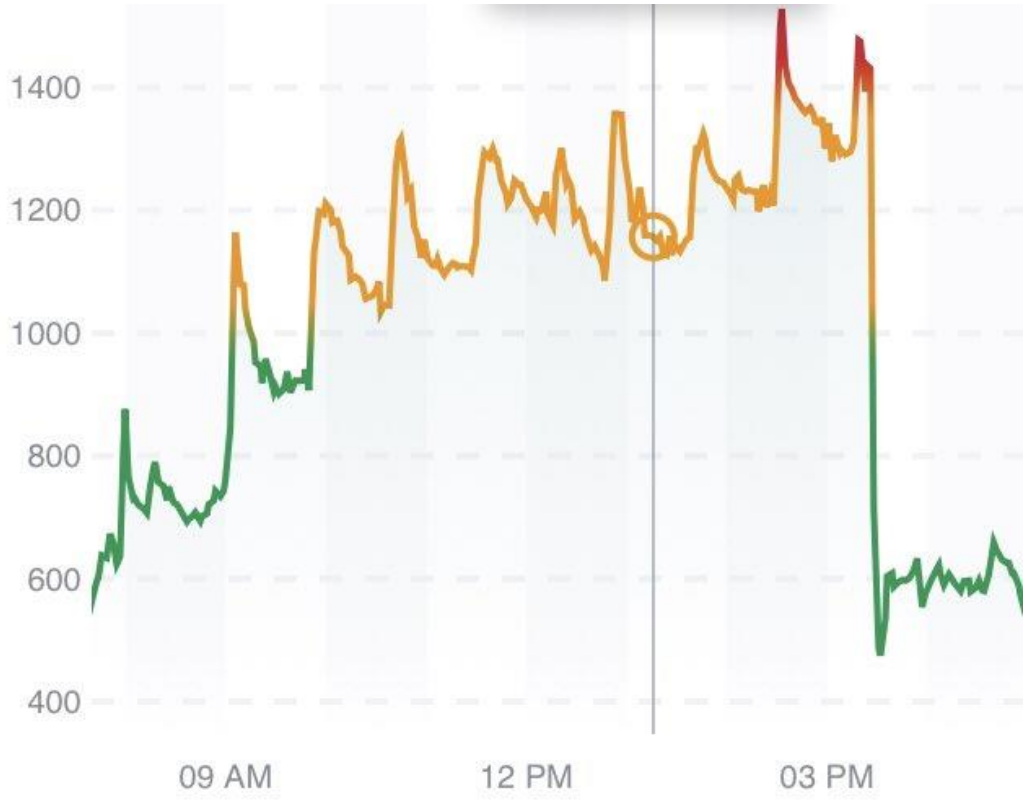
Age (y)	Mean body mass (kg)	BMR (MJ/day)	CO_2 generation rate (L/s) Level of physical activity (met) 1.0	1.2	1.4	1.6	2.0	3.0	4.0
Males									
<1	8.0	1.86	0.0009	0.0011	0.0013	0.0014	0.0018	0.0027	0.0036
1 to <3	12.8	3.05	0.0015	0.0018	0.0021	0.0024	0.0030	0.0044	0.0059
3 to <6	18.8	3.90	0.0019	0.0023	0.0026	0.0030	0.0038	0.0057	0.0075
6 to < 11	31.9	5.14	0.0025	0.0030	0.0035	0.0040	0.0050	0.0075	0.0100
11 to <16	57.6	7.02	0.0034	0.0041	0.0048	0.0054	0.0068	0.0102	0.0136
16 to <21	77.3	7.77	0.0037	0.0045	0.0053	0.0060	0.0075	0.0113	0.0150
21 to < 30	84.9	8.24	0.0039	0.0048	0.0056	0.0064	0.0080	0.0120	0.0160
30 to <40	87.0	7.83	0.0037	0.0046	0.0053	0.0061	0.0076	0.0114	0.0152
40 to <50	90.5	8.00	0.0038	0.0046	0.0054	0.0062	0.0077	0.0116	0.0155
50 to <60	89.5	7.95	0.0038	0.0046	0.0054	0.0062	0.0077	0.0116	0.0154
60 to <70	89.5	6.84	0.0033	0.0040	0.0046	0.0053	0.0066	0.0099	0.0133
70 to <80	83.9	6.57	0.0031	0.0038	0.0045	0.0051	0.0064	0.0095	0.0127
≥80	76.1	6.19	0.0030	0.0036	0.0042	0.0048	0.0060	0.0090	0.0120
Females									
<1	7.7	1.75	0.0008	0.0010	0.0012	0.0014	0.0017	0.0025	0.0034
1 to <3	12.3	2.88	0.0014	0.0017	0.0020	0.0022	0.0028	0.0042	0.0056
3 to <6	18.3	3.59	0.0017	0.0021	0.0024	0.0028	0.0035	0.0052	0.0070
6 to < 11	31.7	4.73	0.0023	0.0027	0.0032	0.0037	0.0046	0.0069	0.0092
11 to < 16	55.9	6.03	0.0029	0.0035	0.0041	0.0047	0.0058	0.0088	0.0117
16 to <21	65.9	6.12	0.0029	0.0036	0.0042	0.0047	0.0059	0.0089	0.0119
21 to < 30	71.9	6.49	0.0031	0.0038	0.0044	0.0050	0.0063	0.0094	0.0126
30 to < 40	74.8	6.08	0.0029	0.0035	0.0041	0.0047	0.0059	0.0088	0.0118
40 to <50	77.1	6.16	0.0029	0.0036	0.0042	0.0048	0.0060	0.0090	0.0119
50 to <60	77.5	6.17	0.0030	0.0036	0.0042	0.0048	0.0060	0.0090	0.0120
60 to <70	76.8	5.67	0.0027	0.0033	0.0038	0.0044	0.0055	0.0082	0.0110
70 to <80	70.8	5.45	0.0026	0.0032	0.0037	0.0042	0.0053	0.0079	0.0106
≥80	64.1	5.19	0.0025	0.0030	0.0035	0.0040	0.0050	0.0075	0.0101

Activity	M (met)	Range
Calisthenics—light effort	2.8	
Calisthenics—moderate effort	3.8	
Calisthenics—vigorous effort	8.0	
Child care		2.0 to 3.0
Cleaning, sweeping—moderate effort	3.8	
Custodial work—light	2.3	
Dancing—aerobic, general	7.3	
Dancing—general	7.8	
Health club exercise classes—general	5.0	
Kitchen activity—moderate effort	3.3	
Lying or sitting quietly		1.0 to 1.3
Sitting reading, writing, typing	1.3	
Sitting at sporting event as spectator	1.5	
Sitting tasks, light effort (e.g, office work)	1.5	
Sitting quietly in religious service	1.3	
Sleeping	0.95	
Standing quietly	1.3	
Standing tasks, light effort (e.g, store clerk, filing)	3.0	
Walking, less than 2 mph, level surface, very slow	2.0	
Walking, 2.8 mph to 3.2 mph, level surface, moderate pace	3.5	

How to use CO2?

- Indirectly related to COVID risk
  - HEPA filters or UV lowers risk without lowering CO2
  - Community infection rate
- Verify ventilation is working
  - Different spaces have different requirements
    - Elementary school classroom 900 ppm
    - Highschool classroom 1000 ppm
    - Office 1000 ppm
    - Party hall > 2000 ppm
    - Search “NIST CO2 calculator”

How to use CO2?

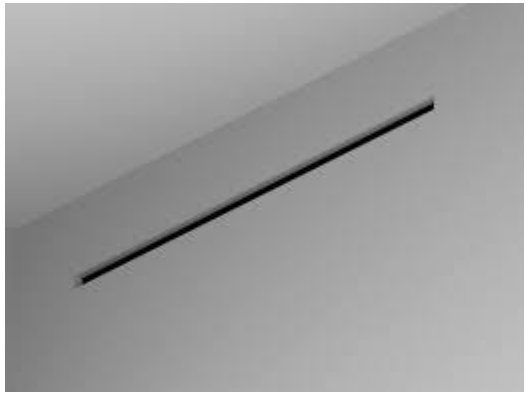


3. Monitor Airflow in HVAC

- Get to know your HVAC system:
  - Supply diffusers
  - Return grille

Types of diffusers and grilles

Supply:



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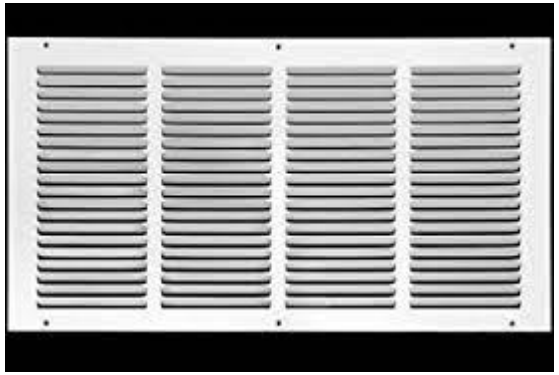
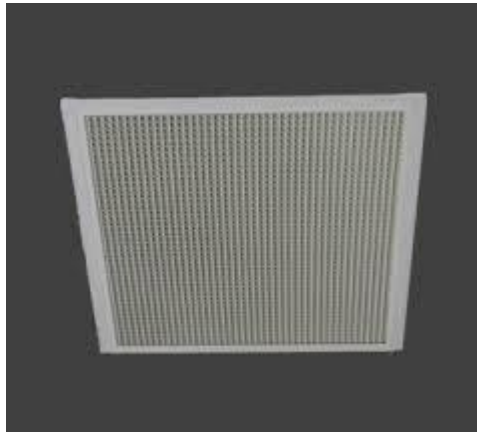




Monitor Airflow in HVAC

- Attach indicator to supply diffuser
- Use a tissue on a pole

4. Open Windows

- Even if they can only be cracked open
- Can use a fan to increase airflow
  - Exhaust air with the fan
  - Make sure you know where the air is replaced

5. Portable HEPA Filters

- What you care about:
  - Clean air delivery rate (CADR)
  - Noise – depending on the space
    - Lots of background noise (kids playing – 55 dB)
    - Medium noise (50 dB)
    - Quiet space (40 dB)
  - Cost – more expensive ones are not better
  - Should be certified HEPA
    - H13
    - True HEPA
    - Medical Grade HEPA
    - AHAM Verified

Portable HEPA Filters

- Avoid misleading names
  - HEPA like
  - HEPA style
- Avoid extra features
  - UV lights often include a catalyst (photocatalytic oxidation)
  - Hydroxyl generators
  - Ionization
  - Wave Plasma
- Corsi-Rosenthal Box

Personal HEPA Filters

- Could work when your face is very close
- Can help as source control if you breathe into the intake
- Many deployed can clean out the space
- Might not be effective as a lone measure when not close to you

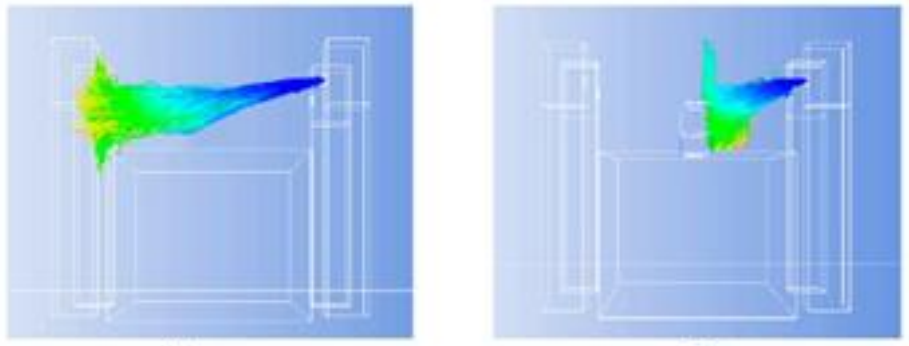
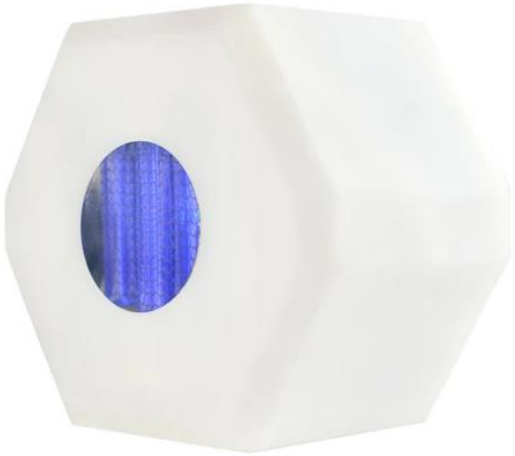


Figure 4. Dispersion of virus particles predicted by CFD: (**a**) without air purifier; (**b**) with air purifiers.

Personal Far UV

- Evidence it is safe and effective in a lab. Not real world yet.
- Need expert to know distance and effectiveness
- Hopefully can be deployed soon



Questions?