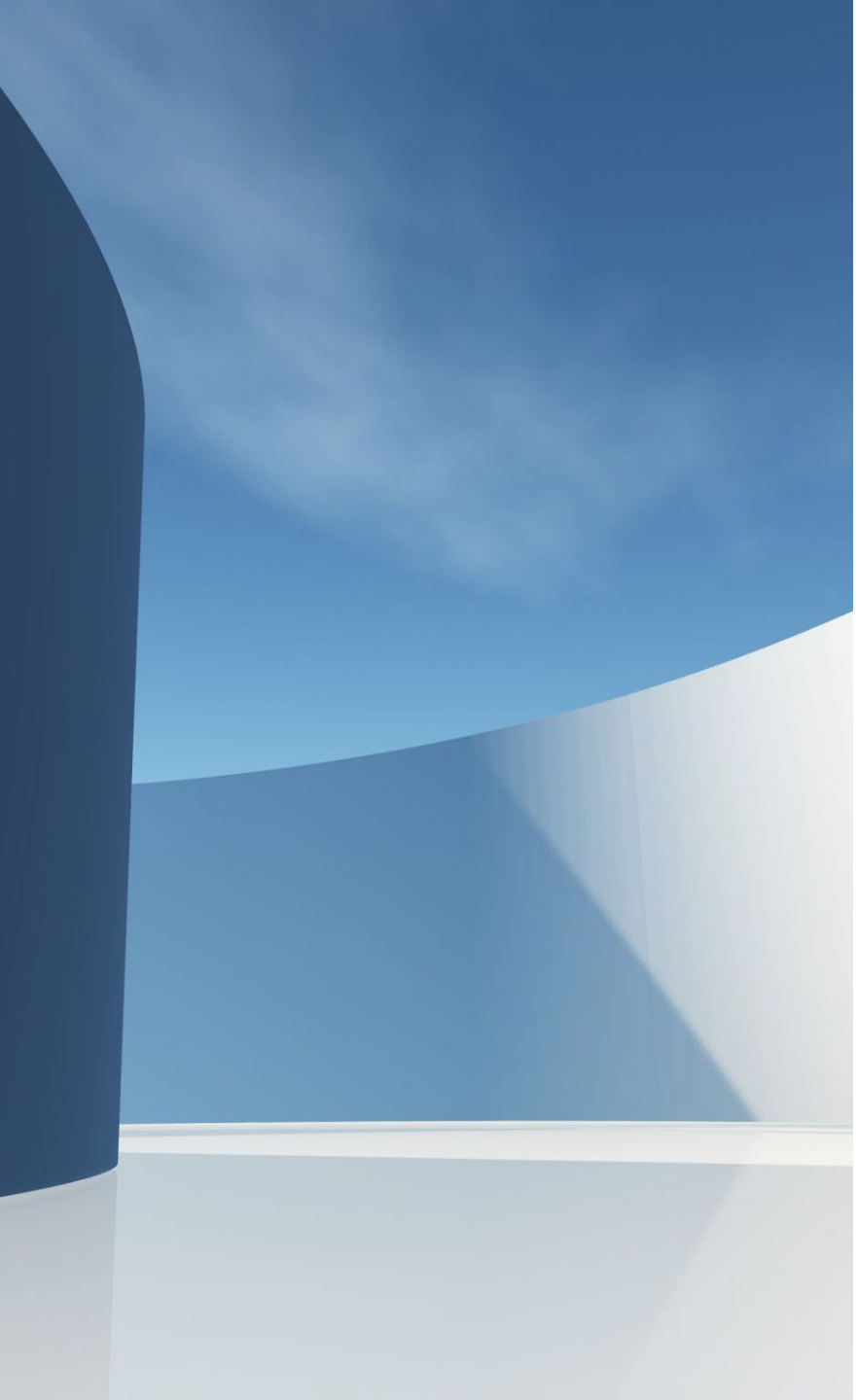
Welcome!

- **Poll**: Which of the following best describes your field of practice?
  - Public health
  - IAQ specialist
  - Childcare or education
  - Facilities or building manager
  - Other!



Do-it-yourself air cleaners: Evidence on effectiveness and considerations for safe operation

NCCEH Environmental Health Seminar Series

Dr. Angela Eykelbosh

January 26th, 2023

Established by the Public Health Agency of Canada in 2005 to promote evidence-informed public policy.

Evidence-based knowledge synthesis and translation

Identify knowledge gaps

Foster networks, build capacity for Canada's public health system

Overview

- Purpose and methods of the study
- Comparing DIY devices to commercial units
- DIY devices in the real world
- Choosing your design and building it well
- Quality control
- Safe operation
- Those pesky limitations!
- Summary

DIY air cleaners have been around for a while

- Widely recommended by public health and other agencies to protect against wildfire smoke
- Renewed interest during COVID-19 pandemic as a supplement to ventilation.
- Made of inexpensive, widely available materials and be assembled quickly and without needing permits or major renos.

But do DIY air cleaners work as well as commercial units?

- Commercial PACs: **HEPA filters** that remove 99.97% of particles 0.3-1.0 µm on a single pass
  - Have other bells and whistles!

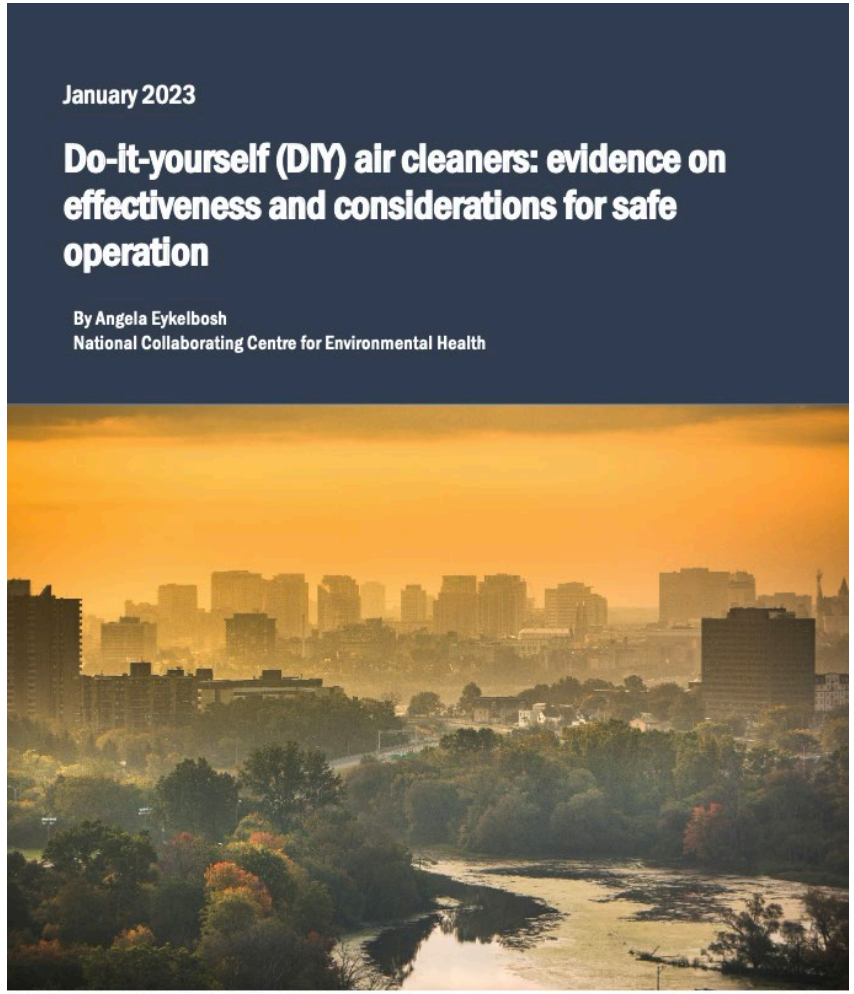
- DIY versions: box fan and a **MERV-13** filter.
  - Lower filtration efficiency (~50%) on a single pass, but will still remove PM
  - Increasing airflow or filter area will help make up for lower filtration efficiency

How do we measure effectiveness in an air cleaner?

- **Clean air delivery rate (CADR):** how quickly the device can remove particulate matter from room air compared to natural “decay” alone.
- Commercial devices evaluated by Association of Home Appliance Manufacturers over several particle size ranges
- Smoke CADR should be at least two-thirds of room area (ft^2)
- Other important factors: noise, energy use, $$$

Purpose of this review

- To examine evidence on DIY air cleaner ***effectiveness*** (CADR) and other important factors like ***cost effectiveness, energy efficiency, and noise.***
- Help decision-makers develop their own strategies for using DIY air cleaners.
- Help people to understanding the use case.
- Download the **full resource** at our website.



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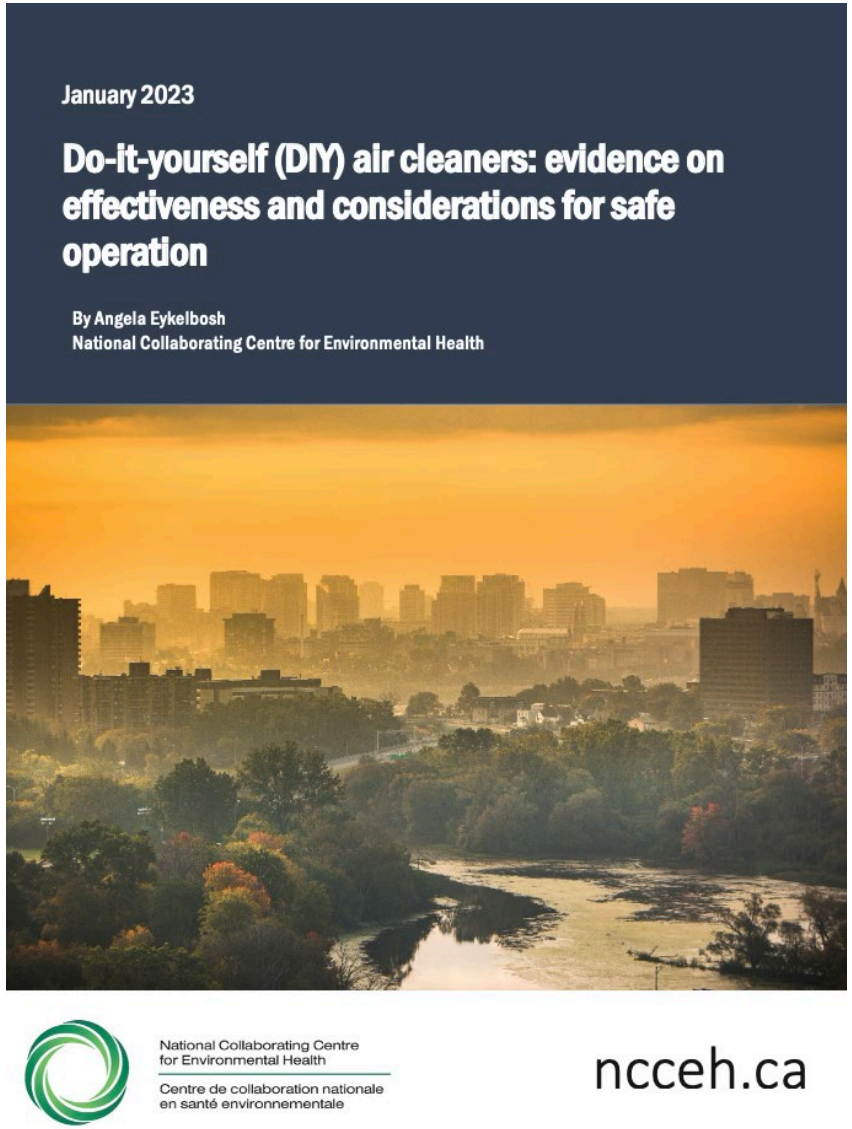
Methods

- Reviewed the scholarly and grey literature (see document for full methods).
- This review covers 20 sources:
  - 9 peer-reviewed
  - 3 pre-prints
  - 8 technical reports
- Document was internally and externally reviewed; collaborations much appreciated!



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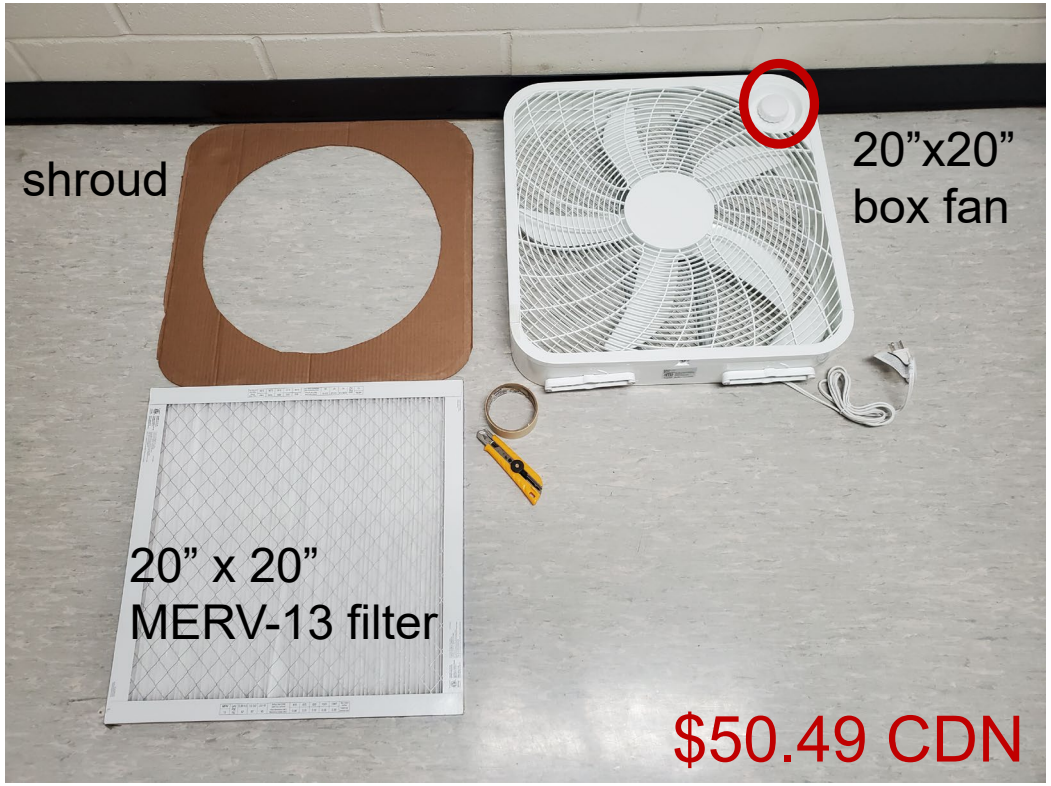
What kinds of DIY air cleaners were included in this review?

- 5 designs, different configurations with the same materials
- There are others out there, but these are simplest and meant to be deployed by the public.

Basic DIY air cleaner designs

1 x 1



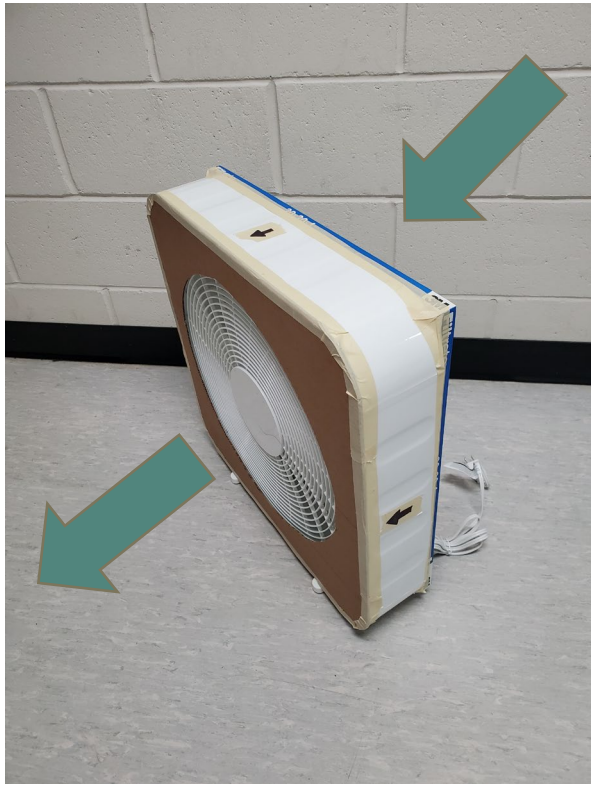


Photo credit: Molly Mastel

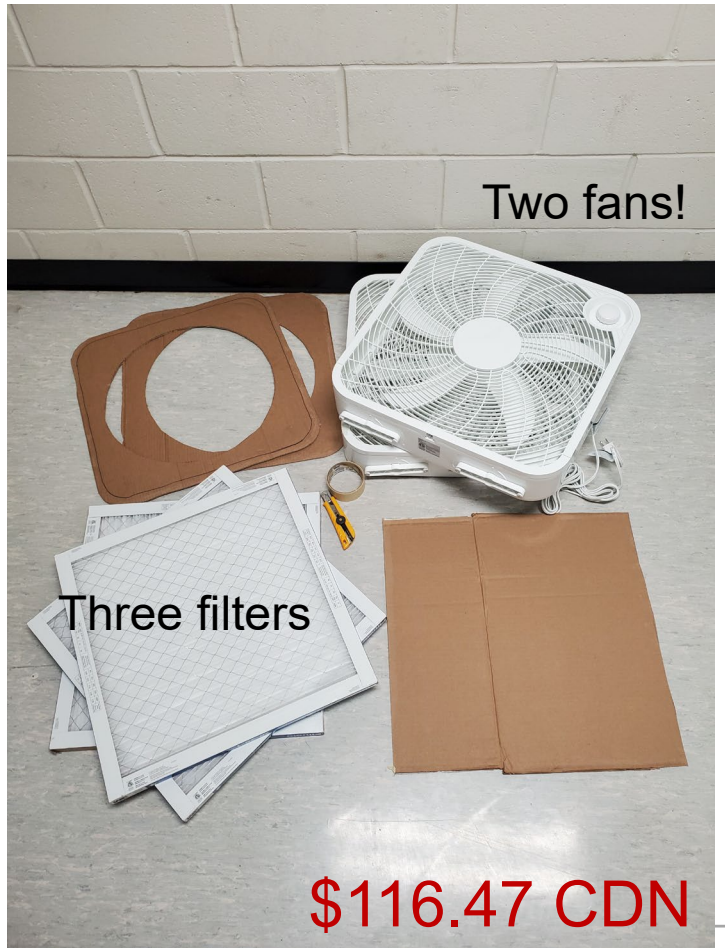
Basic DIY air cleaner designs

2 x 1

Photo credit: Molly Mastel

Basic DIY air cleaner designs

3 x 2



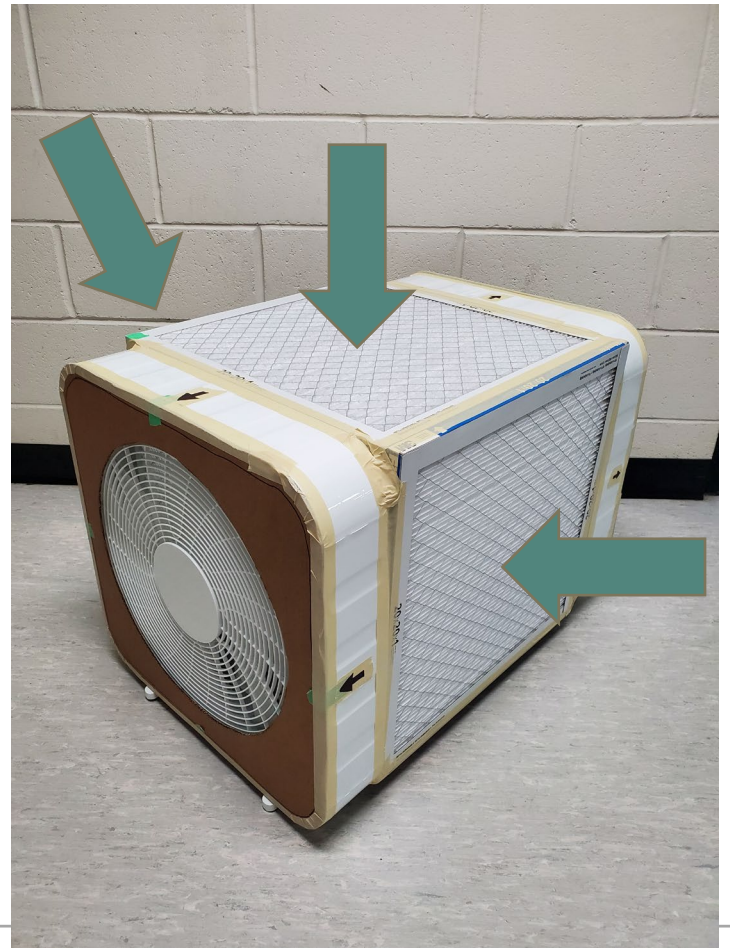


Photo credit: Molly Mastel

Basic DIY air cleaner designs

4 x 1

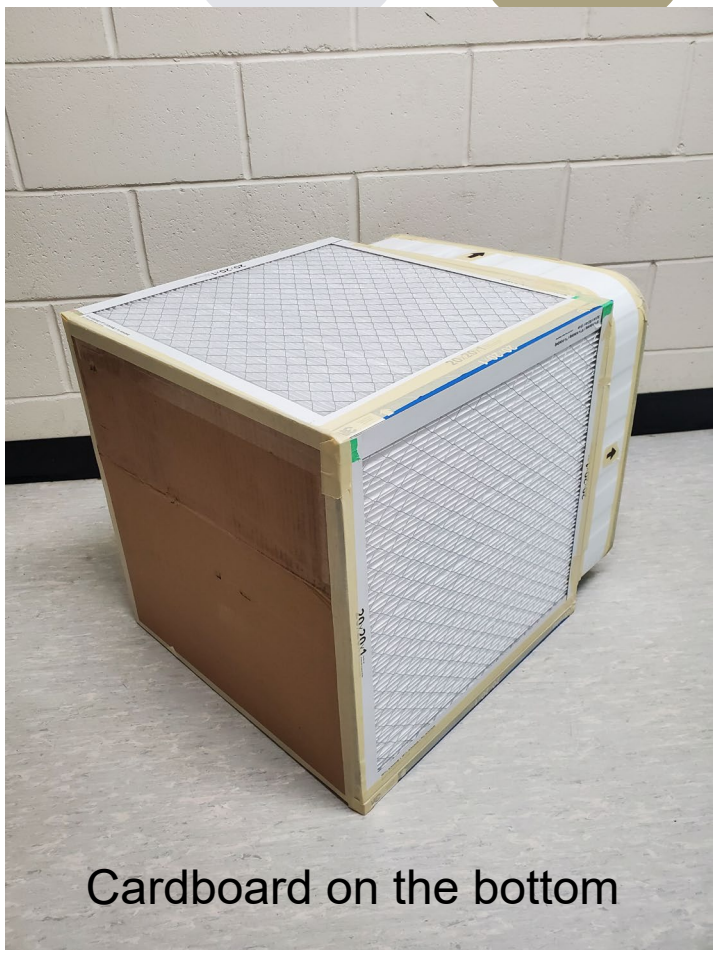


Photo credit: Molly Mastel

Basic DIY air cleaner designs

5 x 1

Filter on the bottom + improvised legs

Photo credit: Molly Mastel

How did DIYs stack up against commercial units?

See the report for the full table

Study	Design (n)	Filter type	CADR (cfm)	Cost per CADR	CADR per watt (cfm/W)	Noise (dB)
Dal Porto et al.[11]	4×1 (n=1)	MERV-13	903	$0.06	8.7	67
	Commercial (n=2)	HEPA	118–300	$0.74–0.86	3.0–3.2	54–59
Holder[25]	1×1 (n=1)	MERV-13	113	$0.27	1.5	67
	Commercial (n=1)	HEPA	108	$0.93	2.0	55
Holder et al.[10]	1×1 (n=1)	MERV-13	156	$0.29	2.0	62
	2×1 (n=1)	MERV-13	263	$0.21	3.5	61
	4×1 (n=1)	MERV-13	401	$0.18	5.3	55
	Commercial (n=1)	HEPA	119	$1.03	2.9	51
Srikrishna[15]	1×1 (n=6)	MERV-13–16	342–645	$0.09–0.12	NR	62–64
	4×1 (n=4)	MERV-13–14	570–652	$0.12–0.14	NR	NR
	3×2 (n=1)	MERV-13	1017	$0.08	NR	NR
	Commercial (n=3)	HEPA	216–354	$0.67–2.07	NR	59–66
Srikrishna[16]	1×1 (n=3)	MERV-13–16	263–360	$0.21–0.36	5.3–7.2	NR
	Commercial (n=4)	HEPA	125–315	$0.64–6.80	NR	NR

How did DIYs stack up against commercial units?

DIYs: <$0.36
HEPA: >$0.65

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How did DIYs stack up against commercial units?

Energy Star thresholds:
1.9 CADR/W for 30 ≤ CADR < 100;
2.4 CADR/W for 100 ≤ CADR < 150,
2.9 CADR/W for CADR ≥ 150

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How did DIYs stack up against commercial units?

Noise measured at highest fan speed

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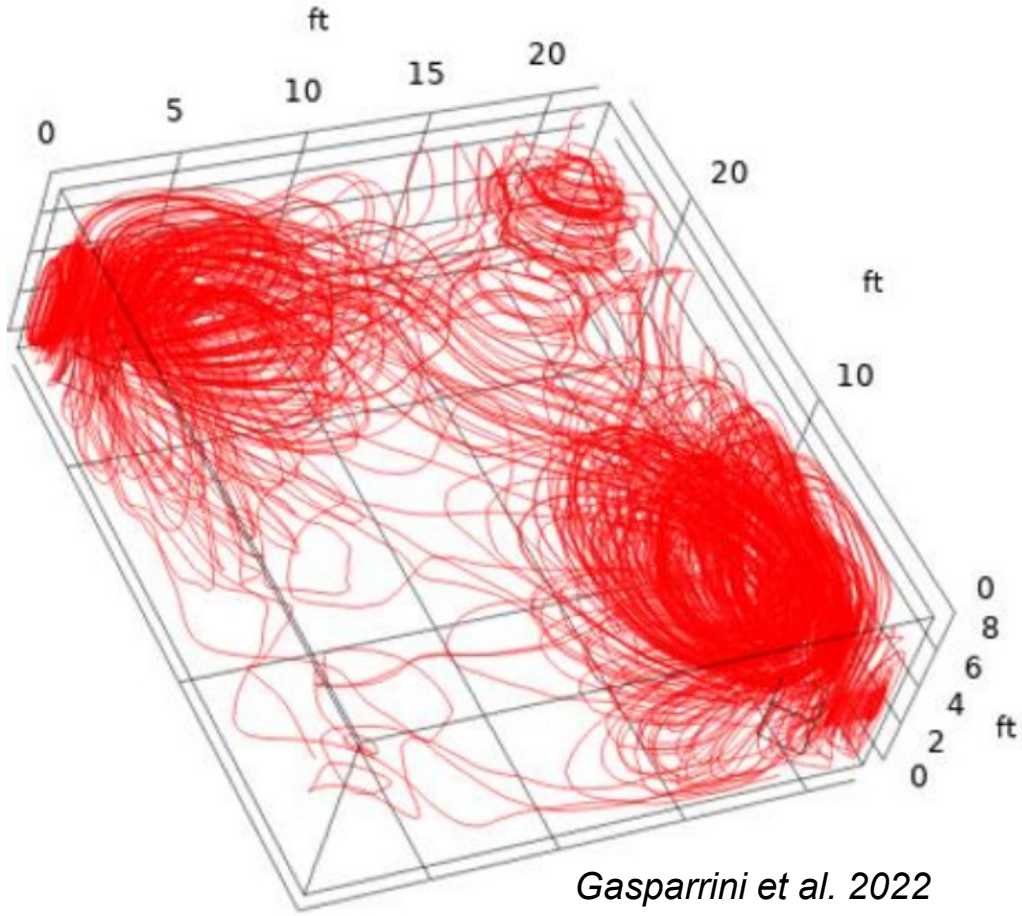
How well do DIY devices work in the real world?

- Only 5 studies
- Longest trial was 6 months; filter efficiency dropped from 92 to 77%, but still working well (no smoke events; Srikrishna 2022)
- Having two devices appeared to provide some mixing (Gasparrini et al. 2022)
- Noise at high fan speed a noted problem; user engagement **not** adequately examined



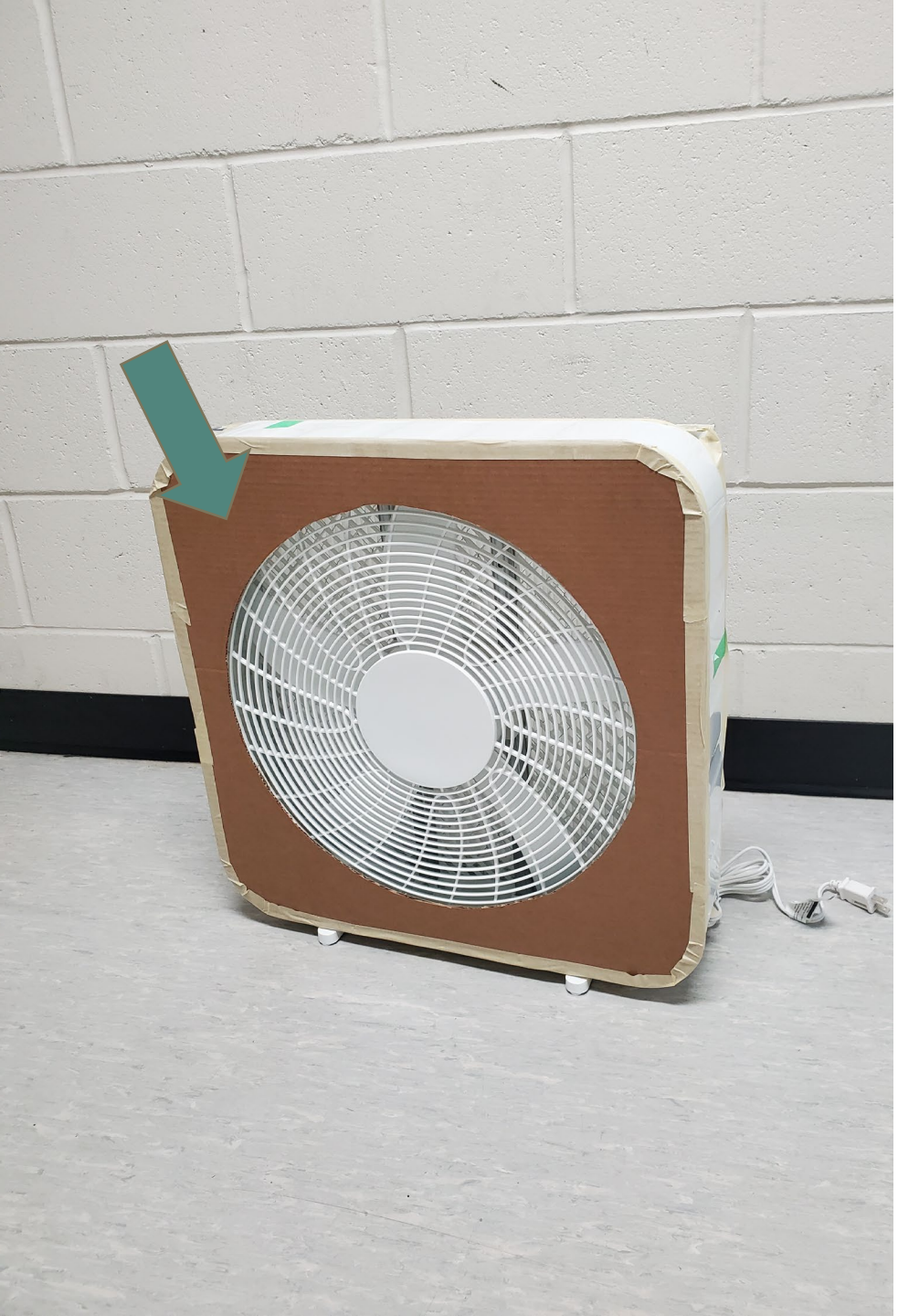
Gasparrini et al. 2022

Poll

- Where are you thinking of deploying a DIY air cleaner???
  - Home
  - School or daycare
  - Office
  - Clinic
  - Other
  - Multiple different spaces

Choose the “right” design for the space

- ***CADR*** and ***cost*** increase with number, thickness and MERV rating of filters, and with number of fans.
  - May need to do some ***prototypes!***
- ***Noise*** depends on fan type, fan speed, and number of fans
- ***Number of devices:*** depending on room size and cost of materials, may be better to have several simple designs than a single more complex unit.
- ***Space:*** cube designs take up more space
- ***Occupants:*** Will occupants use the devices correctly?

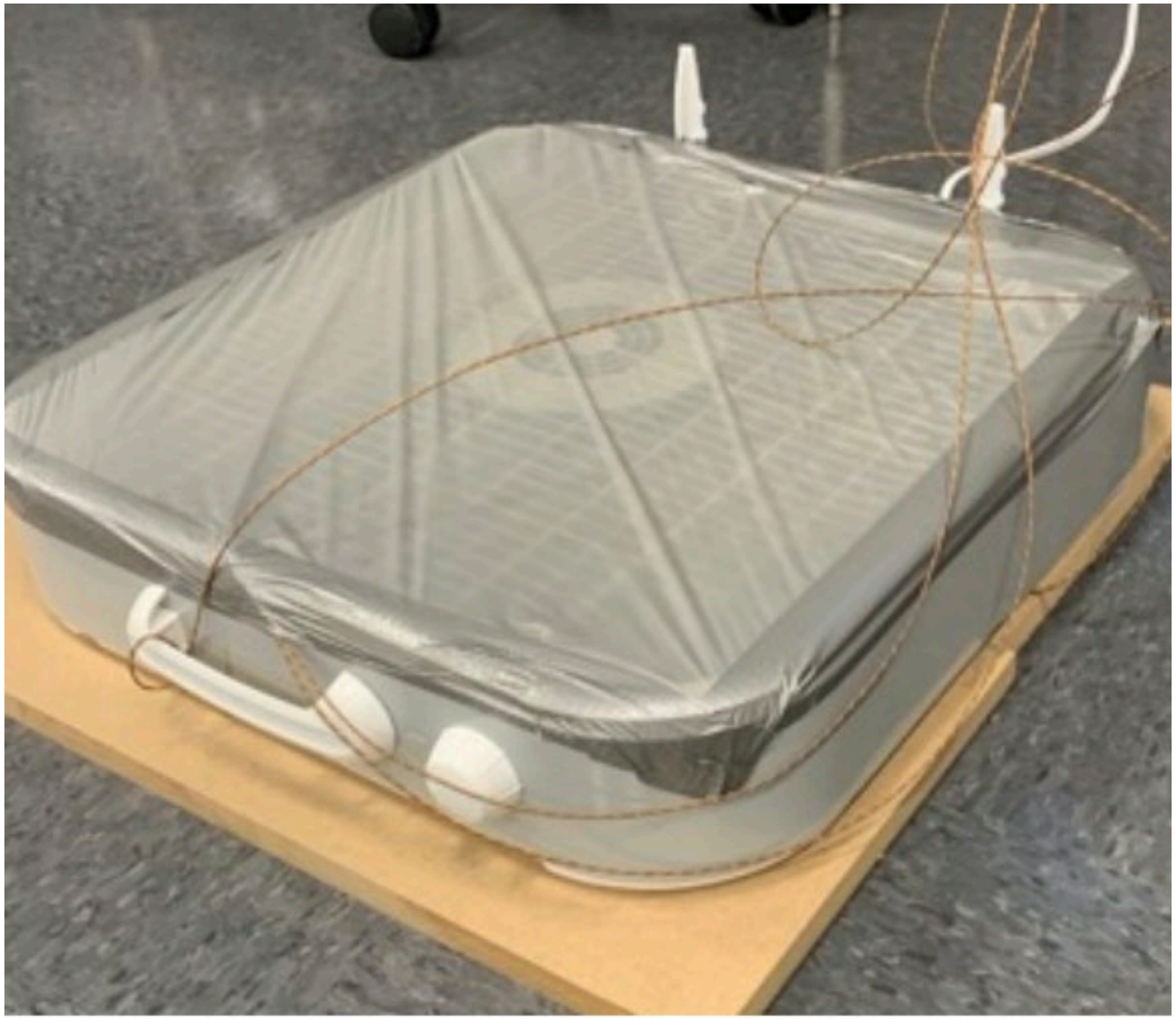


Build it right

- Use a fan shroud:
  - Prevents re-entrainment
  - Holder et al. 2022 saw 40% increase in CADR!
- Use a newer fan with a safety fuse that has been certified by CSA, UL or ETL.
- Seal the gaps well; want the unit to be stable, no bypass
- Make sure direction of air flow is correct.
- EPA **infographic** on how to build a 1x1 design

Use it safely

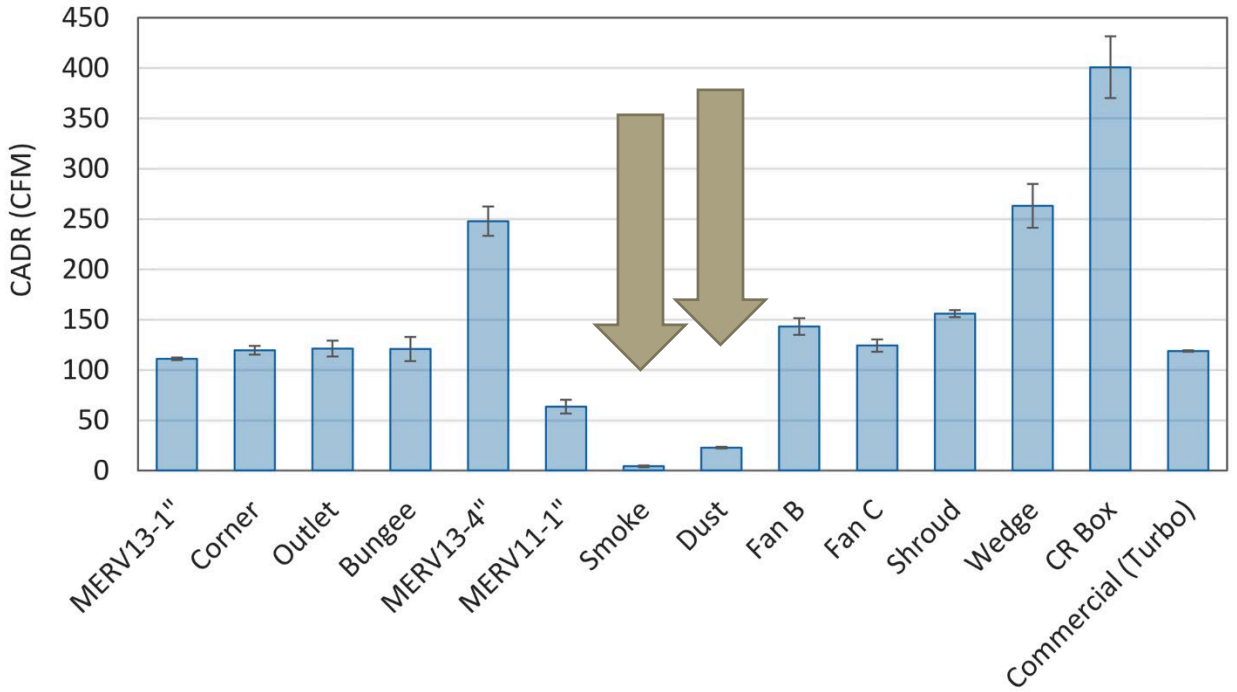
- Concerns about overheating
- Davis and Black 2021:
  - Ran 7 h obstructed on both sides.
  - No risk of burns or ignition but maybe bigger problem during extreme heat event.
  - Use a newer fan with a safety fuse
- High fan speed not necessarily best: more noisy, more drafty, may even kick up particles.



Davis and Black 2021. *Wildfire Safety Research: Evaluation of DIY Air Filtration Report*

Know the hazard you are addressing!

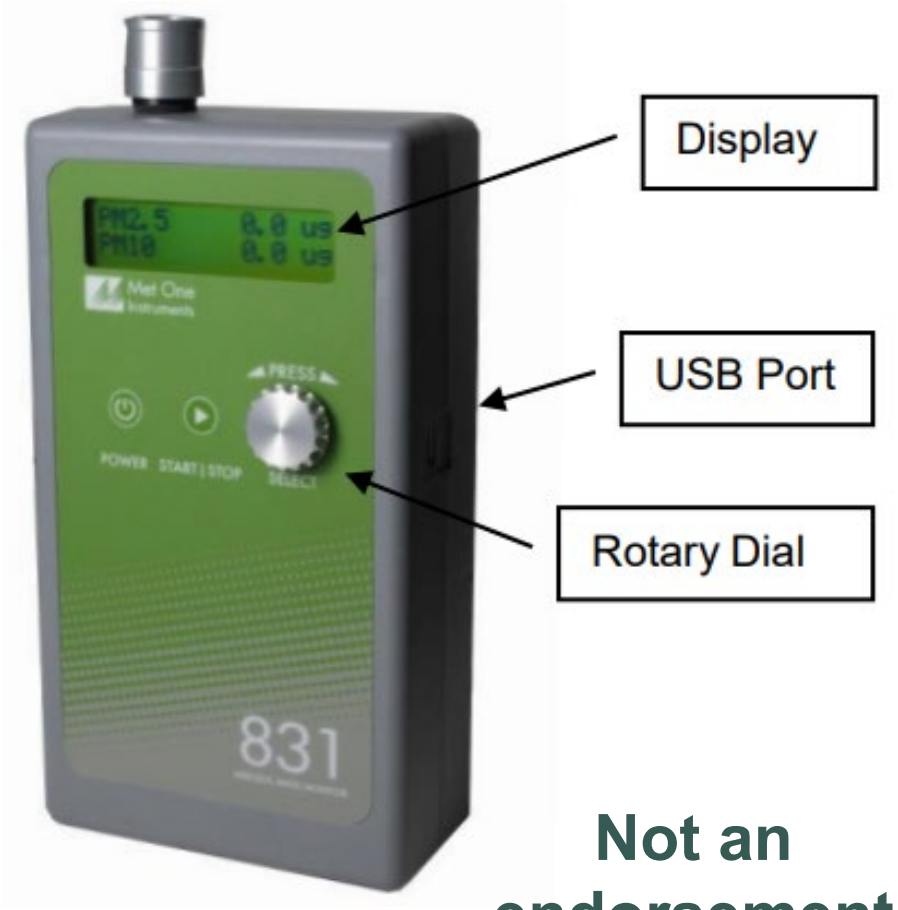
- Smoke (outdoor diffuse source): run with windows closed, vent off, change filter more often
- Virus (indoor point source): increase ventilation while running the air cleaner (increase total ACH)
- Continuous vs. episodic
- Change those filters!
  - Soiling will gradually and then greatly decrease your CADR
  - Soiled filters have all sorts of contaminants: bag them with a mask and gloves



Holder et al. 2022. Impact of do-it-yourself air cleaner design on the reduction of simulated wildfire smoke in a controlled chamber environment.

How do we know it's working?

- Some of the devices used in field studies did not perform as expected!
- Can use **low-cost PM sensors** to see if devices are working
- PM is continuously generated indoors and outdoors
  - **Use two** sensors to understand whether indoor levels are dropping relative to outdoor levels.
- **Check out EPA's Evaluation of Emerging Air Sensor Performance for comparison data.**

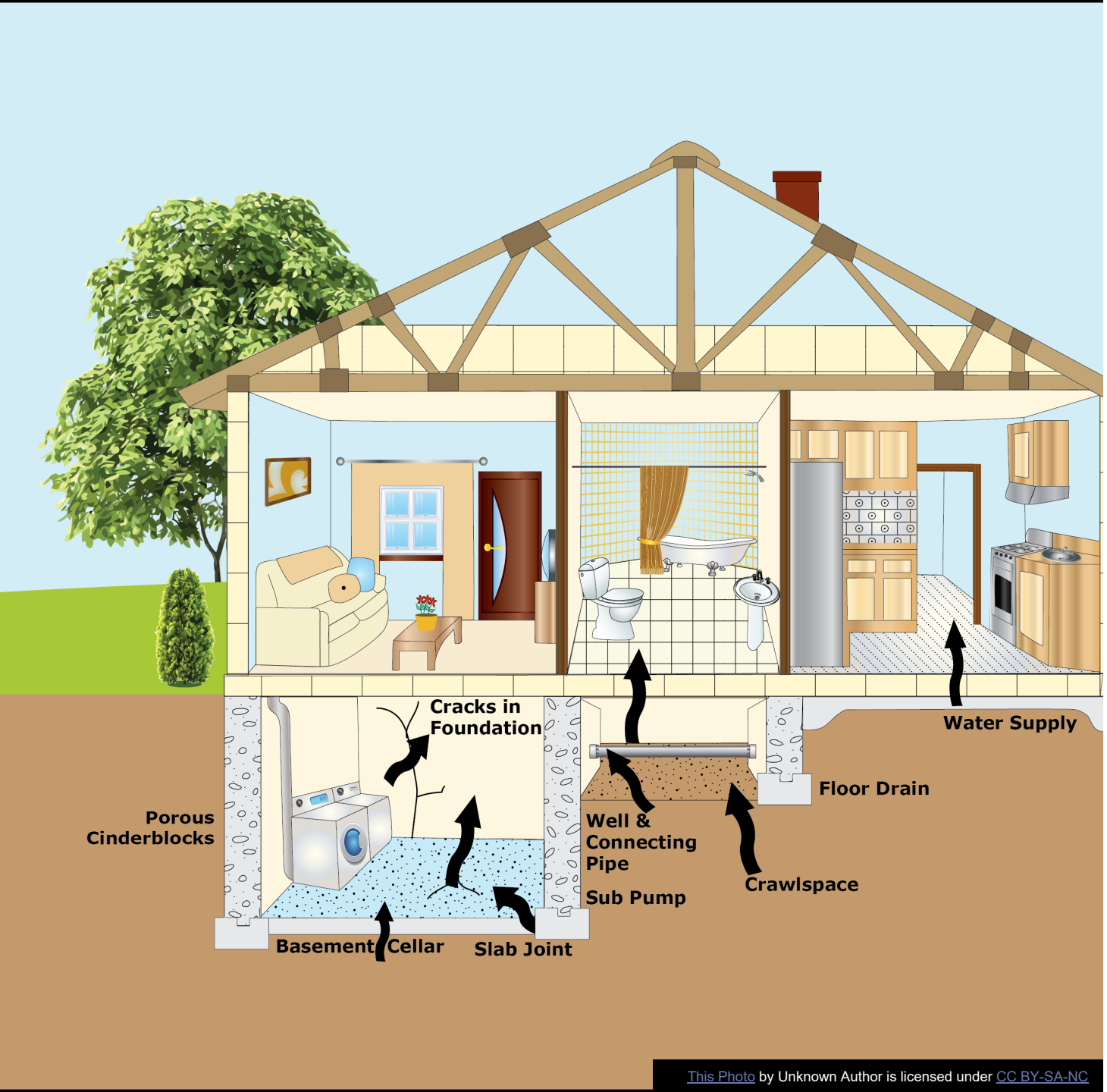


Not an endorsement

☺

How do we know it's working?

- Low-cost air sensors are user friendly, but a little guidance is still required!
- **Newly updated EPA Guidebook!**
  - Selecting a sensor fit for your purpose
  - Using a sensor
  - Designing a monitoring campaign w/ QA/QC
  - Communicating and acting on results



Those pesky limitations….

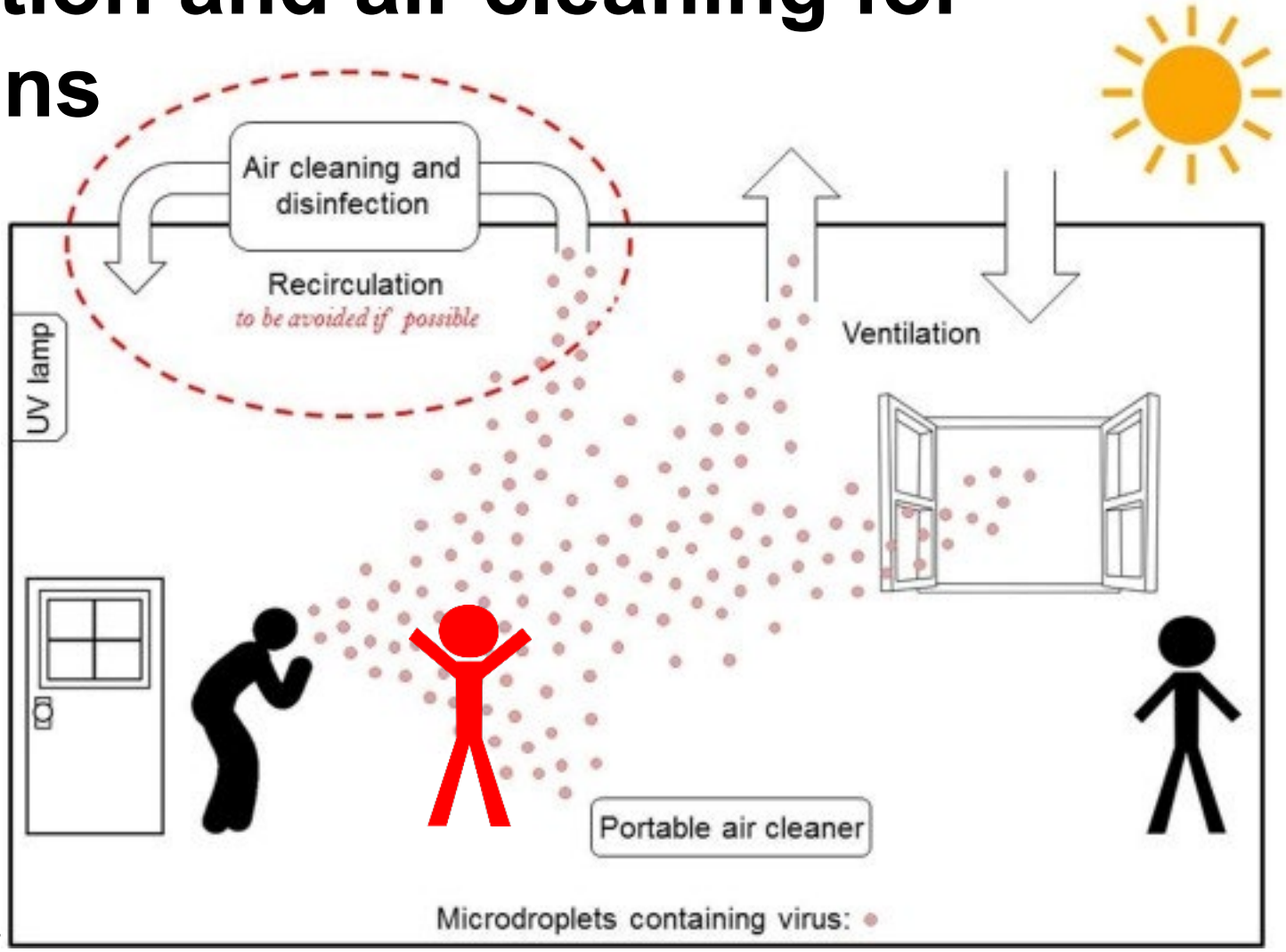
- **DIY air cleaners are NOT "purifiers"**
  - Do not remove **radon**, VOCs, **CO**, or CO_2
- Do NOT replace the need for adequate ventilation
- Use is going to vary depending on what hazard you are dealing with

Those pesky limitations….

- **Do NOT expect occupants to play ball:**
  - CO2 sensing research: effectiveness dependent on occupant willingness and engagement
- Need to plan ahead AND maintain engagement and upkeep over time.
- Not going to be fit for all spaces

The limits of ventilation and air cleaning for respiratory pathogens

- Pathogen has a point source
- Benefit of ventilation/air cleaning is dependent on your **relative position** to the source of pathogen vs. the source of clean air.
- Overall exposure reduced, but not equally.
- **So… do NOT neglect other public health measures**



Adapted from Morawska et al. 2020. Env Int 142:105832

Summary

- In a controlled environment DIY air cleaners with MERV-13 filters perform comparably to commercial devices in reducing indoor particulate matter.
- Less field experience to draw from: data suggest need for QA method and thoughtfulness about how to engage occupants about their use.
- No PAC is a permanent solution to bad ventilation, but rather a supplement or an interim measure

Thank you!

Angela.Eykelbosh@bccdc.ca

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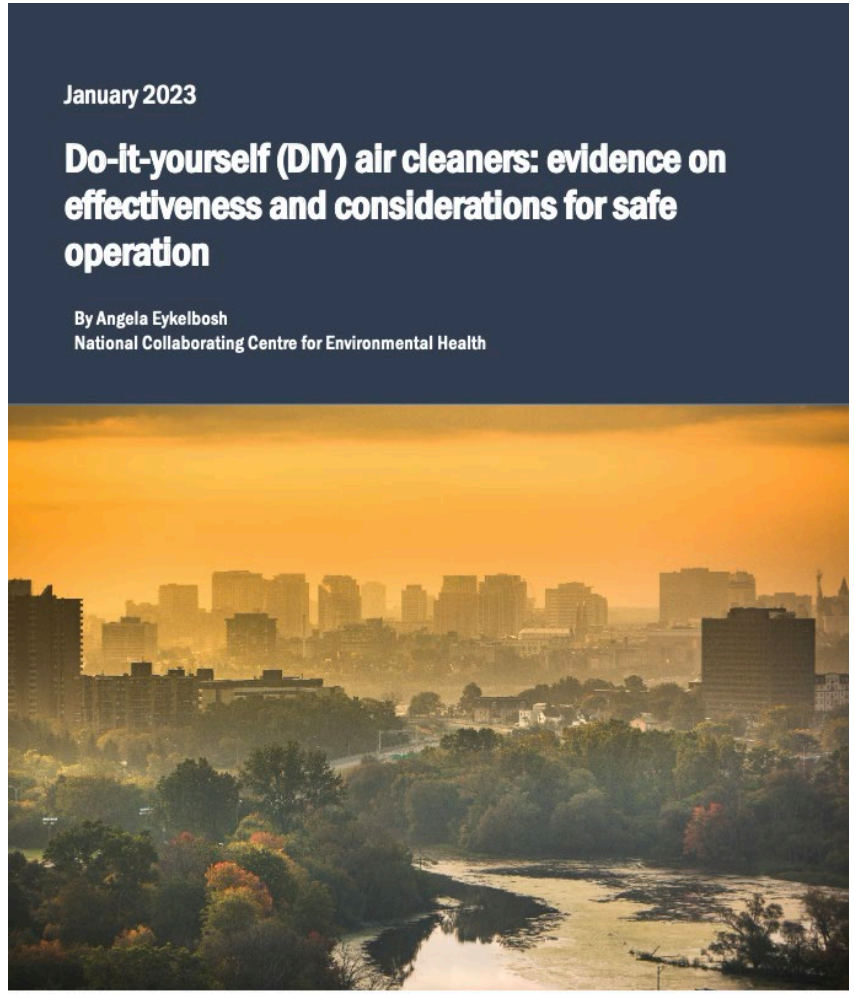

This work was made possible by a financial contribution from the Public Health Agency of Canada.

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