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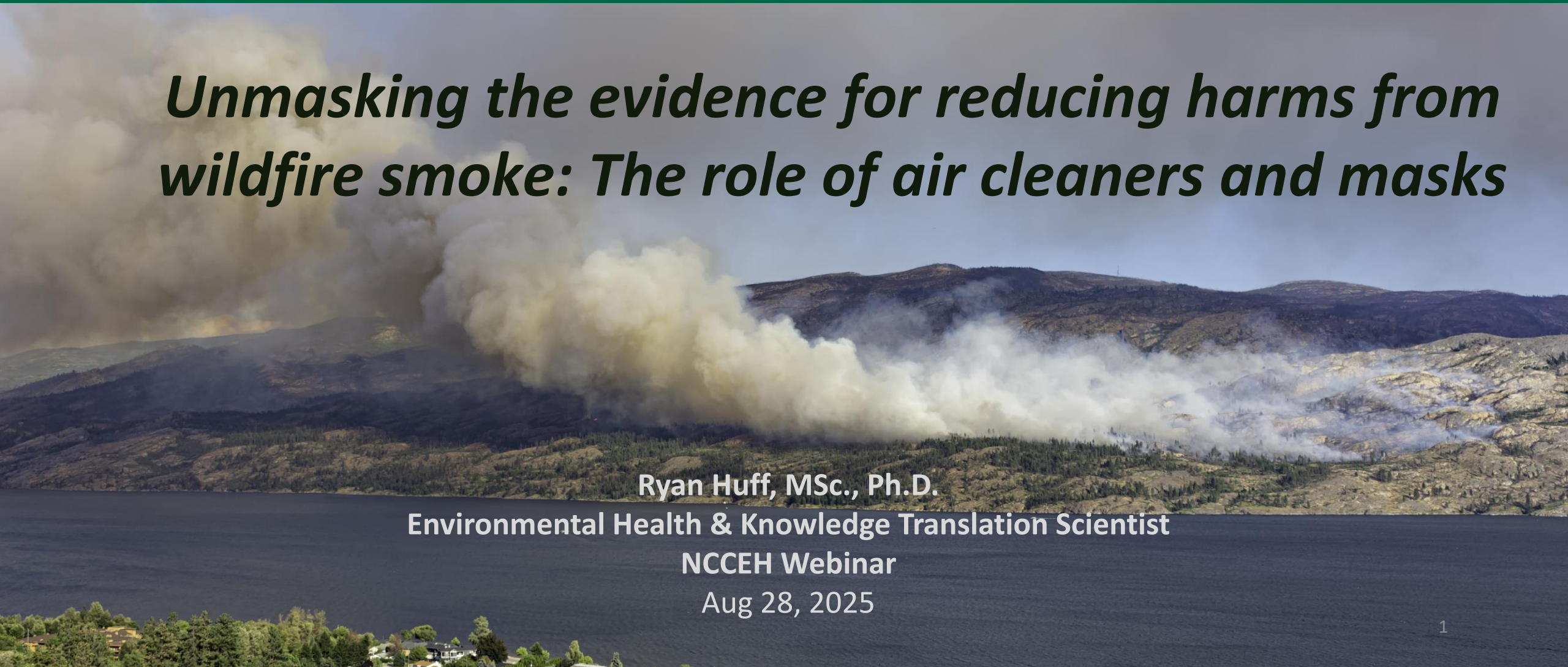
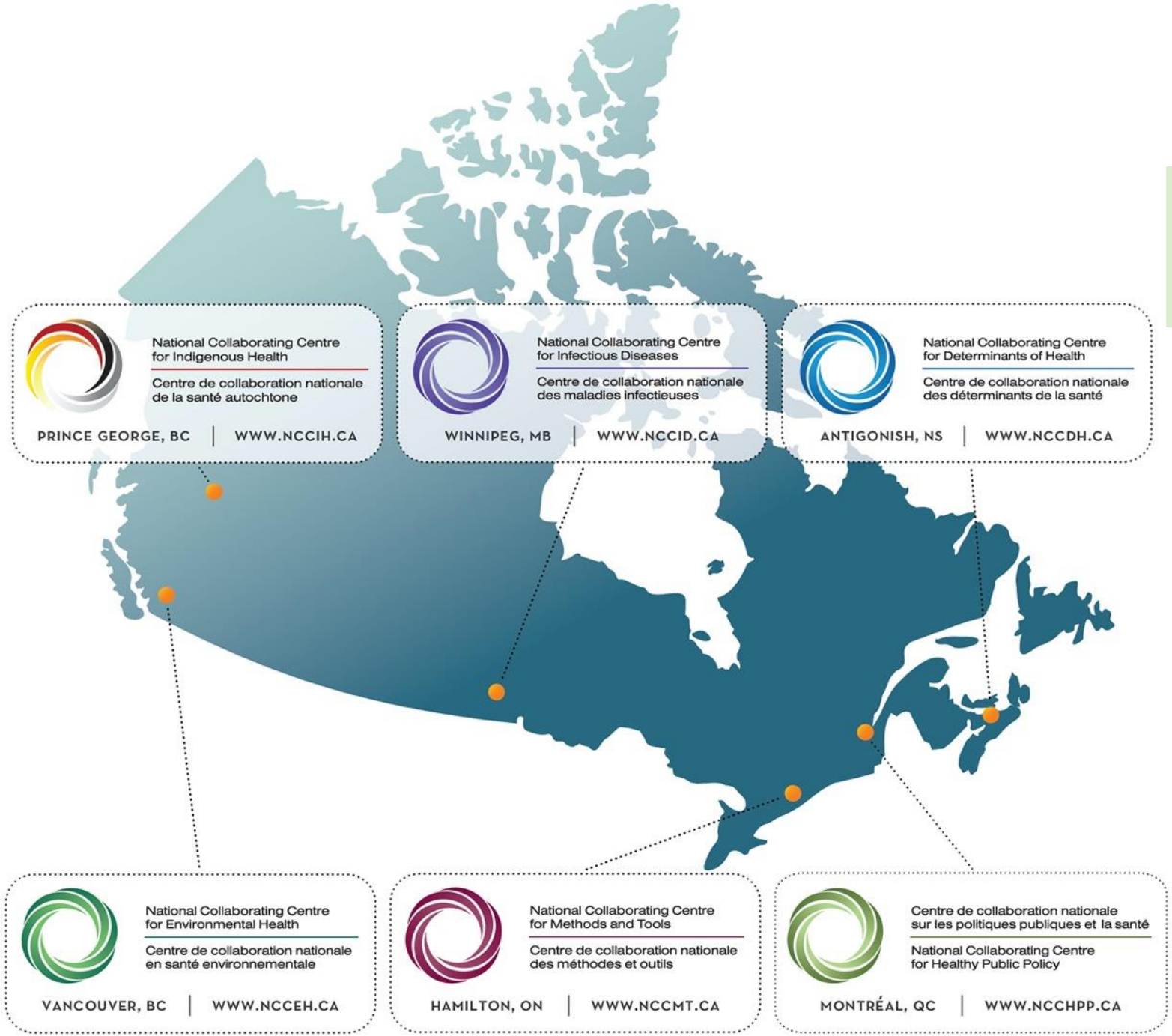


Unmasking the evidence for reducing harms from wildfire smoke: The role of air cleaners and masks

Ryan Huff, MSc., Ph.D.
Environmental Health & Knowledge Translation Scientist
NCCEH Webinar
Aug 28, 2025

Land acknowledgement

The National Collaborating Centre for Environmental Health is located on the unceded and ancestral territories of the xʷməθkwəy̓əm (Musqueam), Skwxwú7mesh (Squamish), and sə̓lílwətaʔ (Tsleil-Waututh) Nations. We recognize the lands, rights, and knowledges of Indigenous Peoples, and the ongoing harms of colonization, and are committed to our role in building a better future.



Evidence-based knowledge synthesis and translation

Identify knowledge gaps

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

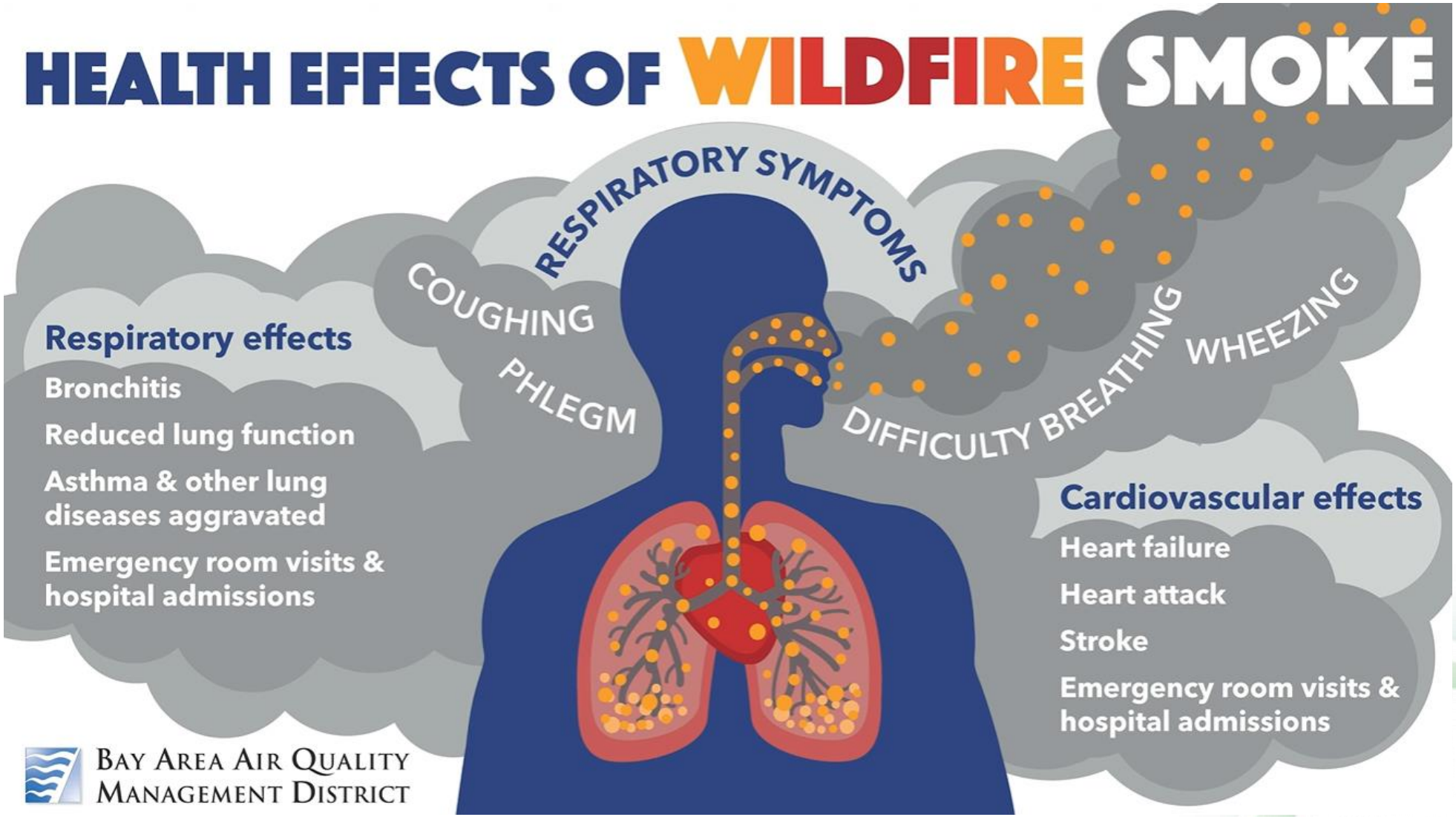
Overview

- Background, purpose, and methods
- Air filtration and air cleaning
  - Technologies
  - Example
  - Considerations and limitations
- Masking
  - Types
  - Example
  - Considerations and limitations
- Summary

Wildfire smoke

- Communities in North America frequently experience periods of **high air pollution** due to drifting **wildfire smoke**

- Wildfire smoke poses significant **health risks**


HEALTH EFFECTS OF WILDFIRE SMOKE
RESPIRATORY SYMPTOMS
COUGHING
PHLEGM
DIFFICULTY BREATHING
WHEEZING
Respiratory effects
Bronchitis
Reduced lung function
Asthma & other lung diseases aggravated
Emergency room visits & hospital admissions
Cardiovascular effects
Heart failure
Heart attack
Stroke
Emergency room visits & hospital admissions
BAY AREA AIR QUALITY MANAGEMENT DISTRICT

Reducing exposure: BC CDC

Wildfire reviews for Health Canada

Purpose: To identify, appraise, and summarize available research evidence to support evidence-informed decision making in public health during episodes of combustion-derived air pollution

Questions:

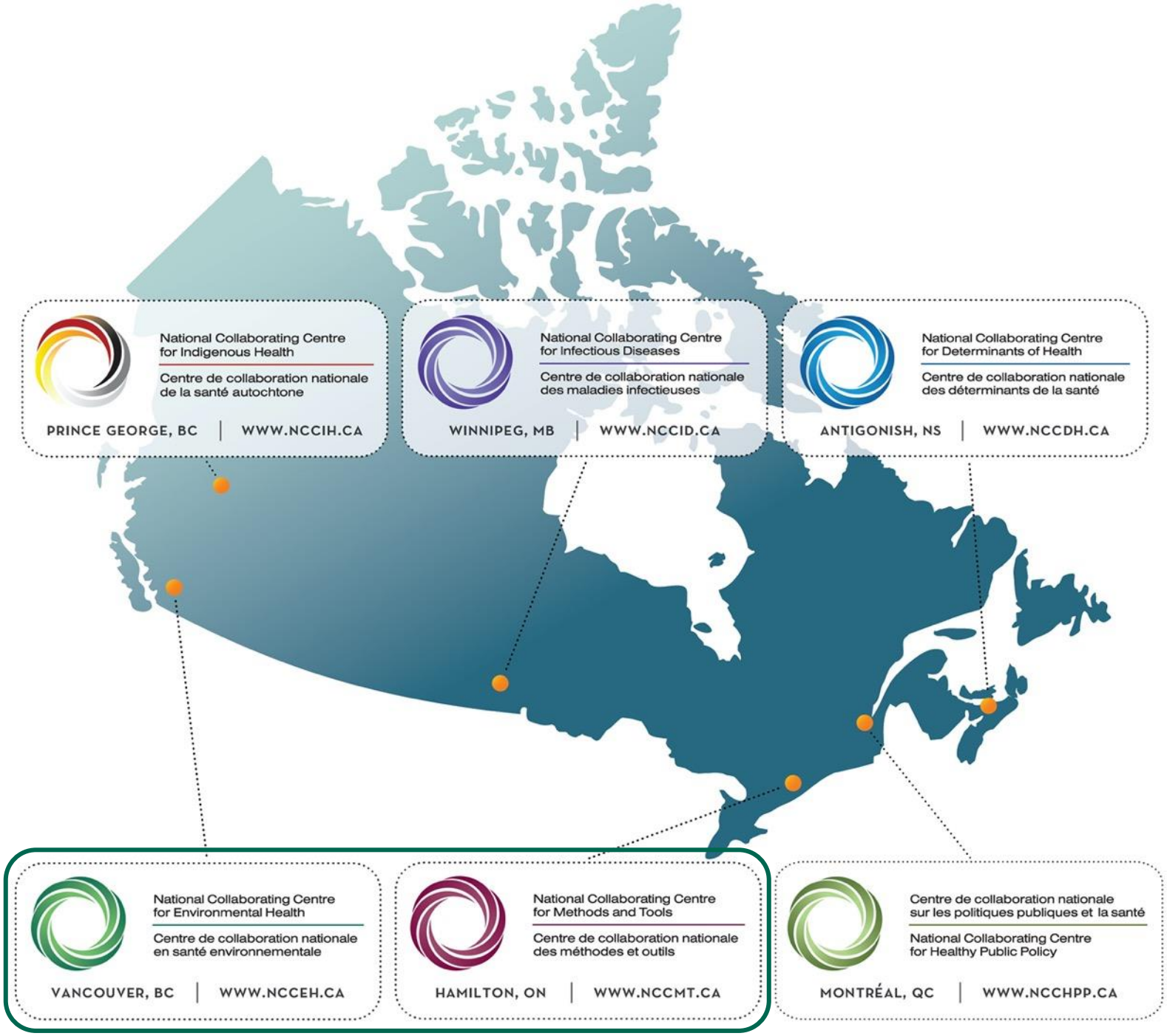
1. What effect does indoor air filtration and air cleaning have on concentrations of pollutants and human health endpoints during combustion-derived air pollution episodes?
   - Prospero: CRD42024550693

2. What effect does wearing a mask or respirator during combustion-derived air pollution episodes have on concentrations of pollutants and human health endpoints?
   - Prospero: CRD42024592977

Collaboration

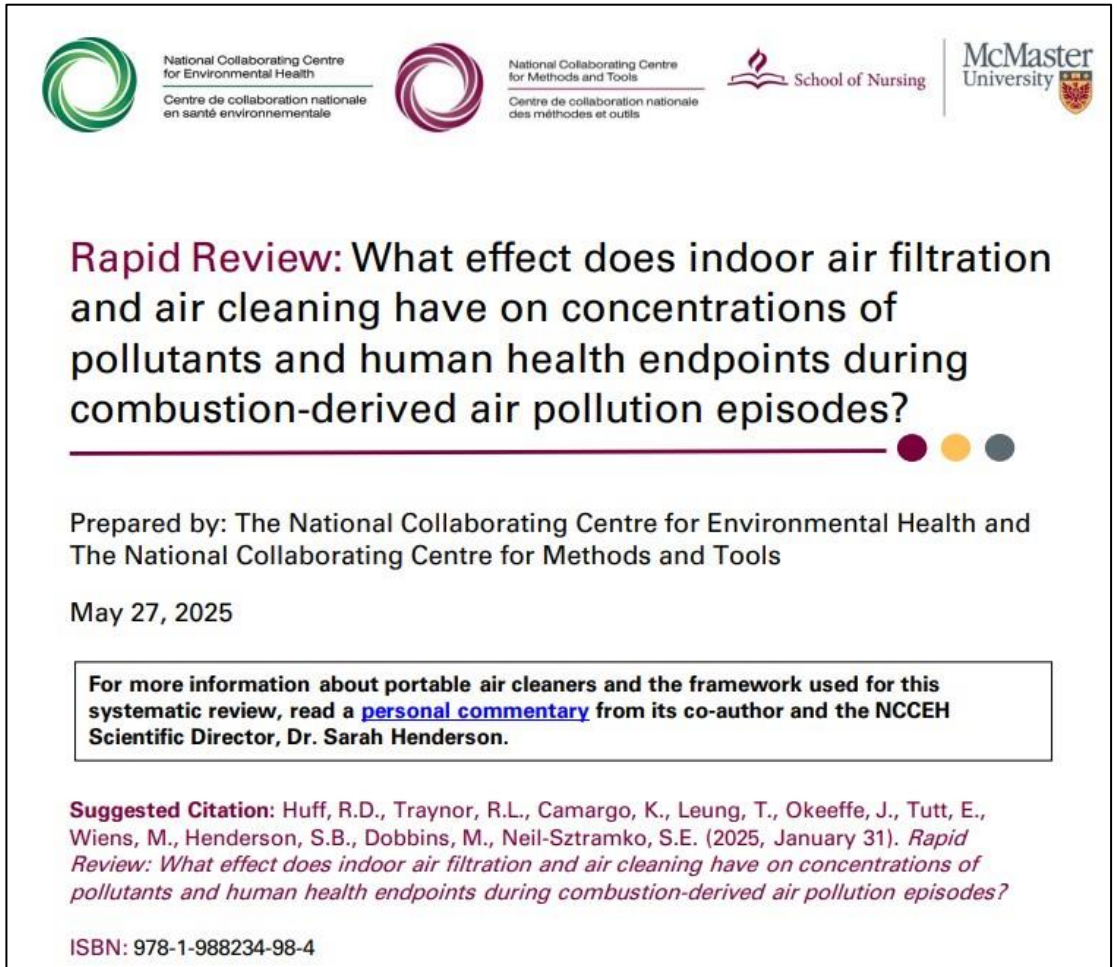
Dr. Sarah Neil-Sztramko

Robyn Traynor



Indoor air cleaners and masking reviews

Both reviews are available and can be accessed on the NCCEH website (https://ncceh.ca)



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School of Nursing
McMaster University

Rapid Review: What effect does indoor air filtration and air cleaning have on concentrations of pollutants and human health endpoints during combustion-derived air pollution episodes?

Prepared by: The National Collaborating Centre for Environmental Health and The National Collaborating Centre for Methods and Tools

May 27, 2025

For more information about portable air cleaners and the framework used for this systematic review, read a personal commentary from its co-author and the NCCEH Scientific Director, Dr. Sarah Henderson.

Suggested Citation: Huff, R.D., Traynor, R.L., Camargo, K., Leung, T., Okeeffe, J., Tutt, E., Wiens, M., Henderson, S.B., Dobbins, M., Neil-Sztramko, S.E. (2025, January 31). *Rapid Review: What effect does indoor air filtration and air cleaning have on concentrations of pollutants and human health endpoints during combustion-derived air pollution episodes?*

ISBN: 978-1-988234-98-4

National Collaborating Centre for Environmental Health
Centre de collaboration nationale en santé environnementale
National Collaborating Centre for Methods and Tools
Centre de collaboration nationale des méthodes et outils
School of Nursing
McMaster University

Rapid Review: What effect does wearing a mask or respirator during combustion-derived air pollution episodes have on concentrations of pollutants and human health endpoints?

Prepared by: The National Collaborating Centre for Environmental Health and The National Collaborating Centre for Methods and Tools

Date: July 16, 2025

Suggested Citation: Huff, R.D., Traynor, R.L., Camargo, K., Okeeffe, J., Tutt, E., Wiens, M., Henderson, S.B., Dobbins, M., Neil-Sztramko, S.E. (2025, July 16). *Rapid Review: What effect does wearing a mask or respirator during combustion-derived air pollution episodes have on concentrations of pollutants and human health endpoints?*

Air filtration and air cleaning

Definitions

Combustion-derived air pollution episode: Unusual episodes of air pollution caused by combustion events such as wildland, coal mine fires, peat fires, interface fires, landscape fires, agricultural fires, prescribed burns, industrial fires, landfill fires, tire fires, any multi-day structural fires, and residential wood combustion. This definition does not include air pollution generated from the combustion of fossil fuels (e.g., traffic-related air pollution (TRAP) or industrial processes).

Wildfire air pollution episode: Unusual episodes of air pollution caused by combustion events such as wildland, forest, peat fires, interface fires, landscape fires, agricultural fires, and prescribed burns.

Haze air pollution episode: Unusual episodes of air pollution caused by regional uncontrolled forest and peatland fires, and open biomass burning in Southeast Asia.

Methods

- Comprehensive search of the peer-reviewed literature and manual searches of relevant special issues over the last 20 years.

Air filtration

- 6344 references screened
- 30 references included
  - 12 wildfire
  - 8 residential wood smoke
  - 2 wildfire/ residential wood smoke
  - 5 haze
  - 3 laboratory/chamber

Masking

- 735 references screened
- 3 references included
  - 3 laboratory

Methods: Appraisal of Evidence Quality

- **Quality:** Joanna Briggs Institute (JBI) critical appraisal tools used to evaluate the individual references

- **Certainty:** Grading of Recommendations, Assessment, Development and Evaluations (GRADE) was used to rate the confidence in effect estimates (i.e., $PM_{2.5}$ concentrations) of the intervention (i.e., air cleaner) across all references

Factors that can <u>reduce</u> GRADE rating

- Limitations in study design or execution (risk of bias)
- Inconsistency of results
- Indirectness of evidence
- Imprecision
- Publication bias

Factors that can <u>increase</u> GRADE rating

- Large magnitude of effect
- All plausible confounding would reduce the demonstrated effect or increase the effect if no effect was observed
- Dose-response gradient

Air filtration

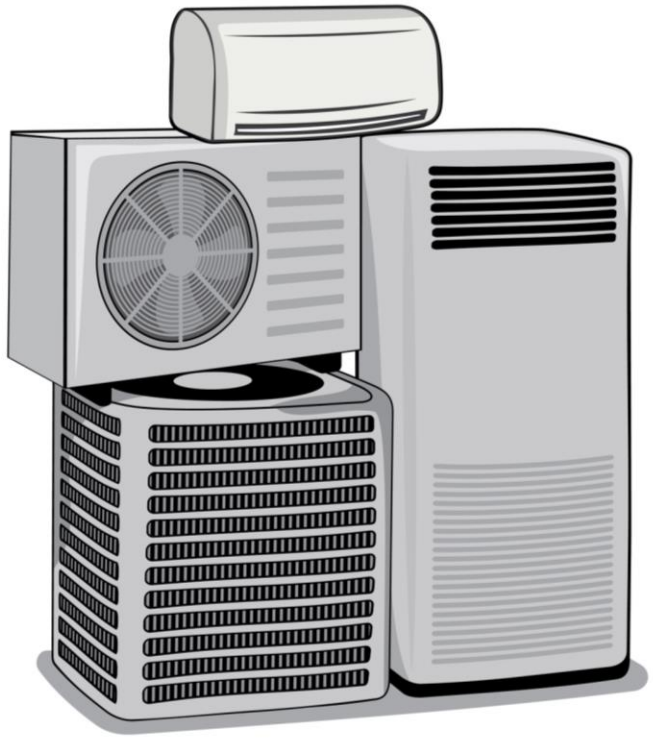
Air filtration and air cleaning in our review referred to passing indoor air through any technology designed to reduce pollutant concentrations, include filters, electrostatic precipitators, sorbent materials (i.e. activated charcoal), and additive technologies (ionizers, plasma, ozone generators)

What kinds of air filters and technologies were included?

- **High efficiency particulate air (HEPA) filters**: Pleated mechanical air filter that removes at least 99.97% of dust, pollen, mold, bacteria, and any airborne particles with a size of 0.3 µm
- **Minimum Efficiency Reporting Value (MERV) 13 filters**: Mechanical air filter that removes at least 50 percent of 0.3–1 µm particles
- **Sorbent Filters**: A high surface area material that captures gaseous pollutants (e.g. activated charcoal)
- **Electrostatic precipitator**: A device that charges particles, which then become attracted to oppositely charged plates or other indoor surfaces
- **Ionizer**: ion generators produce negative ions that attach to airborne particles, increasing how fast they settle on surfaces

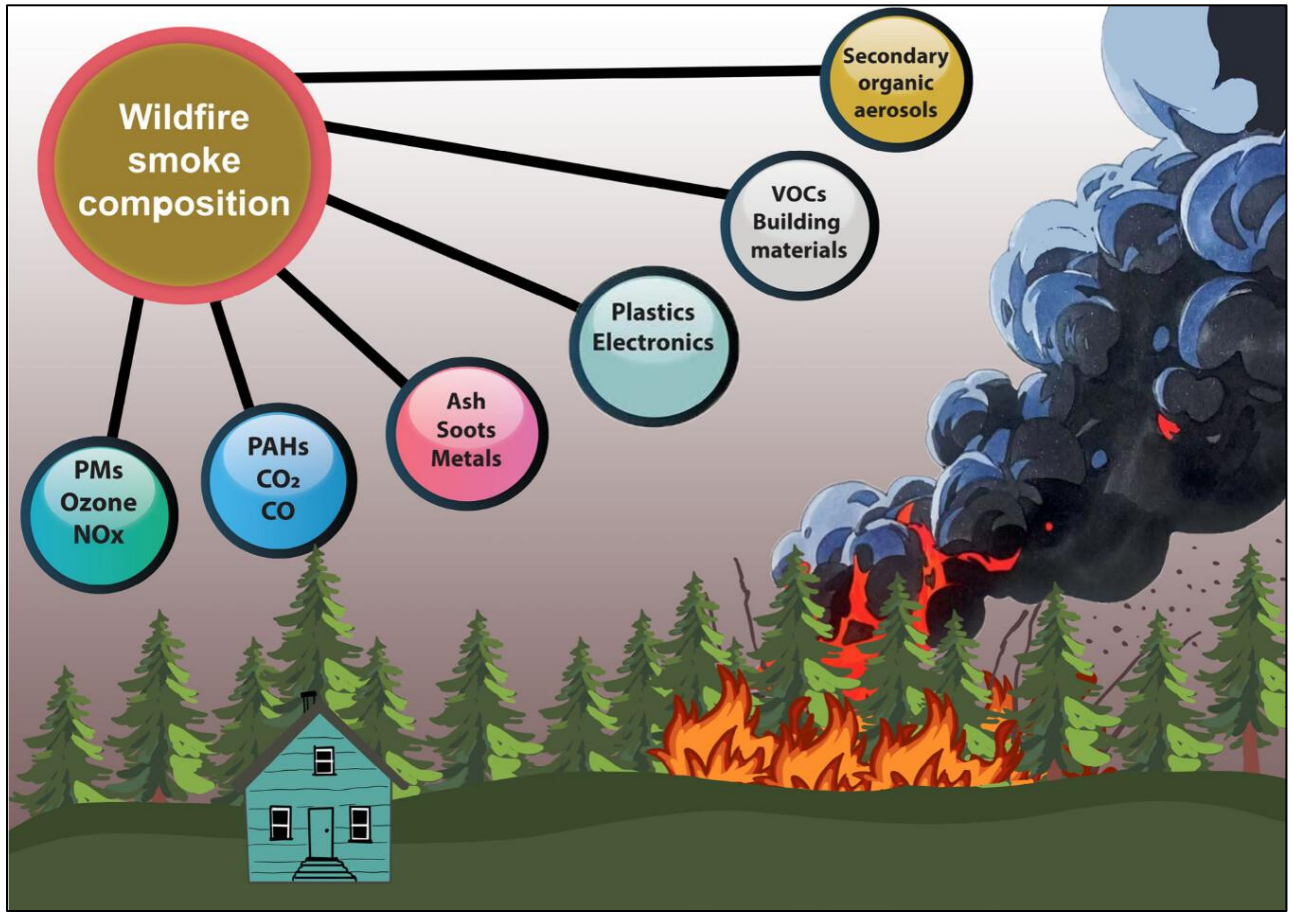
https://www.epa.gov/indoor-air-quality-iaq/air-cleaners-and-air-filters-home

What kinds of air filters and air cleaners were included?



- 25 of 30 examined the use of portable air cleaners (PACs)
  - HEPA filter (n =2),
  - HEPA combined with an activated charcoal filter (n = 9)
  - HEPA and activated charcoal filter combined with an ionizer (n = 3)
  - MERV 13 electrostatic filter (n = 10)
  - Electrostatic precipitation filtration combined with a charcoal filter (n = 1).
- HVAC electrostatic precipitator (n = 1)
- HVAC MERV 11 electrostatic filter (n = 1)
- Fan filter unit (n = 1)

What kind of pollutants were measured?



Environ. Sci. Technol. 2024, 58, 48, 21097-21119

- PM (n=26)
  - $PM_{2.5}$ (n=16)
- VOCs (n=2)
- Ions and trace elements (n=1)

Example study

International Journal of *Environmental Research and Public Health*

MDPI

Article

Can Public Spaces Effectively Be Used as Cleaner Indoor Air Shelters during Extreme Smoke Events?

Amanda J. Wheeler [1,2,*], Ryan W. Allen [3], Kerryn Lawrence [4], Christopher T. Roulston [5], Jennifer Powell [5], Grant J. Williamson [6], Penelope J. Jones [2], Fabienne Reisen [5], Geoffrey G. Morgan [7] and Fay H. Johnston [2]

- **Location:** Media room (22 m^2), Port Macquarie Library, Port Macquarie, New South Wales, Australia
- **Air cleaner:** 2x Cli-Mate AP20 (Aquaport Corporation Pty Ltd.), 20 m^2 capacity, HEPA and activated charcoal filters, CADR: 133 m^3/h for tobacco smoke, set to medium
- **Air sampling period:**
  - 53 days with PAC on and 41 days with PAC off,
  - Only periods with 24-h mean outdoor $PM_{2.5}$ concentrations ≥ 20 µg/m^3
- **Results:**
  - Outdoor $PM_{2.5}$ median (25%-75%) (µg/m^3):
    - PACs on: 23.3 (12.0-49.1)
    - PACs off: 30.7 (12.2-85.9)
  - Indoor $PM_{2.5}$ percent (median (25-75%) µg/m^3)
    - PACs on: 5.7 (5.5-8.5)
    - PACs off: 20.0 (10.5, 39.0)
  - **Percent reduction 72%**

Key takeaways on effectiveness: PM

- Air filtration and air cleaning and overall **Indoor $PM_{2.5}$** mass concentrations
  - Average percent reduction = **56%** (5.3 – 99% range, 17 studies)
  - Average µg/m^3 reduction = **18 µg/m^3** (1.6 – 75 µg/m^3 range, 14 studies)
  - The certainty of evidence, specifically with respect to the magnitude of the effect, is **low (GRADE)** due to risk of bias, indirectness of evidence, and imprecision

- Wildfire studies with **outdoor $PM_{2.5}$ over 27 µg/m^3** (CAAQS guideline)
  - Average indoor percent reduction = **66%** (34 – 99% range, 5 studies)
  - Average µg/m^3 reduction = **19.2 µg/m^3** (2.6 – 39.6 µg/m^3 range, 5 studies)
    - Without PAC (ug/m3): 31.8 µg/m^3 (5.2 – 64 µg/m^3 range)
    - With PAC (ug/m3): 16 µg/m^3 (0.4 – 30.7 µg/m^3 range)

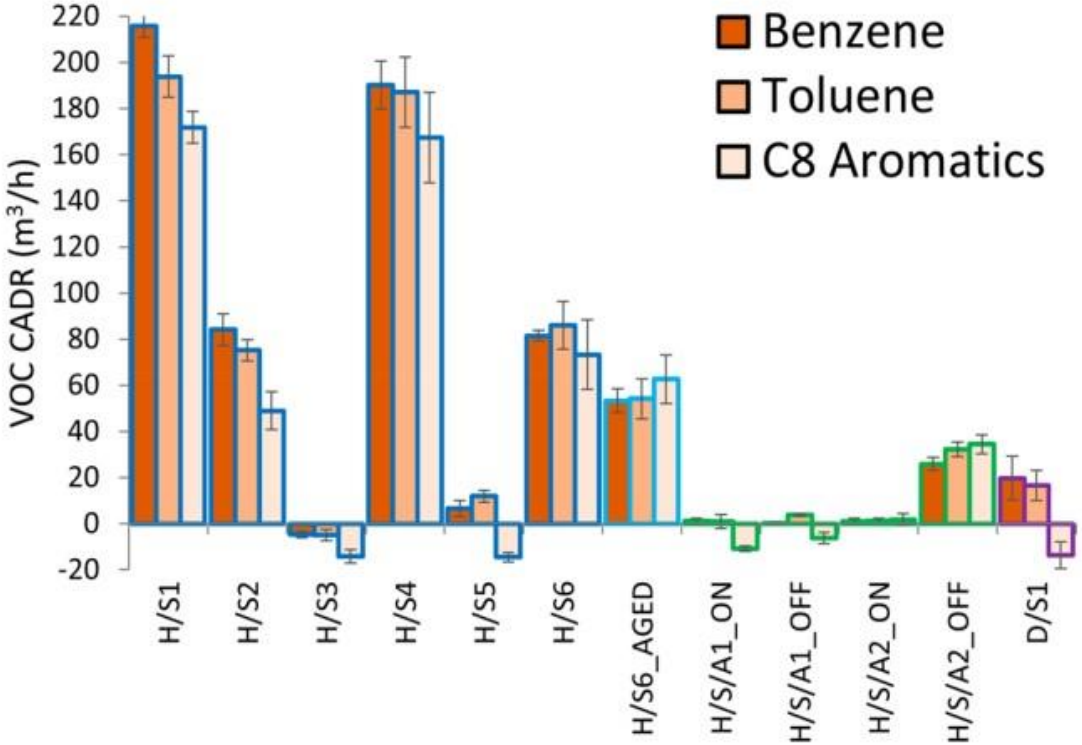
Key takeaways on effectiveness: PM

- Air filtration and air cleaning and overall **$PM_{2.5}$ I/O ratios**
  - Average pre- or placebo intervention = **0.69** (0.28 –1.3 range, 13 studies)
  - Average post-intervention = **0.37** (0.003 –0.87 range, 13 studies)
  - Certainty of evidence, specifically with respect to the magnitude of the effect, is **low (GRADE)** due to risk of bias, indirectness of evidence, and imprecision

- Air filtration and air cleaning and **$PM_{2.5}$ I/O ratios** during wildfires
  - Average pre- or placebo intervention = **0.68** (0.31 –0.93 range, 9 studies)
  - Average post-intervention = **0.34** (0.003 –0.8 range, 9 studies)

Key takeaways on effectiveness: VOCs

- **Insufficient evidence** to evaluate the effects of air filtration and air cleaning on indoor concentrations of **gaseous pollutants such as VOCs**.
- Test-chamber study (right) using pine needle smoke and commercial PACs with HEPA filters combined with activated charcoal filters
- Benzene and toluene CADRs > 75 m^3/h for 4 of 6 commercial PACs



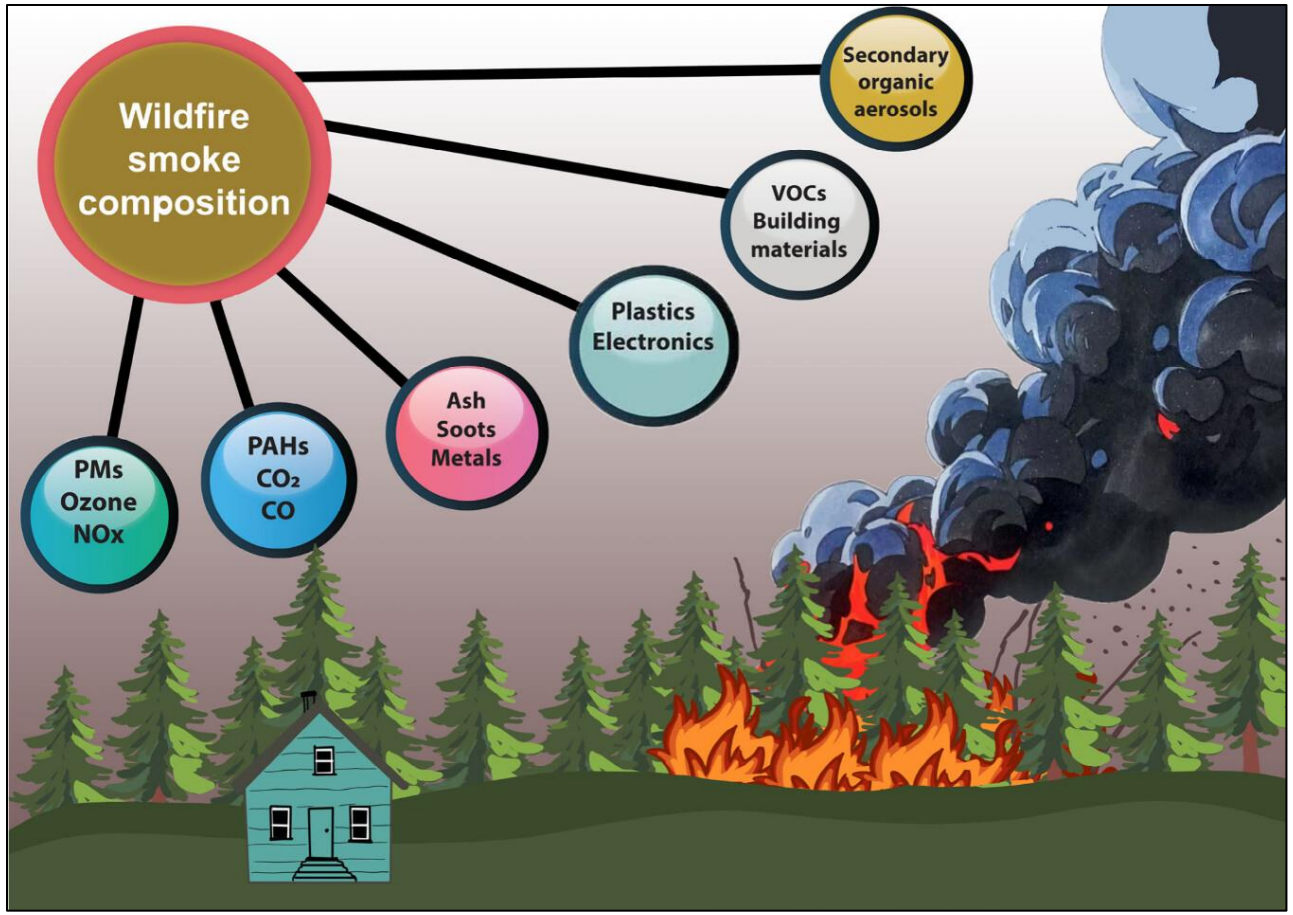
Letter code: H, high-efficiency particle filters; S, sorbents, typically activated carbon filters or banks; A, additive mechanisms (ionization, H2O2 generation, and/or humidification); and D, MERV 13 furnace filters affixed to a box fan (DIY designs)

Stinson *et al. ACS ES&T Air* 2024, 1, 6, 492-501

Considerations and limitations

- Range of technologies (both do-it-yourself (DIY) and commercial)
- Capacity - Clean air delivery rate (CADR) varied
  - CADR: how quickly the device can remove particulate matter from room air compared to natural “decay” alone.
  - Units: cubic meters per hour (m^3/hr) or cubic feet per minute (CFM)
  - AHAM suggested room size is based on 4.8 air changes per hour
- Placement varied in homes, offices, or facilities (including a school, senior assisted living complex, and a homeless shelter)
- Windows, doors, and air changes per hour

Considerations and limitations



- Air filtration and air cleaners do not filter all pollutants
- Ventilation for many houses allows the venting of VOCs, radon, CO, or CO_2

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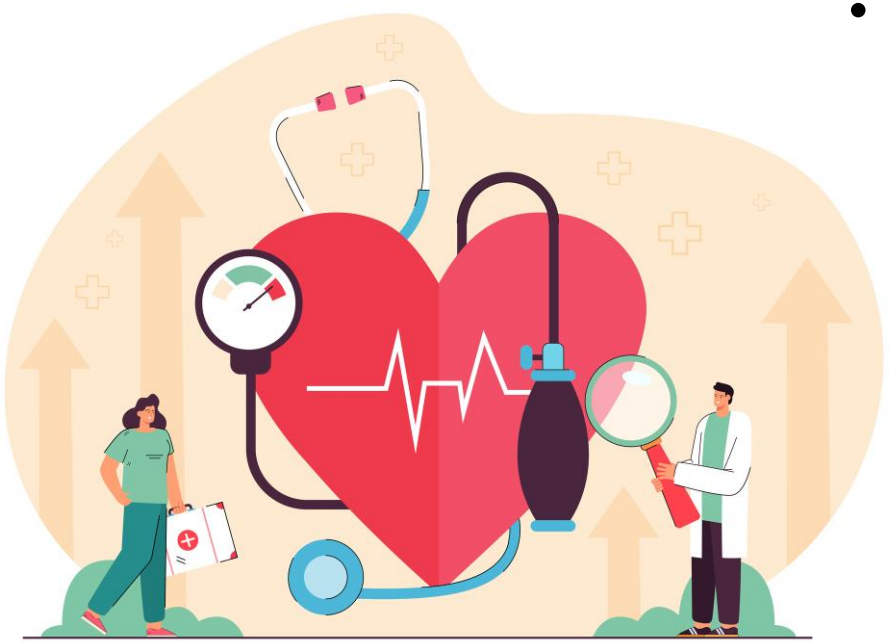
What about air filtration and health outcomes?



- Four studies reported health outcomes (one wildfire study)
- **Uncertain** if air filtration improves cellular-level health outcomes or improves self-reported physical health outcomes
  - **Cellular level:** One RCT (n=45) found that systemic inflammation and impaired endothelial function (i.e., predictors of cardiovascular morbidity) were positively impacted by HEPA filtration use, while another (n=29) reported no effect.
  - **Self Report:** One small quasi-experimental study (n=27) and one RCT (n=93) reported no effect (i.e., asthma symptoms (daytime/nighttime coughing or wheezing, activity limitations, use of asthma medication), and physical, mental or all-cause symptoms)

Masks

Definitions

Mask: Refers to a covering worn over the mouth and nose made of natural or synthetic materials. This includes both natural and synthetic cloth masks and surgical and procedural medical masks.

Respirator: Refers to a well-fitting disposable respirator or filtering facepiece respirator (e.g., N95, KN95, FFP, R95, P95, etc.). This term does not include elastomeric half- or full-face respirators that use disposable cartridges or powered air-purifying or supplied-air respirators.

Masks and exposure

- Personal exposures is governed by several key factors
  - Filtration efficiency: The percentage of particles the mask material can block
  - Bypass rate: The quantity of particles that flow around mask edges
  - Compliance rate: The actual time worn in a polluted environment

What kind of masks were included?

- Particulate filtering respirators:
  - **N95** Masks: Filters at least 95% of 0.3µm airborne particles.
  - **R95** Masks: Filters at least 95% of airborne particles. Somewhat resistant to oil
  - **P95** Masks: Filters at least 95% of airborne particles. Strongly resistant to oil
- Cloth masks
  - Cotton cloth bandana
- Procedure mask
  - ASTM 3 surgical mask: Filters at least 98% of 0.1µm particles and resistant to fluids

Particulate filtering respirator effectiveness

- Canadian Standards Association (**CSA**) is equivalent to National Institute for Occupational Safety and Health (**NIOSH**) for respirators (i.e., N95)
- Testing procedures
  - Air flow that simulates a high work rate (85 liters per minute)
  - Particles **0.3 µm** in diameter
  - Test aerosols sodium chloride (NaCl) (N-series) or dioctyl phthalate (DOP) (R- and P-series)

Example study

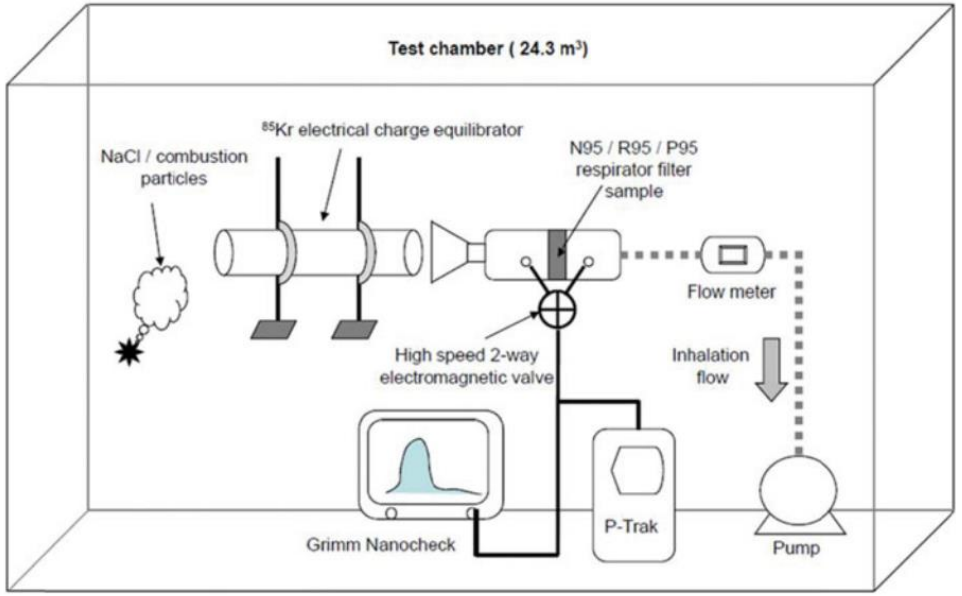
Journal of Occupational and Environmental Hygiene, 12: 678–685
ISSN: 1545-9624 print / 1545-9632 online

DOI: 10.1080/15459624.2015.1043057

Penetration of Combustion Aerosol Particles Through Filters of NIOSH-Certified Filtering Facepiece Respirators (FFRs)

Shuang Gao,[1] Jinyong Kim,[1] Michael Yermakov,[1] Yousef Elmashae,[1] Xinjian He,[2] Tiina Reponen,[1] and Sergey A. Grinshpun[1]

- N95 masks and wood, paper, and plastic combustion PM
- N95 reduced **> 94% of $PM_{0.02-0.9}$** at a range of **flow rates (15 - 85 L/min)**
- Comparison to test aerosol (NaCL)
  - NaCL: **98%**
  - Wood: **97.7%**



Gao *et al*. (2015). Penetration of combustion aerosol particles through filters of NIOSH-certified filtering facepiece respirators (FFRs).

Key takeaways part 1

N95 respirators: 3 studies

- **> 94 per cent reduction** in total PM ranging from 0.02 to 0.9 µm in diameter
- Range of flow rates (15 to 85 L/min) simulating typical respiratory workloads
  - The certainty of evidence, specifically with respect to the magnitude of the effect, is **moderate (GRADE)** due to limitations in study designs

R95 and P95 (oil-resistant and proof): 1 study

- > 99% reduction in $PM_{0.02\text{-}0.9}$
- High flow rate (85 L/min) that simulates strenuous respiratory workloads
  - The certainty of evidence, specifically with respect to the magnitude of the effect, is **low (GRADE)** due to high risk of bias stemming from limitations in study design and lack of corroborating studies

Key takeaways part 2

ASTM3 surgical mask: 1 study

- > 81 per cent reduction in $PM_{0.1\text{-}15}$ from pine needle combustion
- Flow rate of 2.94 L/min (equivalent to a respiration rate of 41 L/min) in one study
  - The certainty of evidence, specifically with respect to the magnitude of the effect, is **low (GRADE)** due to high risk of bias stemming from limitations in study design and lack of corroborating studies

ASTM3 Surgical masks and N95 respirators: 1 study

- Reduced volatile organic compounds (VOCs) such as acrolein and formaldehyde from pine needle combustion (more on next slide)
  - The certainty of evidence, specifically with respect to the magnitude of the effect, is **low (GRADE)** due to high risk of bias stemming from limitations in study design and lack of corroborating studies

Masks and VOCs

Contents lists available at ScienceDirect

Fire Safety Journal

journal homepage: www.elsevier.com/locate/firesaf

The effectiveness of filter material for respiratory protection worn by wildland firefighters

Priya Garg [a], Siyan Wang [a], Jessica M. Oakes [b], Chiara Bellini [b], Michael J. Gollner [a,*]

- Reductions in irritant gasses with surgical and N-95 mask
- Caution:
  - Short duration of the test (15 minutes)
  - Dermal vs inhalational exposure?

Table 1
Concentration of different gaseous species detected by a FTIR downstream the RP mask material.

Species	No mask	Bandana	Surgical	N-95
TPM (mg/L)	2.42 ± 0.03	2.21 ± 0.04	0.45 ± 0.13	0.03 ± 0.01
Carbon Monoxide (%)	0.82 ± 0.06	0.74 ± 0.03	0.53 ± 0.03	0.62 ± 0.04
Carbon Dioxide (%)	4.1 ± 0.4	4.5 ± 0.4	3.9 ± 0.2	3.5 ± 0.4
Hydrogen Cyanide (ppm)	29.6 ± 3.3	27.9 ± 1.2	17.8 ± 0.8	19.7 ± 1.2
Hydrogen Bromide (ppm)	1.7 ± 0.2	1.3 ± 0.3	0.5 ± 0.1	0.5 ± 0.1
Acrolein (ppm)	250.6 ± 38.8	192.9 ± 11.5	129.1 ± 8.0	142.5 ± 10.3
Formaldehyde (ppm)	55.4 ± 5.8	14.9 ± 1.1	3.4 ± 0.5	0
Nitric Oxide (ppm)	39.4 ± 4.5	60.5 ± 4.0	35.8 ± 3.9	43.4 ± 4.8
Methane (ppm)	948.3 ± 91.6	966.2 ± 77.5	667.8 ± 33.6	783.2 ± 54.6
Acetylene (ppm)	31.7 ± 4.3	29.1 ± 2.6	21.0 ± 1.7	22.9 ± 1.8
Ethane (ppm)	108.6 ± 11.5	114.6 ± 12.3	69.2 ± 3.7	84.1 ± 5.3
Butane (ppm)	374.1 ± 33.6	256.4 ± 5.2	111.9 ± 10.8	133.6 ± 13.0
Methanol (ppm)	179.4 ± 26.0	194.0 ± 13.2	119.5 ± 5.2	146.7 ± 4.8
Nitrous Acid (ppm)	13.5 ± 1.1	10.0 ± 0.8	4.3 ± 0.2	4.6 ± 0.2
Formic Acid (ppm)	29.0 ± 1.2	38.9 ± 3.0	10.7 ± 0.2	8.0 ± 0.2
Ethene (ppm)	77.9 ± 7.7	73.1 ± 5.1	52.2 ± 4.7	57.6 ± 5.6
Propene (ppm)	129.8 ± 14.4	114.0 ± 9.0	93.6 ± 3.9	110.5 ± 7.1

Considerations and limitations

- **Model**: Chamber studies use methods that provide a perfect mask fit or seal in a chamber system, simulating a best-possible use scenario
- **Humidity**: Reported to increase mask penetration
- **Particle Size**: Penetration predominantly in the ultrafine range (< 0.1 µm in diameter)

Associated health outcomes?

- Lack of research on the effects of wearing a face mask during combustion-derived air pollution episodes on human health endpoints
- Direct or indirect acute or long-term health outcome, use of emergency services or hospitalizations, and cellular-level outcomes
- Exploring related smoke literature

Associated health outcomes: Other Literature

Cardiorespiratory benefits: Wearing respirators improved heart rate variability by **2.2–18.8%** and reduced mean arterial pressure in short-term studies with ambient air pollution (2–48h, 312 participants) (Liu et al. 2022; Faridi et al. 2022)

Inflammation: A **2-hour walk** beside a busy street with an N95 showed significantly lower systemic inflammation compared to a sham respirator (Guan et al. 2018)

Hospitalizations: Modeling of the 2012 Washington wildfires estimated respiratory hospitalizations could be reduced by **2–11% (cloth)**, **9–24% (surgical)**, and **22–39% (N95)** at 2/3 compliance (Kodros et al. 2021)

Risk reduction: Modeling suggests **57,937 people** would need to wear an N95 for **2 weeks at 200 µg/m³ $PM_{2.5}$** to prevent **1 cardiovascular event**, assuming 75% efficiency (Brook et al. 2024)

Overall Summary

Air filtration and air cleaning

- During combustion-derived air pollution episodes air filtration devices reduce indoor $PM_{2.5}$
- During heavy smoke wildfire episodes air filtration devices reduce indoor $PM_{2.5}$ by 66% (34 – 99% range, 5 studies) to an overall average of 16 µg/m^3 (0.4 – 30.7 µg/m^3 range)
- More studies are needed to understand the effect of air filtering on other components (non-PM) of combustion pollution
- More studies are needed to understand the health benefits of air filtration and air cleaning during combustion-derived air pollution episodes

Masks

- N95 mask reduce PM by > 94 per cent for combustion related air-pollution
- Surgical masks and N95 respirators may have some protection against VOCs, but more study is needed
- More studies are needed to understand the health benefits of wearing masks during combustion-derived air pollution episodes

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Key takeaways

Key Outcome	Evidence included		Certainty of Evidence (GRADE)
	Study design	n*	
N95 respirators are effective at filtering combustion PM (> 94% reduction in $PM_{0.02-0.9}$) at a range of flow rates (15 – 85 L/min) that simulate respiratory workloads	Quasi-experimental	3	⊕⊕⊕◯ MODERATE[1]
R95 and P95 (oil-resistant and proof) respirators may be effective at filtering combustion PM (> 99% reduction in $PM_{0.02-0.9}$) at a high flow rate (85 L/min) that simulates strenuous respiratory workloads	Quasi-experimental	1	⊕⊕◯◯ LOW[2]
Surgical masks may be effective at filtering pine needle combustion PM (> 81% reduction in $PM_{0.1-15}$) at a flow rate of 2.939 L/min (equivalent to a respiration rate of 41 L/min)	Quasi-experimental	1	⊕⊕◯◯ LOW[2]
Surgical masks and N95 respirators may be effective at reducing concentrations of pine needle combustion gases	Quasi-experimental	1	⊕◯◯◯ VERY LOW[3]

Example study continued

Mask Material

- R95 and P95 (oil resistant and proof) masks may be effective at filtering wood, paper, and plastic combustion PM **(> 99% reduction in $PM_{0.02-0.9}$)** at a high flow rate (85 L/min)
- Authors hypothesized R95 and P95 are more effective at resisting degradation by hydrophobic molecules produced by combustion compared to an N95 mask

HC wildfire reviews

Question		Team
1	What is the relationship between **indoor and outdoor concentrations** of pollutants during combustion-derived air pollution episodes?	**NCCEH**
2a	What effect does **indoor air filtration and air cleaning** have **on concentrations of pollutants** during combustion-derived air pollution episodes?	**NCCEH**
2b	What effect does using **indoor air filtration or air cleaning** during combustion-derived air pollution episodes have on **human health endpoints**?	NCCMT
3a	What effect does wearing a **face mask or disposable respirator** have on **concentrations** of combustion-derived air **pollutants**?	**NCCEH**
3b	What effect does wearing a **face mask or disposable respirator** during combustion-derived air pollution episodes have on **human health endpoints**?	NCCMT
4	What **pollutants are found settled indoors** after combustion-derived air pollution episodes and at what concentrations, **to inform post-episode cleanup**?	**NCCEH**
5	What effect does **public health messaging** about wildfire smoke and wildfire smoke + heat have on **human behavior and human health endpoints**?	NCCMT