



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?

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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.

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Summary

Background

Decades of research have demonstrated that short- and long-term exposure to gaseous and particulate matter (PM) air pollution is associated with a broad range of acute and chronic health outcomes across the life course. The primary mechanisms of harm are inflammation and oxidative stress, which can affect all organ systems in the body. Most of the evidence comes from urban environments, where air pollution is typically generated by traffic, industry and other continuous sources. However, large-scale fires (e.g., landscape and interface fires) can cause local, regional, and widespread episodes of reduced air quality. Such events are becoming more frequent and intense under climate change, leading to periods where large populations can be exposed to the resulting gases and PM for days, weeks or months.

Based on the available evidence, public health authorities recommend indoor air cleaning as an effective intervention to improve indoor air quality and protect human health during smoke episodes. Air cleaning can be achieved through in-duct technologies integrated into existing heating, ventilation and air conditioning (HVAC) systems, or through stand-alone in-room portable air cleaners (PACs). Both in-duct and in-room air cleaning devices typically operate by physically removing particles from the air (e.g., filters, precipitators, absorption), or by destroying organic compounds (e.g., plasma generators, ozone generators). Some systems incorporate more than one technology, and some carry risks of generating harmful by-products, such as ozone ([EPA 2018](#)). The effectiveness of these technologies for removing pollutants is affected by multiple factors related to the device and setting. For PACs, these factors include the clean air delivery rate of the device (CADR), measured as treated volume per minute, capacity (i.e., volume of air in the designated room) and placement within the designated room ([Health Canada 2021](#)). Systematic reviews of the effectiveness of PACs for removing ambient or traffic-related air pollution (TRAP) found that they reduced PM_{2.5} by 22–92% and 11–82% compared to relevant controls ([Cheek et al. 2021](#); [Zhu et al. 2021](#)). No consistent improvements in cardiovascular and respiratory parameters and pregnancy outcomes were found ([Cheek et al. 2021](#)). Less is known about their performance during episodes of combustion-derived air pollution (excluding TRAP and industrial pollution, as defined below) and there is limited field data on the use of filtration to reduce gaseous pollutants. In addition, there is very limited evidence on their association with improved health endpoints, especially during large-scale fires.

Research Questions

This rapid review seeks to identify, appraise and summarize available research evidence to support evidence-informed decision making in public health during episodes of combustion-derived air pollution.

This rapid review includes evidence available up to April 23, 2025, to answer the following questions:

1. **What effect does indoor air filtration and air cleaning have on concentrations of pollutants during combustion-derived air pollution episodes?**
2. **What effect does using indoor air filtration or air cleaning during combustion-derived air pollution episodes have on human health endpoints?**

This rapid review was produced through a collaboration between the National Collaborating Centre for Environmental Health (NCCEH) and the National Collaborating Centre for Methods and Tools (NCCMT).

Definitions

Combustion-derived air pollution episode: Refers to 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 (i.e., TRAP or industrial processes).

Wildfire air pollution episode: Refers to 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: Refers to unusual episodes of air pollution caused by regional uncontrolled forest and peatland fires and open biomass burning in Southeast Asia.

Air filtration and air cleaning: Refers to passing air through any technology designed to reduce pollutant concentrations, including filters, electrostatic precipitators, sorbent materials (i.e., activated charcoal) and additive technologies (e.g., ionizers, plasma, ozone generators).

Key Points

Overall

- Current evidence on the effect of air filtration and air cleaning during combustion-derived air pollution episodes is limited. The review identified 30 relevant studies (Table 1), including 29 with information on air quality and four with information on health outcomes (three studies included both).
- This rapid review included a comprehensive search of the peer-reviewed literature and manual searches of relevant special issues. However, it did not include evidence from

the grey literature. Subsequent review updates should consider expanded search strategies and inclusion criteria (e.g., unpublished, non-peer-reviewed sources).

Effectiveness of Air Cleaners for Reducing Combustion-Derived Air Pollutants Indoors

- The evidence suggests air filtration and air cleaning during combustion-derived air pollution episodes may be effective at reducing **indoor PM_{2.5} mass concentrations** (Table 3); the certainty of evidence, specifically with respect to the magnitude of the effect, is **low** (GRADE). An average reduction of 56 percent (range 5.3–99 percent, 17 studies) and 18 µg/m³ (range 1.6–75 µg/m³, 14 studies) was reported for sampling periods ranging from 1.5 hours to 117.7 days. These estimates should be interpreted with caution because the methods for measuring PM_{2.5} concentrations and the interventions varied across all studies.
- The evidence suggests air filtration and air cleaning during combustion-derived air pollution episodes may be effective at reducing **indoor/outdoor (I/O) PM_{2.5} mass concentration ratios** (Table 3); the certainty of evidence, specifically with respect to the magnitude of the effect, is **low** (GRADE). Average I/O ratios across 13 studies from pre- or placebo intervention groups were reduced from 0.69 (range 0.28–1.3) to 0.37 (range 0.003–0.87) post-intervention. The sampling periods ranged from 1.5 hours to 117.7 days. This estimate should be interpreted with caution because the methods for measuring PM_{2.5} concentrations and the interventions varied across all studies.
- There was insufficient evidence to evaluate the effects of air filtration and air cleaning on indoor concentrations of **gaseous pollutants such as VOCs** during combustion-derived air pollution episodes (Table 3). The certainty of evidence, specifically with respect to the magnitude of the effect, is **very low** (GRADE). Two quasi-experimental studies reported results that were not comparable. One test-chamber study reported 4 of 6 commercial PACs with high-efficiency particulate air (HEPA) filters combined with activated charcoal filters effectively filtered the VOCs benzene and toluene (Clean Air Delivery Rates (CADR) > 75 m³/h). The other test-house study reported concentrations of the VOC formaldehyde were reduced by 3.1 percent following a smoke injection when a HEPA, activated carbon filter, and dual polarity ion technology PAC was turned on.
- One study reported PAC use during a combustion-derived air pollution episode reduced total water-soluble **ions and trace elements** by 74 and 86 percent respectively (Table 3). The certainty of evidence, specifically with respect to the magnitude of the effect, is **very low** (GRADE); findings are likely to change as new evidence emerges.

Human Health Endpoints

- The evidence is uncertain whether air filtration and air cleaning during combustion-derived air pollution episodes improves **cellular-level** health outcomes (Table 4). The

certainty of evidence is **very low** (GRADE); findings are likely to change as new evidence emerges. One randomized controlled trial (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.

- The evidence is uncertain whether air filtration and air cleaning during combustion-derived air pollution episodes improves **self-reported physical** health outcomes (Table 4). The certainty of evidence is **very low** (GRADE); findings may change as new evidence emerges. One small quasi-experimental study (n=27) and one randomized controlled trial (n=93) reported no effect.
- In one randomized controlled trial of children with asthma impacted by residential wood combustion smoke (n=93), air filtration did not change pediatric asthma quality of life scores, including symptoms, activity limitation and emotional function (Table 4). The certainty of evidence is **very low** (GRADE); findings may change as new evidence emerges.

Overview of Evidence and Knowledge Gaps

Effectiveness of Air Cleaners for Reducing Combustion-Derived Air Pollutants Indoors

- Of the 29 experimental studies reporting air quality outcomes, 13 were conducted during specific wildfire smoke episodes or seasons, five studies occurred during episodes of haze (biomass, wildfire and urban air pollution), three studies were performed in a chamber or test-facility using smoke generated from pine needles or woodchips, and 10 studies on smoke from residential wood burning (two examined both wildfire and residential wood smoke). Most studies were limited by small sample sizes (Table 1).
- Most air filtration and air cleaner studies (24 of 29) examined the use of PACs during episodes of combustion-derived air pollution (Table 1). Air filtering or air cleaning technologies in these PACs included a HEPA filter (two studies), a HEPA filter combined with an activated charcoal filter (eight studies), a HEPA and activated charcoal filter combined with an ionizer (three studies), a MERV 13 electrostatic filter (nine studies) or electrostatic precipitation filtration combined with a charcoal filter (one study). One chamber-study compared the effectiveness of different PAC technologies in filtering PM generated from the combustion of pine needles and reported that PACs with ionizing technologies performed comparably with HEPA and charcoal filter PACs. There remains a lack of evidence on the effectiveness of HVAC interventions during such episodes.
- No high-quality, peer-reviewed research was identified to assess the effect of air filtration and air cleaning on indoor gases or PM_{2.5} composition during wildfire episodes. Public health authorities must rely on very limited indirect evidence from other contexts (e.g., haze and test-chambers) to understand their potential impacts on indoor non-PM_{2.5}.

mass concentration of components of wildfire smoke.

- Studies on PACs used a range of technologies (both do-it-yourself (DIY) and commercial) placed in different rooms of homes, offices or facilities (including a school, senior assisted living complex and a homeless shelter); however, the evidence is too limited to comment on their ideal location or operation. The capacity (e.g., measured in terms of treatable area) and CADR of PACs also varied across studies. Considering the CADR in context of the building's area or volume in the study design resulted in more effective air filtration of PM_{2.5}.
- Average outdoor PM_{2.5} concentrations varied between 4–157 µg/m³ across non-laboratory studies (16 of 26) and between 5–127 µg/m³ across the wildfire-specific studies (9 of 13). Of these, five of 13 reported average PM_{2.5} concentrations > 27 µg/m³ (24-hour average Canadian Ambient Air Quality Standard) over the sampling periods.
- Average indoor PM_{2.5} concentrations during combustion events in homes or buildings with no filtration varied (mean 34, range 6–98 µg/m³) across all non-laboratory studies reporting on this parameter (13 of 26). Similar levels were measured in the seven reporting wildfire-specific studies (mean 35, range 7–89 µg/m³). Of note, three of seven wildfire-specific studies reported average indoor PM_{2.5} levels < 15 µg/m³ (24-h average World Health Organization (WHO) air quality guideline level) ([WHO 2021](#)), meaning that the indoor air was relatively clean before any intervention was deployed.
- The methods for determining indoor air pollution concentrations relevant to combustion events were not consistent. Several studies applied censoring algorithms to identify and remove indoor peak concentrations due to indoor sources, such as cooking.
- Across wildfire-specific studies, PAC use resulted in a 57 percent (range 5.3–99 percent, 10 studies) reduction in PM_{2.5} mass concentrations, and an average reduction of 17 µg/m³ (range 1.6–46.6 µg/m³, eight studies).
- For wildfire-specific events, use of PACs reduced the pre- or placebo intervention group PM_{2.5} mass concentration I/O ratios from an average of 0.68 (range 0.31–0.93) to 0.34 (range 0.003–0.8) post-intervention in nine of 13 studies reporting on this parameter. Non-intervention I/O ratios varied greatly depending on building age, construction, ventilation (natural or mechanical) and user habits.
- Two laboratory studies examined the effectiveness of PACs (including PACs with activated charcoal filters) on reducing biomass smoke-derived volatile organic compounds (VOCs). Although the results were inconsistent, only devices with activated charcoal filters were shown to reduce VOC levels.

Human Health Endpoints

- Of the four experimental studies that reported health outcomes, only one specifically occurred during a wildfire smoke episode; no included studies reported on the use of emergency services, emergency room visits or hospitalizations as outcomes. The lack of high-quality, peer-reviewed, published research on the effects of air filtration during combustion-derived air pollution episodes on a range of human health endpoints means that public health authorities must rely on indirect evidence of air filtration in other contexts (e.g., residential wood combustion) to inform decisions regarding its use during wildfires. For instance, exposure to ambient particulate matter is known to be associated with a broad range of acute and chronic health outcomes ([Health Canada 2023](#)), and there is no health-based limit for exposure to indoor concentrations of PM_{2.5}. It is important to note that strong recommendations can result from low or very low certainty of evidence (GRADE) when the benefits outweigh the potential harms.
- Average outdoor particulate matter (PM_{2.5}) concentrations varied across studies but were typically low (i.e., air filters may have cleaned already relatively clean air). In general, greater improvements in health outcomes were found in studies with higher mean outdoor PM_{2.5} concentrations.
- All studies involved comparable PACs placed in rooms where residents spent most of their time in their homes; however, the evidence identified in this review is too limited to comment on the ideal location or operation of the filter. In the absence of specific evidence, general guidance on PAC placement for improving indoor air quality by Health Canada may be the most applicable ([Health Canada 2021](#)).
- The studies identified in this review provide no evidence for the experiences of populations who live with social and structural inequities, such as Indigenous or racialized communities. Further research is required to ensure the representation of these populations in decision making.

Methods

This review was performed using NCCMT's rapid review process. An overview of the development of NCCMT's Rapid Evidence Service, including rationale for methodological decisions, has been published ([Neil-Sztramko *et al.* 2021](#)).

Research Question

This rapid review addresses the following research questions, developed in collaboration with public health decision makers:

- 1. What effect does indoor air filtration and air cleaning have on concentrations of pollutants during combustion-derived air pollution episodes?**
- 2. What effect does using indoor air filtration or air cleaning during combustion-derived air pollution episodes have on human health endpoints?**

The study protocol was registered in PROSPERO ([CRD42024550693](#)).

Search

Information specialists from the NCCEH and McMaster University were involved in developing and conducting the search.

On April 23, 2025, the following databases were searched using key terms, including: "wildfire," "smoke," "air filter," "air cleaning," "air quality":

- [MEDLINE](#)
- [Embase](#)
- [CINAHL](#)
- [Environment Complete](#)

A special issue of Environmental Science & Technology – [Emissions, Chemistry, and the Environmental Impacts of Wildland Fire](#) – and four other journals, not indexed in the databases above, were hand searched for relevant studies. The reference lists of related systematic reviews were screened and subject matter experts in the field were consulted.

This search builds upon the previous search (November 21, 2024) conducted in the first version of this rapid review. A copy of the full search strategy is available in [Appendix 1](#).

Study Selection Criteria

The titles and abstracts of a proportion of results (14 percent) were screened in duplicate to confirm reviewer agreement; disagreements were resolved through consensus or consulting with a third reviewer. The remaining results were screened by a single reviewer. The full texts

of results included in title and abstract screening were retrieved and screened by a single reviewer. Continuous artificial intelligence (AI) reprioritization was used to sort results during both levels of screening, but all references were screened manually.

English-language, peer-reviewed sources were eligible for inclusion; sources published ahead of print, before peer review, and surveillance sources and mathematical modelling studies that exclusively used estimated data were excluded.

1. What effect does indoor air filtration and air cleaning have on concentrations of pollutants during combustion-derived air pollution episodes?

	Inclusion Criteria	Exclusion Criteria
Population	General population exposed in residential environments (both indoor and outdoor), clean air spaces, public/institutional buildings (e.g., schools, daycares, malls, libraries, community centres, healthcare centres, long-term care centres, etc.), vehicles	Population exposed in industrial workplaces
Intervention	Portable air cleaners (including DIY air cleaners); air or in-duct filtration; car filters / other vehicles' filters (during fire event); or ionizers, plasma, ozone generators, etc.	Filters embedded in facemasks or traffic-related air pollution and general vehicle combustion emissions
Comparisons	Prior to use of air filtration or air cleaning; or spaces not using air filtration or air cleaning	
Outcomes	Indoor/outdoor ratio of concentration of non-particulate matter (PM) or PM pollutants; and or concentration of non-PM pollutants	
Context	During <i>combustion</i> -derived air pollution episodes that may be caused by fire (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 (e.g., 9/11) and residential wood combustion (i.e., wood stoves), including studies that use source attribution methods)	During <i>non-combustion</i> derived episodes; air pollution events exclusively due to engine exhaust, traffic pollution, coal combustion, etc. (not excluding coal mine fires)
Study Design	Exposure studies (including randomized and non-randomized), before-and-after studies, case studies, laboratory studies, grey literature (incl. technical reports from standard setting bodies, NRC/NIST, etc.), systematic reviews	
Setting	Any country	
Time	2004–2025	

2. What effect does using indoor air filtration or air cleaning during combustion-derived air pollution episodes have on human health endpoints?

	Inclusion Criteria	Exclusion Criteria
Population	General population exposed in residential environments (both indoor and outdoor), clean air spaces, public/institutional buildings (e.g., schools, daycares, malls, libraries, community centres, healthcare centres, long-term care centres, etc.), vehicles	Population exposed in industrial workplaces
Intervention	Portable air cleaners (including DIY air cleaners); air or in-duct filtration; car filters / other vehicles' filters (during fire event); or ionizers, plasma, ozone generators, etc.	Filters embedded in facemasks or traffic-related air pollution and general vehicle combustion emissions
Comparisons	No air filtration or air cleaning	
Outcomes	Any direct or indirect, acute or long-term health outcomes; use of emergency services, emergency room visits, or hospitalizations; or cellular-level outcomes* (e.g., inflammation markers, oxidative stress)	
Context	During <i>combustion</i> -derived air pollution episodes that may be caused by fire (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 (e.g., 9/11) and residential wood combustion (i.e., wood stoves), including studies that use source attribution methods)	During <i>non-combustion</i> derived episodes; air pollution events exclusively due to engine exhaust, traffic pollution, coal combustion, etc. (not excluding coal mine fires)
Study Design	Randomized and non-randomized trials, cohort studies, panel studies, case-control studies, cross-sectional studies, systematic reviews	Laboratory studies, modelling studies, non-systematic literature reviews, protocols / in progress studies
Setting	Any country	
Time	2004–2025	

*Cellular-level outcomes, as indirect subclinical effects, were originally excluded; they were included after it became clear that the data on more direct health outcomes was limited.

Data Extraction and Synthesis

When reported in the included studies, data relevant to the research question, including study design, setting, location, population characteristics, interventions and outcomes, were extracted by one reviewer and verified by a second. For the question related to human health endpoints, information on the social determinants of health (based on the PROGRESS-Plus framework) was extracted where reported ([O'Neill *et al.* 2014](#)).

The results were synthesized narratively due to the variation in methodology and outcomes for the included studies.

Appraisal of Evidence Quality and Certainty

The quality of included evidence was evaluated using critical appraisal tools, as indicated by the study design below. Quality assessment was completed in duplicate by two independent reviewers; conflicts were resolved through discussion or by a third reviewer.

Study Design	Critical Appraisal Tool
Randomized Controlled Trial	JBI Checklist for Randomized Controlled Trials
Quasi-experimental	JBI Checklist for Quasi-Experimental Studies
Analytical Cross Sectional	JBI Checklist for Analytical Cross Sectional Studies

Completed quality assessments for each included study are available on request.

The Grading of Recommendations, Assessment, Development and Evaluations ([GRADE](#)) ([Schünemann et al. 2013](#)) approach provides a framework for assessing health care questions and, importantly, clearly separates rating the confidence in an effect estimate of an intervention from rating the strength of a recommendation on using the intervention. It should be noted that strong recommendations can be formed from low quality evidence and vice versa. The GRADE approach was used to assess the **certainty in the findings** in **quantitative research** based on eight key domains.

In the GRADE approach to quality of evidence, **observational studies**, as included in this review, provide **low quality** evidence, and this assessment can be further reduced based on:

- High risk of bias
- Inconsistency in effects
- Indirectness of interventions/outcomes
- Imprecision in effect estimate
- Publication bias

and can be upgraded based on:

- Large effect
- Dose-response relationship
- Accounting for confounding

The overall certainty in the evidence for each outcome was determined, considering the characteristics of the available evidence (observational studies, some not peer-reviewed, unaccounted-for potential confounding factors, different tests and testing protocols, lack of valid comparison groups). A judgement of “overall certainty is very low” means that the findings are very likely to change as more evidence accumulates.

In addition to considering the quality and certainty of the included evidence, the findings from this rapid review should be interpreted in the context of the methodological restrictions inherent in a rapid review process ([Garritty *et al.* 2024](#)). For example, limited database searching and single reviewer screening may result in missed studies. Another potential limitation of this review stems from applying the GRADE framework to studies regarding personal air purifiers and cleaners as experimental health interventions, which are not defined as medical devices.

Findings

Summary of Evidence

1. What effect does indoor air filtration and air cleaning have on concentrations of pollutants during combustion-derived air pollution episodes?

This rapid review included 29 single studies. The certainty of the key findings included in this review is as follows:

Key Outcome	Evidence included		Certainty of Evidence (GRADE)
	Study design	n*	
Air filtration during combustion-derived air pollution episodes may reduce indoor PM_{2.5} levels by 56% (range 5.3–99%).	Randomized controlled trial	6	⊕⊕○○ LOW ¹
	Quasi-experimental	9	
	Analytical cross sectional	2	
Air filtration during combustion-derived air pollution episodes may reduce indoor/outdoor PM_{2.5} mass concentration ratios from an average of 0.69 (range 0.28–1.3) to 0.37 (range 0.003–0.87).	Randomized controlled trial	3	⊕⊕○○ LOW ¹
	Quasi-experimental	8	
	Analytical cross sectional	2	
The effect of air filtration using a sorbent filter (i.e., activated charcoal) during combustion-derived air pollution episodes at reducing indoor VOC levels is uncertain.	Quasi-experimental	2	⊕○○○ VERY LOW ²
The effect of air filtration during combustion-derived air pollution episodes at reducing indoor water-soluble trace elements and ions is uncertain.	Quasi-experimental	1	⊕○○○ VERY LOW ²

*Values exceed the total number of studies (n=29) as some studies contributed to multiple key findings.

¹In the GRADE approach to certainty of evidence, experimental studies, as included in this review, provide moderate certainty evidence; this was downgraded to **low** due to high risk of bias, differences in interventions and imprecision in effect estimates.

²In the GRADE approach to certainty of evidence, experimental studies, as included in this review, provide moderate certainty evidence; this was downgraded to **very low** due to high risk of bias and inconsistency, and imprecision in effect estimates.

2. What effect does using indoor air filtration or air cleaning during combustion-derived air pollution episodes have on human health endpoints?

This rapid review included four single studies. The certainty of the key findings included in this review is as follows:

Key Outcome	Evidence included		Certainty of Evidence (GRADE)
	Study design	n*	
The effect of air filtration during combustion-derived air pollution episodes on cellular-level health outcomes is uncertain.	Randomized controlled trial	2	⊕○○○ VERY LOW ¹
The effect of air filtration during combustion-derived air pollution episodes on self-reported physical health outcomes is uncertain.	Randomized controlled trial	1	⊕○○○ VERY LOW ¹
	Quasi-experimental	1	
Air filtration may not impact quality of life among children with asthma during combustion-derived air pollution episodes, although the evidence is very uncertain.	Randomized controlled trial	1	⊕○○○ VERY LOW ¹

*Values exceed the total number of studies (n=4) as some studies contributed to multiple key findings.

¹In the GRADE approach to certainty of evidence, experimental studies, as included in this review, provide moderate certainty evidence; this was downgraded to **very low** due to high risk of bias and inconsistency and imprecision in effect estimates.

Table 1: Summary of study details

Reference	Study Design	Combustion Episode	Date/Season	Population/Setting	Context	Comparator	Air Cleaner Type and Rating
Wildfire References							
Singh et al. 2025	Quasi-experimental	Wildfire	Jun 26–27, 2023	Laboratory building, Chicago, Illinois, United States	Reducing indoor air pollution infiltrating inside via residential evaporative cooler (EC) units during wildfire smoke episodes	No filter vs. filter attached to EC unit	<ul style="list-style-type: none"> - Filters attached to EC BW4002 (Phoenix/Brisa), flow rate 6,800m³/h, (1) MERV13 and activated charcoal filter 10 cm CA-13 (Rensa), (2) MERV13 10 cm AMAir/C (AAF) and activated charcoal filter, (3) MERV13 10 cm (AAF), EC set to high, installed in an exterior building door with a temporary sheath used to mimic an insulated wall
Prathibha et al. 2024 ^{&}	Quasi-experimental	Wildfire and residential wood combustion (RWC)	Wildfire (Sep–Oct 2021), RWC (Jan–Mar 2022) <i>(Of note: wildfires were extinguished prior to data collection in the “wildfire” study; the “RWC” study captured open burning of trees felled during a storm)</i>	19 homes (n=8 wildfire smoke study, n=11 RWC), in Hoopa, California, United States	Reducing indoor air pollution infiltrating inside from wildfire smoke or wood stove smoke	Baseline vs. DIY PAC vs. commercial PAC, crossover design	<ul style="list-style-type: none"> - DIY PAC: 20” × 20” MERV 13 electrostatic filter taped to a box fan, capacity not reported, installed in wood stove room - Commercial PAC: HPA-100 (Honeywell), capacity not reported, HEPA and activated charcoal filters, CADR: 170 m³/h for pollen, 180 m³/h for dust, and 170 m³/h for tobacco smoke, installed in wood stove room - PACs set to high for ≥ 8 hours for ≥ 33% of study days
Turner et al. 2024 ^{&}	Quasi-experimental	Wildfire and RWC	Wildfire (Sep–Oct 2021), RWC (Jan–Mar 2022) <i>(Of note: wildfires were extinguished prior to data collection in the “wildfire” study; the “RWC” study captured open burning of trees felled during a storm)</i>	Adults, aged ≥ 18; Wildfire smoke study (n=10, in 8 homes), RWC study (n=17, in 11 homes with wood stoves), in Hoopa, California, United States*	Reducing indoor air pollution infiltrating inside from wildfire smoke or wood stove smoke	Baseline vs. DIY PAC vs. commercial PAC, crossover design	<ul style="list-style-type: none"> - DIY PAC: 20” × 20” MERV 13 electrostatic filter taped to a box fan, capacity not reported, installed in wood stove room - Commercial PAC: HPA-100 (Honeywell), capacity not reported, HEPA and activated charcoal filters, CADR: 170 m³/h for pollen, 180 m³/h for dust, and 170 m³/h for tobacco smoke, installed in wood stove room - PACs set to high for ≥ 8 hours for ≥ 33% of study days

Wheeler et al. 2024	Quasi-experimental	Wildfire (prescribed burns)	Mar 2021	10 homes, within 5 km of planned prescribed burns, semirural Victoria, Australia	Reducing indoor air pollution infiltrating inside from wildfire smoke generated by nearby prescribed burns	PAC on vs. off	- HEPA cleaner model AUS-1250AZPU (Winix), capacity not reported, HEPA and activated charcoal filters, installed in bedroom or main living room
Walker et al. 2023	Quasi-experimental	Wildfire	Jul–Oct 2022	20 homes (n=14 PAC, n=6 no PAC), Missoula, Montana, United States	Assessing indoor air pollution infiltrating inside from wildfire smoke	PAC vs. no PAC	- NR
Willis et al. 2023	Quasi-experimental	Wildfire	Aug–Oct 2021	2 comparable-sized rooms in homeless shelter, senior assisted living complex, and a school building, Butte, Montana, United States	Reducing indoor air pollution infiltrating inside from wildfire smoke	PAC vs. no PAC	- Pet 300 with H13 True HEPA 5 stage filtration filter (Unbeaten), 46.45 m ² capacity, CADR: 177 ft ³ /min for tobacco smoke, set to high, installed in one of each pair of rooms in each public building
He et al. 2022	Analytical Cross Sectional	Wildfire	Sep 10–21, 2020	7 homes (n=3 PAC or HVAC filter, n=4 without), Seattle, Washington, United States	Reducing indoor air pollution infiltrating inside from wildfire smoke	Filtration vs. no filtration	- HEPA PACs (model and make not specified) or HVAC electrostatic precipitator (model and make not specified), capacity not reported, installation location not consistent
Dev et al. 2021	Quasi-experimental	Wildfire	Jun 2015 and Aug 2017	3 buildings (William Elmhirst Duckering Building, University of Alaska Fairbanks, and residential houses A and B), Fairbanks, AK, USA	Reducing indoor air pollution infiltrating inside from wildfire smoke	Fire smoke episode vs. non-fire soke episode	- Duckering Building: HVAC (model and make not specified), MERV 8 prefilter and MERV 11 final filter, capacity not reported - House A: Ventilation system turned off - House B: HVAC (model and make not specified), MERV 11 (GQP), capacity not reported
May et al. 2021	Quasi-experimental	Wildfire	Sep 13, 2020	2 rooms in a home (Room A 200 m ³ and B 50 m ³), Seattle, Washington, United States	Reducing indoor air pollution infiltrating inside from wildfire smoke	PAC on vs. off	- 50.8 cm × 50.8 cm MERV 13 air filter, attached to a standard home box fan with tape, capacity not reported, calculated CADR 1130 m ³ /h, installed in room A and B

Wheeler et al. 2021	Quasi-experimental	Wildfire	Aug–Nov 2019	Media room (22 m ²), Port Macquarie Library, Port Macquarie, New South Wales, Australia	Reducing indoor air pollution infiltrating inside from wildfire smoke	PAC on vs. off	- Cli-Mate AP20 (Aquaport Corporation Pty Ltd.), 20 m ² capacity, grade H12 HEPA filter and activated charcoal filters, CADR: 133 m ³ /h for tobacco smoke, set to medium, installed in the media room
Xiang et al. 2021	Quasi-experimental	Wildfire	Sep 16–18, 2020	7 homes (n=5 PAC, n=2 no filtration), naturally vented, Seattle, United States	Reducing indoor air pollution infiltrating inside from wildfire smoke	PAC on vs. off	- Air Purifier 2000i (Philips) (Auto setting), capacity not reported, HEPA and activated charcoal filters, CADR: of 198 m ³ /h for dust and 179 m ³ /h for tobacco smoke, set to auto, installed in living room
Stauffer et al. 2020	Quasi-experimental	Wildfire	Aug–Sep 2018	2 Montana Technological University offices (12.2 m ²), Butte, Montana, United States	Reducing indoor air pollution infiltrating inside from wildfire smoke	One office with PAC vs. one without PAC, crossover design	- Filtrete Ultra Clean Air Purifier FAP02-RS (3M), 14.8 m ² capacity, MERV 13, CADR: 253 m ³ /h for pollen, 217 m ³ /h for dust, and 175 m ³ /h for tobacco smoke, set to high, installed in both offices
Barn et al. 2008	RCT	Wildfire and RWC	Winter 2004 (RWC), Summer 2004–2005 (wildfire smoke)	21 homes (residential woodsmoke group), Prince George, BC, Canada; 17 homes (wildfire smoke group), Southern British Columbia, Canada	Reducing indoor air pollution infiltrating inside from wildfire smoke or residential woodsmoke	PAC on vs. off	- Honeywell HEPA filter 18150 (Honeywell), 20.9 m ² capacity, HEPA and activated charcoal filters, CADR: 255 m ³ /h for tobacco smoke, set to high, installed in the primary bedroom
Henderson et al. 2005	Quasi-experimental	Wildfire	Oct 2021–Jul 2022	4 home pairs (1 with PACs, 1 without per wildfire event, n=4)	Reducing indoor air pollution infiltrating inside from wildfire smoke	PAC vs. no PAC	- Friedrich C90 electrostatic precipitating (ESP) cleaners (Friedrich Air Conditioning Company), 54 m ² capacity, activated charcoal filter, CADR: 629 m ³ /h for pollen, 552 m ³ /h for dust, and 510 m ³ /h for tobacco smoke, installation location not reported
Haze References							
Tham et al. 2021	Quasi-experimental	Haze (distant wildfire and biomass fires)	Oct 20, 2015	Two classrooms (313 m ³), same location one floor apart, Singapore	Reducing indoor air pollution infiltrating inside from haze	Fan filter unit (FFU) vs. no intervention	- FFU with 350 mm diameter axial fan 50 Hz, 1420 RPM, 2559 m ³ /h, with a MERV13 filter, installed in one classroom

Tran et al. 2021	Quasi-experimental	Haze	Aug–Sep 2019	Bedroom in a residential apartment (10.5 m ²), 13th of 25 stories, natural ventilation, Singapore	Reducing indoor air pollution infiltrating inside from haze	Open windows (NV) vs. air conditioner (AC) vs. portable air cleaner (PAC) plus fan	<ul style="list-style-type: none"> - City M Air Purifier (Camfil), capacity not reported, HEPA H13 and molecular activated carbon filters, CADR: 433 m³/h for tobacco smoke, set to medium speed, installed in bedroom - Household standing fan, HP-116SF (Home Proud) - Panasonic Air Conditioner CS-S12TKZW (Panasonic), capacity not reported, with a MERV7 polypropylene one-touch filter, set to medium speed
Sharma et al. 2017	Quasi-experimental	Haze	Sep–Oct 2015	Living room in a residential apartment, 20th floor, natural ventilation, Singapore	Reducing indoor air pollution infiltrating inside from haze	Open windows vs. closed windows vs. PAC	<ul style="list-style-type: none"> - F-PXH55A (Panasonic), 42 m² capacity, HEPA filter, CADR: 292 m³/h for tobacco smoke
Cao et al. 2016	Quasi-experimental	Haze	Sep 17–25, 2015	5 neighboring classrooms (60m ²), Nanyang Technological University, Singapore	Reducing indoor air pollution infiltrating inside from haze	Filter vs. no filter in fan coil units	<ul style="list-style-type: none"> - Filters attached to fan coil unit, capacity not reported, (1) F25: MERV 7, (2) F65: MERV 11, (3) F85: MERV 13, (4) F95: MERV 14, each filter fan coil unit installed in one classroom
Chen et al. 2016	Quasi-experimental	Haze	Haze: Jun 14–29, 2013; Clear sky: Aug 13–26, 2013	Staff office (300 m ²), Nanyang Technological University, Singapore	Reducing indoor air pollution infiltrating inside from haze	Air-conditioning and mechanical ventilation (ACMV) system on vs. off	<ul style="list-style-type: none"> - MERV 7 filter in the air handling unit, capacity not reported, installed in staff office
Test-Chamber or Test-House References							
Stinson et al. 2024	Quasi-experimental	Smoke from pine needles injected into a test-chamber	NR	Test chamber (17.8 m ³)	Reducing indoor air pollution from wildfire smoke	HEPA + sorbent PACs vs. HEPA + sorbent + additive/ionization PACs vs. DIY PACs	<ul style="list-style-type: none"> - (H/S) PACs: Unidentified commercial HEPA + activated charcoal filter - (H/S/A) PACs: Unidentified commercial HEPA + activated charcoal + ionizer - (DIY/H) PACs: 4-filter box design using a 53 × 61 × 18 cm box fan 9723 (Air King) and MERV 13 filters (Tex-Air Filters) or a HF-910 box fan (Honeywell) with a Filtrete filter (3M) - (DIY/S) PAC: 4-filter box design using a 53 × 61 × 18 cm box fan 9723 (Air King) and Odor Relief Carbon filters (Tex-Air Filters) - All PACs run on high setting

Li et al. 2023	Quasi-experimental	Smoke from pine woodchips injected into a test-house	Mar–Apr 2022	Two-story test home (485 m ²), National Institute of Standards and Technology’s (NIST) Net-Zero Energy Residential Test Facility (NZERTF)	Reducing indoor air pollution infiltrating inside from smoke generated and injected into a model house	PAC on vs. off	- Prefilter, HEPA, activated carbon filter, and dual polarity ion technology air cleaner, 65 m ² capacity, CADR: 688 m ³ /h for particles
Holder et al. 2022	Quasi-experimental	Smoke from pine needles injected into a test-chamber	NR	Test chamber (29.3 m ³)	Reducing indoor air pollution from wildfire smoke	DIY-PAC configurations	- 20” 3-speed box fan, 83 W, 1820 CFM with 1” thick MERV 13 furnace filters with electrostatic media (electret filters) attached in (1) 1-filter, (2) 2-filter wedge, or (3) 4-filter box designs, set to high - Commercial air cleaner (model and make not specified), capacity not reported, CADR 170 m ³ /h for tobacco smoke
Residential Wood Combustion References							
Walker et al. 2022	RCT	RWC	Winter 2014–2019	94 participants (n=47 filtration, n=47 placebo,) 84 homes (n=41 filtration, n=43 placebo), rural households of the Navajo and Nez Perce Tribe, United States	Reducing indoor air pollution from residential wood combustion	PAC vs. placebo (i.e., no internal filter used)	- Filtrete FAP03 and FAP02 (3M), capacity not reported, or Winix 5500 and 5300 (Winix America Inc), capacity not reported, set to high, installed in wood stove room
McNamara et al. 2017	RCT	RWC	Winter 2010–2012	48 homes (n=25 PAC, n=23 placebo), rural Montana, Nez Perce Indian Reservation in Idaho, and Fairbanks Alaska, United States	Reducing indoor air pollution from residential wood combustion	PAC vs. placebo (i.e., sham internal filter used)	- Filtrete Ultra Clean Air Purifiers (3M), 33 m ² capacity unit in the wood stove room and 16 m ² capacity unit in the bedroom of the child with asthma, MERV 13, CADR: 190 m ³ /h for tobacco smoke, set to high, installed in wood stove room - Placebo filters were manufactured at the University of Montana using a porous filter media

Noonan et al. 2017	RCT	RWC	Winters 2008–2013	Children with asthma, aged 6–18 (n=93, from 82 homes with wood stoves) 72 homes (n=35 PAC, n=37 placebo), Butte and western Montana, Nez Perce Indian Reservation, Idaho, and Fairbanks Alaska, United States*	Reducing indoor air pollution from residential wood stoves	PAC vs. placebo (i.e., sham internal filter used)	<ul style="list-style-type: none"> - Filtrete Ultra Clean Air Purifiers (3M), 33 m² capacity unit in the wood stove room and 16 m² capacity unit in the bedroom of the child with asthma, MERV 13, CADR: 190 m³/h for tobacco smoke, set to high, installed in wood stove room - Placebo filters were manufactured at the University of Montana using a porous filter media
Ward et al. 2017	RCT	RWC	Winters 2008–2013	73 homes (n=35 PAC, n=38 placebo), Butte and western Montana, Nez Perce Indian Reservation, Idaho, and Fairbanks Alaska, United States	Reducing indoor air pollution from residential wood stoves	PAC vs. no PAC and PAC vs. placebo (i.e., sham internal filter used)	<ul style="list-style-type: none"> - Filtrete Ultra Clean Air Purifiers (3M), 33 m² capacity unit in the wood stove room and 16 m² capacity unit in the bedroom of the child with asthma, MERV 13, CADR: 190 m³/h for tobacco smoke, set to high, installed in wood stove room - Placebo filters were manufactured at the University of Montana using a porous filter media
Kajbafzadeh et al. 2015	RCT	RWC	Dec 2011–Aug 2012	Adults, aged ≥ 19 (n=29, from 20 homes); 20 homes, Vancouver, British Columbia, Canada	Reducing indoor air pollution from residential wood combustion and possibly ambient wildfire smoke	PAC vs. placebo (i.e., no internal filter used), crossover design	<ul style="list-style-type: none"> - Honeywell HEPA filter (model 50300 in main activity room, and 18150 in bedroom), capacity not reported, HEPA and activated charcoal filters, set to high, installed in bedroom
Wheeler et al. 2014	RCT	RWC	Dec 2009–Apr 2010	31 homes, Annapolis Valley, Nova Scotia, Canada	Reducing indoor air pollution from residential wood combustion	PAC vs. placebo (i.e., sham internal filter used), crossover design	<ul style="list-style-type: none"> - Filtrete Ultra Clean Air Purifier FAP02-RS (3M), 15.8m² capacity, CADR: 252 m³/h for pollen, 216 m³/h for dust, and 174 m³/h for tobacco smoke, set to high, installed in wood burning appliance room

Allen et al. 2011	RCT	RWC	Nov 2008–Apr 2009	Adults, aged ≥ 19 (n=45) 25 homes (n=13 woodburning homes, n=12 non-woodburning homes) Smithers, British Columbia, Canada	Reducing indoor air pollution from residential wood combustion	PAC vs. placebo (i.e., no internal filter used), crossover design	- Honeywell HEPA filter (model 50300 in main activity room, and 18150 in bedroom), capacity not reported, HEPA and activated charcoal filters, set to high, installed in main living room
Hart et al. 2011	RCT	RWC	Spring 2008	2 homes, Butte, Montana, United States	Reducing indoor air pollution from residential wood combustion	PAC on vs. off	- Filtrete Ultra Clean Air Purifier FAP02-RS (3M), 15.8 m ² capacity, CADR: 253 m ³ /h for pollen, 217 m ³ /h for dust, and 175 m ³ /h for tobacco smoke, set to high, installed in wood stove room

Abbreviations: **DIY**: do-it-yourself; **HEPA**: high-efficiency particulate air; **MERV**: minimum efficiency reporting values; **NR**: not reported; **PAC**: portable air cleaner; **RCT**: randomized controlled trial; **RWC**: residential wood combustion; **CADR**: clean air delivery rate

&[Turner et al. 2024](#) and [Prathibha et al. 2024](#) reported air pollution data from the same Hoopa study. Only air pollution data from [Prathibha et al. 2024](#) was considered in the air pollution summary findings. Air pollution data from [Turner et al. 2024](#) is presented to provide context for the health outcomes reported in this reference that are not included in [Prathibha et al. 2024](#).

*[PROGRESS-Plus](#): place of residence (rural), race/ethnicity/culture/language (American Indian / Alaska Native)

Table 2: Summary of air pollution monitoring methods

Reference	Combustion Episode	Pollutants Measured	Data Collection Methods	Sampling Period
Wildfire References				
Singh <i>et al.</i> 2025	Wildfire	Size- and time-resolved PM _{0.01-0.4} concentrations	<ul style="list-style-type: none"> - GT-526 handheld particle counters (Met One Instruments) were used to measure particle concentrations at 1-minute intervals, data averaged over test interval - Monitoring immediately upstream of EC air intake and downstream of supply air outlet 	30 minutes to 2 hours per test run
Prathibha <i>et al.</i> 2024^{&}	Wildfire and residential wood combustion (RWC)	PM _{2.5}	<ul style="list-style-type: none"> - PurpleAir PM sensors PA-II-SD (PurpleAir Inc.) were used to measure 24-hour averaged PM_{2.5} mass concentrations at 2-minute intervals, corrected using EPA's US-wide correction methods, 10-min averaged indoor and outdoor matched data accounting for door opening and CO₂ as a proxy for human activity (exhalation, cooking, etc.) - HOBO UX120-018 plug load data loggers (Onset) were used to measure PAC usage at 1-minute intervals - HOBO UX90-001 state data loggers (Onset) to track main door opening in seconds - HOBO MX1102 carbon dioxide (CO₂) monitors during wood stove study - Indoor monitoring in the same room as the PAC (wood stove room) 	5–14 days per condition phase, each phase was sampled consecutively
Turner <i>et al.</i> 2024^{&}	Wildfire and RWC	PM _{2.5}	<ul style="list-style-type: none"> - PurpleAir PM sensors PA-II-SD (PurpleAir Inc.) were used to measure 24-hour averaged PM_{2.5} mass concentrations at 2-minute intervals, corrected using EPA's US-wide correction methods, 10-min averaged indoor and outdoor matched data accounting for door opening and CO₂ as a proxy for human activity (exhalation, cooking, etc.) - HOBO UX120-018 plug load data loggers (Onset) were used to measure PAC usage at 1-minute intervals - HOBO UX90-001 state data loggers (Onset) to track main door opening in seconds - HOBO MX1102 carbon dioxide (CO₂) monitors during wood stove study - Indoor monitoring in the same room as the PAC (wood stove room) 	5–14 days per condition phase, each phase was sampled consecutively
Wheeler <i>et al.</i> 2024	Wildfire (prescribed burns)	PM _{2.5}	<ul style="list-style-type: none"> - CSIRO-developed Smoke Observation Gadgets V2 with Plantower 3003 sensors (Beijing Ereach Technology Co., Ltd.) to measure PM_{2.5} mass concentrations at 5-minute intervals - Smoke periods defined as PM_{2.5} concentrations exceeding 20 µg/m³, used to calculate PAC efficacy - Indoor monitoring in the same room as the PAC (bedroom or main room) 	1–20 days surrounding a prescribed burn
Walker <i>et al.</i> 2023	Wildfire	PM _{2.5}	<ul style="list-style-type: none"> - PurpleAir-II-SD optical sensors (PurpleAir Inc.) were used to measure 1-hour averaged PM_{2.5} mass concentrations at 2-minute intervals and corrected using a modified EPA national correction equation using data from a BAM 1020 (Met One Instruments), 24-hour means reported - Indoor monitoring in a common room (PACs not supplied and location not reported) 	117.7 days maximum per house, 1312 total days with PAC and 548 total days with no PAC across all houses

Willis et al. 2023	Wildfire	PM _{2.5}	<ul style="list-style-type: none"> - PurpleAir-II-SD PM sensors (PurpleAir Inc.) were used to measure 1-hour averaged PM_{2.5} and corrected using the EPA national correction equation - Data collected on days when NAAQS Air Monitoring Station measured PM_{2.5} concentrations over 50 µg/m³ for a 1-hour average 	10-11 days
He et al. 2022	Wildfire	PM _{2.5}	<ul style="list-style-type: none"> - Plantower PMS A003 (Beijing Ereach Technology Co., Ltd.) was used to measure 11-day averaged PM_{2.5} mass concentrations at 10-second intervals - Indoor sampling site not consistent 	11 days
Dev et al. 2021	Wildfire	Size-resolved and mass PM _{0.3-10} concentrations	<ul style="list-style-type: none"> - Optical particle sizer spectrometer 3330 (TSI Inc.) was used to measure size-resolved particle and mass concentrations at 1-minute intervals, data averaged over 10-minute sampling periods - Indoor sampling site not reported, outdoor sampling sites were at least 3 m away from other objects - Doors and windows were closed while measurements were conducted, and no cooking was conducted just prior to or during measurements 	10 min, 10 replicate measurements per site
May et al. 2021	Wildfire	PM _{2.5}	<ul style="list-style-type: none"> - PurpleAir PM sensors (PurpleAir Inc.) were used to measure 1-hour averaged PM_{2.5} and corrected using the EPA national correction equation - Indoor monitoring in the same room as the PAC 	5 hours, 3.5 hours PAC on and 1.5 hours PAC off
Wheeler et al. 2021	Wildfire	PM _{2.5}	<ul style="list-style-type: none"> - Plantower 3003 PM sensor (Beijing Ereach Technology Co., Ltd.) was used to measure 1-hour averaged PM_{2.5} mass concentrations at 1-minute intervals, corrected using data from the DPIE managed 1405-DF TEOM located in Port Macquarie - Only periods with 24-h mean outdoor PM_{2.5} concentrations ≥ 20 µg/m³ and valid indoor and outdoor measurements considered in analysis - Indoor monitoring in the same room as the PAC (media room) 	53 days with PAC on and 41 days with PAC off, 140 hours with PAC on and 609 hours with PAC off analyzed
Xiang et al. 2021	Wildfire	PM _{2.5}	<ul style="list-style-type: none"> - Plantower PMSA003 (Beijing Ereach Technology Co., Ltd.) was used to measure 1-hour averaged PM_{2.5} mass concentrations at 10 second intervals - Only periods with; (1) steady-state indoor PM_{2.5} concentrations, (2) absence of indoor-generated PM_{2.5} impacts, and (3) hourly outdoor PM_{2.5} levels that were ≥ 50 µg/m³ considered in analysis - Indoor monitoring in the same room as the PAC (living room) with all windows and doors closed in homes 	18–24 hours PAC on and 18–24 hours PAC off per house, 71 hours with PAC on and 65.5 hours of PAC off analyzed
Stauffer et al. 2020	Wildfire	PM _{2.5}	<ul style="list-style-type: none"> - SidePak AM520 (TSI instrument along with a MetOne Instruments Beta Ray Attenuation Monitor 1020 (BAM 1020) were used to measure 1-hour averaged PM_{2.5} mass concentrations - Sampling was only conducted when smoke was visibly impacting the airshed and ambient PM_{2.5} concentrations exceeded 12.0 µg/m³ threshold which was based on the EPA Air Quality Index “moderate” health effects category (12.1–35.4 µg/m³) - Indoor monitoring in each office 	10 hours, 6-day (8:00 am–6:00 pm) and 8-night (8:00 pm–6:00 am) sampling periods completed for a total of n=48-day hours and n=64 hours
Barn et al. 2008	Wildfire and RWC	PM _{2.5}	<ul style="list-style-type: none"> - Personal DataRAM (pDR)-1000 photometer (Thermo Andersen) was used to collect 30-minute averages of PM_{2.5} mass concentrations at 1-minute intervals. - Indoor monitoring in the same room as the PAC (primary bedroom) and residents asked to not use wood stoves 	48 hours, 24 hours PAC on and 24 hours PAC off

Henderson et al. 2005	Wildfire	PM _{2.5}	<ul style="list-style-type: none"> - Single-stage Harvard impactors (Air Diagnostics and Engineering Inc.) were used with two-micron pore-size Teflon 37-mm polytetrafluoroethylene membrane filters for a 24-hour sampling period and time-weighted average mass concentrations were calculated - Indoor monitoring in the main living area, and 2 or 3 PACs were placed in designated houses depending on overall house area 	24 hours per fire event
Haze References				
Tham et al. 2021	Haze (distant wildfire and biomass fires)	PM ₁₀ , PM _{2.5} , PM ₁	<ul style="list-style-type: none"> - GRIMM 1.108 spectrometer was used to measure mass concentrations of PM₁, PM_{2.5}, and PM₁₀ - Classrooms vented for 30 mins and then allowed to equilibrate, then the FFU was turned on in one classroom for 2.5 hours, both classrooms monitored simultaneously 	3 hours
Tran et al. 2021	Haze	PM _{2.5} , BC, Ions, Trace Elements	<ul style="list-style-type: none"> - MiniVol™ TAS portable air samplers (Airmetrics) were used to measure 24-hour averaged PM_{2.5} mass concentrations - Micro-aethalometers AE51 (Aethlabs) was used to measure BC - 7700 Series (Agilent Technologies) inductively coupled plasma mass spectrometry (ICP-MS) was used to measure 26 water soluble trace elements (WSTE) (Li, B, Mg, Al, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Se, Rb, Sr, Cd, Sn, Cs, Ba, Ti and Pb) - Ion chromatography (Metrohm) was used to measure water-soluble ions; cations (Li⁺, Na⁺, NH₄⁺, K⁺, Ca²⁺, Mg²⁺) and anions (F⁻, Cl⁻, NO₂⁻, NO₃⁻, Br⁻, PO₄³⁻, SO₄²⁻, Oxalate) - Indoor monitoring in the same room as the PAC (bedroom) 	24 hours
Sharma et al. 2017	Haze	PM _{2.5}	<ul style="list-style-type: none"> - Sioutas cascade impactor sampler (SKC Inc.) was used to collect PM samples on Teflon fiber filters over 24 hours, size-fractionated gravimetric PM measurements were averaged over 24 hours - Indoor monitoring in the same room as the PAC (living room) 	24 hours, for PAC condition, 12 hours with PAC on and 12 hours with PAC off
Cao et al. 2016	Haze	PM _{0.3-0.5} , PM _{0.5-1.0} , and PM _{1.0-2.5}	<ul style="list-style-type: none"> - Optical Particle Counters 9306 and 8220 (TSI Inc.) were used to measure indoor and outdoor particle number and mass concentrations at 2-minute intervals - Indoor monitoring in each classroom 	9 days
Chen et al. 2016	Haze	Size- and time-resolved PM _{0.01-10} concentrations	<ul style="list-style-type: none"> - Nanoscan SMPS Nanoparticle Sizer 3910 (TSI Inc.) and optical particle sizer 3330 (TSI Inc.) were used to measure particle concentrations at 1-minute intervals - Indoor monitoring in the office 	14 days (Haze period)
Test-Chamber or Test-House References				
Stinson et al. 2024	Smoke from pine needles injected into a test-chamber	PM _{0.02-0.3} , PM _{0.3-1.0} , PM _{1.0-2.5} , benzene, toluene, C8 aromatics, BC, and BrC	<ul style="list-style-type: none"> - Optical particle sizer 3330 (TSI) and a condensation particle counter 8525 (TSI) were used to measure PM mass concentrations - Proton transfer reaction time-of-flight mass spectrometry (PTR-ToF MS) PTR1000 instrumentation (Ionicon Analytik GmbH) was used to measure VOCs - Aethalometer AE33 (Magee Scientific) was used to measure BC and BrC - Pull-down method used to calculate CADR 	NR

Li et al. 2023	Smoke from pine woodchips injected into a test-house	HCOOH, HCOH, and C ₄ H ₄ O	<ul style="list-style-type: none"> - Ponderosa pine woodchips (0.25–1.0g) were burned using a cocktail smoker (Breville) and the smoke was injected into the house (mean indoor PM_{2.5} of 11.1 ± 8.3µg/m³) - Time-of-flight (TOF) Chemical Ionization Mass Spectrometry (CIMS): iodide reagent ions-CIMS and H₃O⁺ proton transfer reaction-TOF-MS was used to measure gas-phase compounds - Aerodyne TILDAS compact single laser trace gas analyzer detected HCHO (1-s resolution) 	NR
Holder et al. 2022	Smoke from pine needles injected into a test-chamber	PM _{2.5}	<ul style="list-style-type: none"> - DustTrak DRX (TSI Inc.) was used to continuously measure PM_{2.5} concentrations, corrected using the filter-based correction factor of 0.2 for wildfire smoke - CADR for each design/condition was measured using the AHAM test protocol AC-1 (n=3) 	NR
Residential Wood Combustion References				
Walker et al. 2022	RWC	PM _{2.5}	<ul style="list-style-type: none"> - DustTrak 8530 (TSI) was used to measure 48-hour averaged PM_{2.5} mass concentrations at 60-second time intervals - MicroPEM v3.2 (RTI International) was used to measure personal PM_{2.5} mass concentrations - Indoor monitoring in the same room as the PAC (wood stove room) 	48 hours, twice per pre- or post-intervention winter
McNamara et al. 2017	RWC	PM _{10-2.5} , PM _{2.5} , Endotoxin	<ul style="list-style-type: none"> - DustTrak[®] Aerosol Monitor 8520/8530 (TSI) was used to measure 48-hour averaged PM_{2.5} mass concentrations at 60-second intervals - Teflon filters were collected using a coarse particle environmental monitor (RTI International) using a MSP Model 200 PM10 PEM air sampler and weighed using a MT5 microbalance (Mettler-Toledo LLC) to measure PM_{10-2.5} mass concentrations, multiple sampling events were averaged into one winter mean - An Endosafe Endochrome-K (Charles River Laboratories Inc.) assay was used to measure endotoxin in teflon filter extracts - Indoor monitoring in the same room as the PAC (wood stove room) 	48 hours, twice per pre- or post-intervention winter
Noonan et al. 2017	RWC	PM _{2.5}	<ul style="list-style-type: none"> - DustTrak[®] Aerosol Monitor 8520/8530 (TSI) was used to continuously measure 48-hour averaged PM_{2.5} at 60-second intervals - Indoor monitoring in the same room as the PAC (wood stove room) 	48 hours, twice per pre- or post-intervention winter
Ward et al. 2017	RWC	PM _{2.5} , PM number concentrations, CO	<ul style="list-style-type: none"> - DustTrak[®] Aerosol Monitor 8520/8530 (TSI) was used to continuously measure 48-hour averaged PM_{2.5} mass concentrations at 60-second intervals, wood smoke-specific correction factor of 1.65 applied to all data - Lighthouse 3016-IAQ particle counter was used to continuously measure particle number concentrations - Q-Trak (TSI) was used to measure CO - Indoor monitoring in the same room as the PAC (wood stove room) 	48 hours, twice per pre- or post-intervention winter
Kajbafzadeh et al. 2015	RWC	PM _{2.5} , levoglucosan	<ul style="list-style-type: none"> - Filter samples were collected indoors and outdoors using Harvard Impactors (Air Diagnostics and Engineering) and analyzed for PM_{2.5} mass concentrations and levoglucosan levels over each 7-day sampling period - Levoglucosan levels measured via gas chromatography/mass spectroscopy - Indoor monitoring in the same room as the PAC (bedroom) 	7 days

Wheeler et al. 2014	RWC	PM, PM _{2.5} , levoglucosan	<ul style="list-style-type: none"> - DustTrak® Aerosol Monitor 8520 (TSI) was used to continuously measure PM and not corrected for PM_{2.5} concentrations and averaged over 24 hours - MS&T area samplers using 37 mm diameter, 2 µm pore size, ring supported PTFE filters (Air Diagnostics and Engineering Inc) was used to measure 24-h PM_{2.5} mass concentrations - Thermo ChemCombs Model 3500 using 47mm diameter pre-fired Quartz filters (Thermo Scientific) was used to collect 24-hour samples that were analyzed for levoglucosan by gas chromatography/mass spectrometry - Indoor monitoring in the main room of the house, PAC placed in same room as wood burning appliance 	3 days, 1 day wood burning appliance on, 1 day PAC on, 1 day PAC off per house
Allen et al. 2011	RWC	PM _{2.5} , levoglucosan	<ul style="list-style-type: none"> - Filter samples were collected indoors and outdoors using Harvard Impactors (Air Diagnostics and Engineering) and analyzed for PM_{2.5} mass concentrations and levoglucosan levels over each 7-day sampling period - Levoglucosan levels measured via gas chromatography/mass spectroscopy - Indoor monitoring in the same room as one PAC (main living room) 	7 days
Hart et al. 2011	RWC	Particle number concentrations, and PM _{2.5} and PM ₁	<ul style="list-style-type: none"> - Lighthouse model 3016 direct reading laser particle counter was used to measure 12-hour averaged particle concentrations - TSI DustTrak model 8520 aerosol monitor, 1.0 µm inlet or a 2.5 µm inlet was used (5 sampling periods each) was used to measure 12-hour averaged PM₁ and PM_{2.5} mass concentrations at 5-minute intervals - Indoor monitoring in the same room as the PAC (wood stove room) 	24 hours, 12 hours with PAC on and 12 hours with PAC off, 10 sampling periods completed per house

Abbreviations: **DIY**: do-it-yourself; **HEPA**: high-efficiency particulate air; **MERV**: minimum efficiency reporting values; **NR**: not reported; **PAC**: portable air cleaner; **PM₁₀**: particulate matter under 10.0 µm in diameter; **PM_{2.5}**: fine particulate matter under 2.5 µm in diameter; **PM_{0.1}**: ultrafine particulate matter under 1.0 µm in diameter; **PM_{x-y}**: particulate matter ranging in x-y µm in diameter; **BC**: black carbon; **BrC**: brown carbon; **RWC**: residential wood combustion; **CADR**: clean air delivery rate

& [Turner et al. 2024](#) and [Prathibha et al. 2024](#) reported air pollution data from the same Hoopa study. Only air pollution data from [Prathibha et al. 2024](#) was considered in the air pollution summary findings. Air pollution data from [Turner et al. 2024](#) is presented to provide context for the health outcomes reported in this reference that are not included in [Prathibha et al. 2024](#).

Table 3: Summary of air filtration outcomes

Reference	Combustion Episode	Outdoor Pollutant Levels	Indoor/Outdoor ratios*	Air Filter Effectiveness#	Summary of Findings	Study Quality
Wildfire References						
Singh et al. 2025	Wildfire	NR	NR	PM0.01–0.4 percent removal efficiency: - No filter: 2% - MERV13 10cm CA-13 (Rensa): 49% - MERV13 10cm AMAir/C (AAF): 65% - MERV13 10cm (AAF): 81%	- Adding MERV13 filters increased removal efficiencies from 2% to 49–81% for particles of 0.01–0.4 μm in diameter during a wildfire smoke episode	High
Prathibha et al. 2024 ^{&}	Wildfire and residential wood combustion (RWC)	<i>Wildfire Study</i> PM _{2.5} mean ± SD (μg/m ³): Baseline 9.1 ± 8.4, DIY PAC 5.0 ± 1.7, commercial PAC 5.8 ± 3.1 <i>RWC Study</i> PM _{2.5} Mean ± SD (μg/m ³): Baseline 38.1 ± 24.4, DIY PAC 60.1 ± 35.3, commercial PAC 58.5 ± 38.5	<i>Wildfire Study</i> PM _{2.5} (infiltrated/outdoor) mean ± SD: Baseline 0.7 ± 0.2, DIY PAC 0.7 ± 0.2, commercial PAC 0.8 ± 0.2 <i>RWC Study</i> PM _{2.5} (infiltrated/outdoor) mean ± SD: Baseline 0.7 ± 0.2, DIY PAC 0.6 ± 0.2, commercial PAC 0.6 ± 0.2	<i>Wildfire Study</i> PM _{2.5} percent reduction (95% CI): DIY PAC vs. baseline 7% (2.5, 11.3), commercial PAC vs. baseline 5.3% (-0.15, 10.4) <i>RWC Study</i> PM _{2.5} percent reduction (95% CI): DIY PAC vs. baseline 9.59% (7.43, 11.7), commercial PAC vs. baseline 19.65% (17.4, 21.84)	- DIY and commercial PAC use significantly decreased indoor PM _{2.5} by 7–10% and 5–20% compared to baseline during RWC and wildfire studies - I/O ratio for PM _{2.5} was reduced from 0.7 to 0.6 and 0.6 for DIY and commercial PACs respectively comparing PAC use to baseline periods during the woodstove study	High
Turner et al. 2024 ^{&}	Wildfire and RWC	<i>Wildfire Study</i> PM _{2.5} mean ± SD (μg/m ³): Baseline 12.61 ± 1.77, DIY PAC 6.8 ± 1.72, commercial PAC 9.46 ± 1.39 <i>RWC Study</i> PM _{2.5} mean ± SD (μg/m ³): Baseline 47.84 ± 24.02, DIY PAC 72.55 ± 34.63, commercial PAC 73.74 ± 39.41	<i>Wildfire Study</i> PM _{2.5} (indoor/outdoor) mean: Baseline 1.51, DIY PAC 2.02, commercial PAC 1.62 <i>RWC Study</i> PM _{2.5} (indoor/outdoor) mean: Baseline 0.76, DIY PAC 0.37, commercial PAC 0.36	<i>Wildfire Study</i> PM _{2.5} percent reduction (95% CI): DIY PAC vs. baseline 7% (2.5, 11.3), commercial PAC vs. baseline 5.3% (-0.15, 10.4) <i>RWC Study</i> PM _{2.5} percent reduction (95% CI): DIY PAC vs. baseline 9.59% (7.43, 11.7), commercial PAC vs. baseline 19.65% (17.4, 21.84)	- DIY and commercial PAC use significantly decreased indoor PM _{2.5} by 7–10% and 5–20% compared to baseline during wood smoke and wildfire studies - I/O ratio for PM _{2.5} was reduced from 0.76 to 0.37 and 0.36 for DIY and commercial PACs respectively comparing PAC use to baseline periods during the woodstove study	High

Wheeler et al. 2024	Wildfire (prescribed burns)	PM _{2.5} (µg/m ³): No summary data reported, levels peaked at approximately 250	Permeability mean (m ³ /h/m ²): - House 5: 8.34 - House 7: 16.96 - House 8: 28.94 - House 9: 20.95	PM _{2.5} percent reduction PAC on vs. off: - House 5: 30% - House 8: 74% - House 9: 68%	- The percentage reduction of PM _{2.5} attributable to using a PAC ranged between 30 and 75% - House with a low air change rate (ACH50 10.31 /h), suggesting a tighter building envelope had a lower reduction of PM _{2.5} (30%)	Moderate
Walker et al. 2023	Wildfire	PM _{2.5} mean ± SD (µg/m ³): 9.1 ± 16.1	PM _{2.5} mean (95% CI): PAC 0.25 (0.24, 0.26), no PAC 0.57 (0.54, 0.60)	PM _{2.5} percent reduction (95% CI); (mean ± SD µg/m ³) PAC vs. no PAC: 9.8% (-0.9, 21.6); (5.1 ± 7.4 vs. 6.7 ± 11.3)	- PAC use reduced indoor PM _{2.5} by 9.8% (1.6 µg/m ³) - I/O ratio for PM _{2.5} was reduced from 0.57 to 0.25 comparing homes with a PAC vs. homes without a PAC	High
Willis et al. 2023	Wildfire	PM _{2.5} mean (µg/m ³): Homeless shelter 42.17, Senior assisted living complex 44.79, School building: 42.65	PM _{2.5} mean: - Homeless shelter: PAC 0.54, no PAC 0.75 - Senior assisted living complex: PAC 0.49, no PAC 0.8 - School building: PAC 0.72, no PAC 0.87	PM _{2.5} percent reduction (mean µg/m ³) PAC vs. no PAC: - Homeless shelter: 34.36% (22.67 vs. 31.52) - Senior assisted living complex: 35.92% (21.95 vs. 35.88) - School building: 15.67% (30.66 vs. 37.2)	- Using a PAC in a range of public facilities reduced PM _{2.5} by 16–35% (6.5–13.9 µg/m ³) - I/O ratios for PM _{2.5} was reduced from 0.75–0.87 to 0.49–0.72 during wildfire smoke events comparing rooms with or without a PAC	High
He et al. 2022	Wildfire	PM _{2.5} mean (µg/m ³): 108.8 filtration, 112.9 no filtration	PM _{2.5} mean: 0.43 filtration, 0.82 no filtration	PM _{2.5} percent reduction (range); (mean µg/m ³) filtration vs. no filtration: 61% (48–80); (42.7 vs. 89.3)	- Using filtration technologies inside during wildfire events reduced PM _{2.5} by 61% (mean 46.6 µg/m ³) compared to homes without filtration - Houses with air filtration devices still had relatively high levels of PM _{2.5} (greater than EPA guidelines) - I/O ratio for PM _{2.5} was reduced from 0.82 to 0.43 comparing homes with filtration technologies vs. homes without	Moderate

Dev et al. 2021	Wildfire	<p>PM_{0.3-10} mean ± SD (µg/m³)</p> <ul style="list-style-type: none"> - Duckering: wildfire period 90.8 ± 13.32, non-wildfire period 8.3 - House A: wildfire period 114.15 ± 8.85, non-wildfire period 6.3 - House B: wildfire period 59.1 ± 9.2, non-wildfire period 5.1 <p>PM_{0.3-10} number concentration mean ± SD (number/cm³)</p> <ul style="list-style-type: none"> - Duckering: wildfire period 1589.9 ± 202.2, non-wildfire period 8.3 ± 0.71 - House A: wildfire period 1583.6 ± 16.35, non-wildfire period 6.5 ± 0.39 - 3) House B: wildfire period 1184.8 ± 24.2, non-wildfire period 5.3 ± 0.3 	<p>PM_{0.3-10} mean ± SD</p> <ul style="list-style-type: none"> - Duckering: wildfire period 0.37 ± 0.06, non-wildfire period 1.7 ± 0.3 - House A: wildfire period 0.14 ± 0.01, non-wildfire period 0.6 ± 0.37 - House B: wildfire period 0.44 ± 0.04, non-wildfire period 1 ± 0.96 <p>PM_{0.3-10} number concentration mean ± SD</p> <ul style="list-style-type: none"> - Duckering: wildfire period 0.76 ± 0.11, non-wildfire period 1 ± 0.17 - House A: wildfire period 0.13 ± 0.001, non-wildfire period 1.6 ± 0.18 - 3) House B: wildfire period 0.61 ± 0.02, non-wildfire period 1.3 ± 0.03 	<p>PM_{0.3-10} mean ± SD (µg/m³)</p> <ul style="list-style-type: none"> - Duckering: wildfire period 33.5 ± 1.08, non-wildfire period 11.7 - House A: wildfire period 16.7 ± 2.54, non-wildfire period 5.5 - House B: wildfire period 26.1 ± 1.78, non-wildfire period 4.4 <p>PM_{0.3-10} number concentration mean ± SD (number/cm³)</p> <ul style="list-style-type: none"> - Duckering: wildfire period 1195.1 ± 19.9, non-wildfire period 8.02 ± 1.04 - House A: wildfire period 206.9 ± 3.71, non-wildfire period 10.6 ± 0.55 - 3) House B: wildfire period 721.7 ± 13.49, non-wildfire period 6.8 ± 0.39 	<ul style="list-style-type: none"> - PM_{0.3-10} number and mass concentrations remained significantly elevated during fire season while HVAC systems were running in the Duckering building and House B - When comparing House A (no ventilation) and House B (HVAC), measurements for PM_{0.3-10} number and mass concentrations and I/O ratios were significantly (P < 0.05) higher for House B 	High
May et al. 2021	Wildfire	PM _{2.5} mean ± SD (µg/m ³): 127 ± 9	<p>PM_{2.5} mean:</p> <ul style="list-style-type: none"> - Room A: PAC on 0.22, PAC off 0.50 - Room B: PAC on 0.003, PAC off 0.31 	<p>PM_{2.5} percent reduction (mean ± SD µg/m³) PAC on vs. off:</p> <ul style="list-style-type: none"> - Room A: 56% (28 ± 2 vs. 64 ± 2) - Room B: 99% (0.4 ± 0.4 vs. 40 ± 2) 	<ul style="list-style-type: none"> - PAC use reduced indoor PM_{2.5} by 56–99% (36–39.6 µg/m³) - I/O ratios for PM_{2.5} was reduced from 0.31–0.50 to 0.003–0.22 comparing PAC on vs. off 	Moderate
Wheeler et al. 2021	Wildfire	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)	NR	<p>PM_{2.5} percent reduction (median (25–75%) µg/m³) PACs on vs. off: 72% (5.7 (5.5–8.5) vs. 20.0 (10.5, 39.0))</p>	<ul style="list-style-type: none"> - PAC use a public library reduced PM_{2.5} by 72% (median 14.3 µg/m³) compared to not using a PAC - I/O ratios not reported 	High
Xiang et al. 2021	Wildfire	PM _{2.5} mean ± SD (µg/m ³): 64 ± 17	<p>PM_{2.5} mean ± SD: PAC 0.19 ± 0.09, PAC off 0.56 ± 0.13</p>	<p>PM_{2.5} percent reduction (mean ± SD µg/m³) PAC on vs. off: 70% (14 ± 7 vs. 47 ± 24)</p>	<ul style="list-style-type: none"> - PAC use reduced indoor PM_{2.5} by 70% (33 µg/m³) compared to not using a PAC - I/O ratio for PM_{2.5} was reduced from 0.56 to 0.19 comparing PAC on vs. off 	High

Stauffer et al. 2020	Wildfire	PM _{2.5} mean ± SD (µg/m ³): 22.80 ± 12.37	PM _{2.5} mean: PAC off 0.60, PAC on not reported	PM _{2.5} percent reduction (mean ± SD µg/m ³) PAC vs. no PAC: - Day: 73% (2.95 ± 2.39 vs. 11.09 ± 9.70) - Night: 92% (0.50 ± 0.39 vs. 6.55 ± 7.10)	- PAC intervention reduced indoor PM _{2.5} concentrations by 73% (8.14 µg/m ³) during daytime hours and 92% (6.05 µg/m ³) during nighttime hours in an office building impacted by wildfire smoke - I/O ratio was 0.60 for PM _{2.5} when the PAC was turned off	High
Barn et al. 2008	Wildfire and RWC	<i>Wildfire smoke</i> PM _{2.5} mean ± SD (µg/m ³): PAC on 11.4 ± 10.0, PAC off 10.6 ± 6.8 <i>RWC</i> PM _{2.5} mean ± SD (µg/m ³): PAC on 18.7 ± 19.4, PAC off 16.2 ± 14.2	<i>Wildfire smoke</i> PM _{2.5} mean ± SD: PAC on 0.19 ± 0.2, PAC off 0.61 ± 0.27 <i>RWC</i> PM _{2.5} mean ± SD: PAC on 0.10 ± 0.08, PAC off 0.28 ± 0.18	<i>Wildfire smoke</i> PM _{2.5} infiltration factor percent reduction ± SD (mean ± SD µg/m ³) PAC on vs. off: 64.5 ± 35.0% (4.9 ± 1.6 vs. 8.2 ± 5.0) <i>RWC</i> PM _{2.5} infiltration factor percent reduction ± SD (mean ± SD µg/m ³) PAC on vs. off: 54.5 ± 37.6% (5.8 ± 7.0 vs. 9 ± 8.6)	- PAC use reduced indoor PM _{2.5} during wildfire smoke events and in homes with wood stoves by 65% (3.3 µg/m ³) and 55% (3.2 µg/m ³) respectively compared to when the PAC was turned off - I/O ratios for PM _{2.5} was reduced from 0.61 to 0.19 during wildfire smoke events and 0.28 to 0.10 in homes with wood stoves comparing PAC on vs. off	Moderate
Henderson et al. 2005	Wildfire	PM _{2.5} mean (µg/m ³): - Polhemus prescribed burn: House 1 (PAC) 21.7, House 2 37.5 - Snaking wildfire: House 1 (PAC) 7.52, House 2 5.54 - Schnoover wildfire: House 1 (PAC) 20.7, House 2 19.6 - Hayman wildfire: House 1 (PAC) 32.7, House 2 32.9	PM _{2.5} mean: - Polhemus prescribed burn: House 1 (PAC) 0.09, House 2 0.85 - Snaking wildfire: House 1 (PAC) 0.35, House 2 0.93 - Schnoover wildfire: House 1 (PAC) 0.06, House 2 0.58 - Hayman wildfire: House 1 (PAC) 0.09, House 2 0.74	PM _{2.5} percent reduction PAC house vs. no PAC house: - Polhemus prescribed burn: 84% - Snaking wildfire: 63% - Schnoover wildfire: 88% - Hayman wildfire: 88%	- Using a PACs inside during wildfire events reduced PM _{2.5} by 63–88% (4.91–29.68 µg/m ³), compared to similar homes without PACs; PAC use in homes reduced all indoor PM _{2.5} levels to < 3µg/m ³ - I/O ratio for PM _{2.5} was reduced from 0.58–0.93 to 0.06–0.34 comparing similar homes with PACs vs. homes without PACs	Moderate
Haze References						
Tham et al. 2021	Haze	PM ₁₀ mean (µg/m ³): 110 PM _{2.5} mean (µg/m ³): 85 PM ₁ mean (µg/m ³): 70	PM ₁₀ : FFU 0.05, control room 0.50 PM _{2.5} : FFU 0.06, control room 0.49 PM ₁ : FFU 0.07, control room 0.47	PM ₁₀ percent reduction (mean µg/m ³) FFU vs. control room: 85% (~10 vs. 66) PM _{2.5} percent reduction (mean µg/m ³) FFU vs. control room: 83% (~10 vs. 58) PM ₁ percent reduction (mean µg/m ³) FFU vs. control room: 75% (~10 vs. 40)	- Using a FFU inside during haze events reduced PM ₁₀ , PM _{2.5} , and PM ₁ by 75–85% (56, 48, and 30 µg/m ³) - I/O ratios for all PM sizes were reduced from 0.47–0.50 to 0.05–0.07 comparing FFU room to a control room - FFU created an overpressure that reduced infiltrating PM	Moderate

<p>Tran et al. 2021</p>	<p>Haze (distant wildfire and biomass fires)</p>	<p>PM_{2.5} mean ± SD (µg/m³): - Hazy days: PAC 60.93 ± 5.65, AC 37.22 ± 10.62, NV 49.78 ± 8.84 - Non-hazy days: PAC 25.26 ± 5.14, AC 25.48 ± 6.44, NV 25.77 ± 2.71</p> <p>BC mean ± SD (µg/m³): - Hazy days: PAC 5.99 ± 2.01, AC 4.95 ± 1.78, NV 4.55 ± 1.76 - Non-hazy days: PAC 3.86 ± 1.82, AC 3.94 ± 2.21, NV 4.01 ± 1.84</p> <p>Total Ions mean (µg/m³): - Hazy days: PAC 18.96, AC 13.71, NV 14.93 - Non-hazy days: PAC 8.89, AC 7.26, NV 9.47</p> <p>Total WSTE mean (µg/m³): - Hazy days: PAC 2.24, AC 1.79, NV 1.84 - Non-hazy days: PAC 0.96, AC 0.68, NV 0.95</p>	<p>PM_{2.5} mean ± SD: - Hazy days: PAC 0.25, AC 0.72, NV 0.98 - Non-hazy days: PAC 0.21, AC 0.63, NV 0.99</p> <p>BC mean ± SD: - Hazy days: PAC 0.15, AC 0.60, NV 0.97 - Non-hazy days: PAC 0.22, AC 0.62, NV 0.96</p> <p>Total Ions mean: - Hazy days: PAC 0.21, AC 0.71, NV 1.00 - Non-hazy days: PAC 0.1, AC 0.55, NV 0.93</p> <p>Total WSTE mean: - Hazy days: PAC 0.07, AC 0.42, NV 0.79 - Non-hazy days: PAC 0.21, AC 0.51, NV 0.99</p>	<p>PM_{2.5} percent reduction (mean ± SD µg/m³): - Hazy days: PAC vs. NV 69% (15.12 ± 3.79 vs. 48.93 ± 9.72), AC vs. NV 45% (26.8 ± 7.64 vs. 48.93 ± 9.72) - Non-hazy days: PAC vs. NV 79% (5.26 ± 1.36 vs. 25.42 ± 2.7), AC vs. NV 37% (16.07 ± 2.9 vs. 25.42 ± 2.7)</p> <p>BC percent reduction (mean ± SD µg/m³): - Hazy days: PAC vs. NV 80% (0.9 ± 0.34 vs. 4.4 ± 1.24), AC vs. NV 33% (2.97 ± 1.07 vs. 4.4 ± 1.24) - Non-hazy days: PAC vs. NV 78% (0.83 ± 0.18 vs. 3.85 ± 1.31), AC vs. NV 37% (2.43 ± 0.68 vs. 3.85 ± 1.31)</p> <p>Total Ions percent reduction (mean µg/m³): - Hazy days: PAC vs. NV 74% (3.91 vs. 14.98), AC vs. NV 35% (9.68 vs. 14.98) - Non-hazy days: PAC vs. NV 90% (0.86 vs. 8.77), AC vs. NV 55% (3.97 vs. 8.77)</p> <p>Total WSTE percent reduction (mean µg/m³): - Hazy days: PAC vs. NV 86% (0.21 vs. 1.53), AC vs. NV 54% (0.7 vs. 1.53) - Non-hazy days: PAC vs. NV 92% (0.06 vs. 0.75), AC vs. NV 61% (0.29 vs. 0.75)</p>	<p>- PAC with HEPA and activated charcoal filter reduced PM_{2.5}, BC, Ions, and trace elements by 69, 80, 74, and 86% (33.81, 3.50, 11.07, 1.32 µg/m³) during smoke haze events respectively, comparisons are made to a room with the windows open</p> <p>- I/O ratios were reduced for PM_{2.5} (0.98 to 0.25), BC (0.97 to 0.15), Ions (1.00 to 0.21), and trace elements (0.79 to 0.07) comparing PAC use to windows open</p>	<p>High</p>
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Sharma et al. 2017	Haze	PM _{2.5} mean ± SD (µg/m ³) PAC 72, Windows closed 157 ± 107, Windows open 94 ± 34	PM _{2.5} mean ± SD PAC 0.32, Windows closed 0.62, Windows open 0.76	PM _{2.5} percent (mean ± SD (µg/m ³) PAC vs. windows closed 48% (23 vs. 98 ± 54), windows open vs. closed 27% (71 ± 20 vs. 98 ± 54)	<ul style="list-style-type: none"> - PAC reduced indoor PM_{2.5} by 48% (75 µg/m³) compared to windows closed in a haze impacted apartment; I/O ratio for PM_{2.5} was reduced from 0.62 to 0.32 comparing PAC use to windows closed - Outdoor PM_{2.5} varied greatly between conditions and likely impacted indoor levels independent of intervention 	High
Cao et al. 2016	Haze	PM _{2.5} mean (µg/m ³): 88	<p>PM_{0.3-0.5} particle concentration mean: Control: 0.62, F25: 0.65, F65: 0.43, F85: 0.24, F95 0.21</p> <p>PM_{0.5-1.0} particle concentration mean: Control: 0.40, F25: 0.39, F65: 0.25, F85: 0.13, F95 0.13</p> <p>PM_{1.0-2.5} particle concentration mean: Control: 0.2, F25: 0.19, F65: 0.15, F85: 0.06, F95: 0.06</p>	<p>PM_{0.3-0.5} percent reduction particle removal efficiency: Control: 3.7%, F25: 4.8%, F65: 15.8%, F85: 34.5%, F95: 36.2%</p> <p>PM_{0.5-1.0} percent reduction particle removal efficiency Control: 9.7%, F25: 13.5%, F65: 28.5%, F85: 48.3%, F95: 49.0%</p> <p>PM_{1.0-2.5} percent reduction particle removal efficiency Control: 21.9%, F25: 29.3%, F65: 42.5%, F85: 68.2%, F95: -67.3%</p>	<ul style="list-style-type: none"> - MERV 13 or 14 filters reduced indoor PM by 34.5–67.3%; MERV 13 or 14 filters more effective at removing larger particles; On heavy haze days (Outdoor PM_{0.3-2.5} 279 µg/m³) MERV 13 filter reduced indoor PM_{0.3-2.5} by 48% (68.5 µg/m³) - I/O ratios for all PM sizes were reduced from 0.2–0.62 to 0.06–0.24 comparing MERV 13 or 14 filters to control 	High
Chen et al. 2016	Haze	PM _{2.5} mean (µg/m ³): 96	PM _{0.3} particle concentration mean: ACMV on 0.59, ACMV off 0.64	PM _{0.37-3.74} removal efficiency: 4–25% ACMV on vs. off	<ul style="list-style-type: none"> - Removal efficiencies for particles of 0.37–3.74 µm are significantly higher in the AC on mode than in the AC off mode (4–25%) during haze periods - I/O ratio for PM_{0.3} particle concentration was reduced from 0.64 to 0.059 comparing AC on vs. off 	High

Test-Chamber or Test-House References						
Stinson et al. 2024	Smoke from pine needles injected into a test-chamber	NR	NR	<p>PM_{0.02-0.3} CADR_s (range, m³/h): 76–416 H/S, 178–344 H/S/A, 296–866 DIY/H, and 21 DIY/S</p> <p>PM_{0.3-1} CADR_s (range, m³/h): 66–416 H/S, 154–350 H/S/A, 507–1165 DIY/H, and 9 DIY/S</p> <p>PM_{1-2.5} CADR_s (range, m³/h): 82–465 H/S, 154–399 H/S/A, 842–1470 DIY/H, and 18 DIY/S</p> <p>Benzene CADR_s (range, m³/h): -4–216 H/S, 0.4–0.9 H/S/A, and 20 DIY/S</p> <p>Toluene CADR_s (range, m³/h): -6–194 H/S, 0.4–0.9 H/S/A, and 17 DIY/S</p> <p>C8 Aromatics CADR_s (range, m³/h): -15–172 H/S, -11–1.3 H/S/A, and -13 DIY/S</p> <p>BC CADR_s (range, m³/h): 76–422 H/S, 150–406 H/S/A, 531–1214 DIY/H, and 8 DIY/S</p> <p>BrC CADR_s (range, m³/h): 90–504 H/S, 202–439 H/S/A, 556–1264 DIY/H, and 11 DIY/S</p>	<ul style="list-style-type: none"> - DIY/H PACs were the most effective at removing BC, BrC and PM of all size ranges from the air due to the high airflow rate of the box fan and large filter surface area - Commercial H/A PACs were the most effective at removing VOCs, although the range in efficacy is large and overlaps with H/S/A and DIY/S PACs - DIY PACs without a sorbent filter were ineffective at reducing VOCs 	Moderate
Li et al. 2023	Smoke from pine woodchips injected into a test-house	NR	NR	<p>Percent reduction PAC on vs. off:</p> <ul style="list-style-type: none"> - Formic acid (HCOOH): 3.8% - Formaldehyde (HCOH): 3.1% - Furan (C₄H₄O): 4.8% 	<ul style="list-style-type: none"> - PAC use lowered emission rates of HCOOH (3.8%), HCOH (3.1%), and C₄H₄O (4.8%) from indoor reservoirs and surfaces compared to PAC off - PACs had no net effect on VOC levels investigated; Calculated CADR_s for smoke VOCs is too low to effect ongoing release of smoke VOCs from surfaces into the air 	High

Holder et al. 2022	Smoke from pine needles injected into a test-chamber	NR	NR	CADRs (mean \pm SD m ³ /h): - 1-filter: 188.9 \pm 2.2 (Initial PM _{2.5} 109.9 μ g/m ³) - 2-filter wedge: 447 \pm 37.0 (Initial PM _{2.5} 104.4 μ g/m ³) - 4-filter box: 681.1 \pm 52.2 (Initial PM _{2.5} 138.2 μ g/m ³) - Commercial air cleaner: 129.0 \pm 1.0 (Initial PM _{2.5} 121.7 μ g/m ³)	- DIY-PACs are effective at reducing smoke concentrations in a controlled setting with CADRs exceeding a commercial PAC	High
Residential Wood Combustion References						
Walker et al. 2022	RWC	NR	NR	PM _{2.5} percent reduction (95% CI); (mean \pm SD μ g/m ³) PAC vs. placebo: - Indoor Levels: 50.5% (27.8, 66.1); (30.5 \pm 51.5 vs. 41.6 \pm 39.2) - Personal Levels: 44.7% (1.2, 69.0); (23.1 \pm 34.5 vs. 29.2 \pm 22.3)	- PAC use in homes with wood stoves reduced indoor PM _{2.5} mass concentrations by 51% (11.1 μ g/m ³) compared to placebo; I/O ratios not reported	High
McNamara et al. 2017	RWC	NR	NR	PM _{10-2.5} percent reduction (95% CI); (median (range) μ g/m ³) PAC vs. placebo: 38.2% (16.8, 67.3); (5.3 (0.2, 12.3) vs. 7.5 (0.6, 17.2)) PM _{2.5} percent reduction (95% CI); (median (range) μ g/m ³) PAC vs. placebo: 65.7% (42.2, 79.7); (5.7 (0.7, 65.6) vs. 22.0 (2.4, 163.2)) Endotoxin percent reduction (95% CI); (median (range) EU/m ³) PAC vs. placebo: 58.1% (-96.9, 91.1); (0.1 (0, 13.6) vs. 1.3 (0, 9.0))	- PAC use reduced PM _{10-2.5} , PM _{2.5} , and Endotoxin levels by 38, 66, and 58% (median 2.2, 16.3 μ g/m ³ , and 1.2 EU/m ³) compared to placebo respectively - I/O ratios not reported	Moderate
Noonan et al. 2017	RWC	NR	NR	PM _{2.5} percent reduction (95% CI) PAC vs. placebo: 67% (50, 77)	- PAC intervention in homes with wood stoves reduced indoor PM _{2.5} levels by 67% compared to homes without PACs - I/O ratios not reported	Moderate

Ward et al. 2017	RWC	NR	NR	<p>PM_{2.5} percent reduction (median (range) $\mu\text{g}/\text{m}^3$):</p> <ul style="list-style-type: none"> - Pre- vs. post-PAC: 69% (17.1 (6.1, 163.1) vs. 6.5 (0.7, 65.6)) - Pre- vs. post-placebo: 9% (16.1 (3.9, 508.2) vs. 16.9 (2.4, 163.2)) <p>PM_{2.5} percent reduction (median (range) particles/cm³):</p> <ul style="list-style-type: none"> - Pre- vs. post-PAC: 75% (40.6 (5.3, 192.3) vs. 15.5 (0, 106.1)) - Pre- vs. post-placebo: 27% (43.8 (15.5, 303.6) vs. 43.9 (0, 409.3)) <p>CO percent reduction (median (range) p.p.m.):</p> <ul style="list-style-type: none"> - Pre- vs. post-PAC: 78% (0.1 (0, 13.5) vs. 0.3 (0, 1.2)) - Pre- vs. post-placebo: 55% (0.1 (0, 6.5) pre vs. 0.2 (0, 1.6)) 	<ul style="list-style-type: none"> - Using PACs inside homes using wood-burning stoves during the winter reduced PM_{2.5} by 69% (median 10.6 $\mu\text{g}/\text{m}^3$) and PM_{2.5} particle count concentrations by 75% (median 25.1 particles/cm³) post-intervention; PACs did not influence CO levels - I/O ratios not reported 	Moderate
Kajbafzadeh et al. 2015	RWC	<p>PM_{2.5} mean \pm SD ($\mu\text{g}/\text{m}^3$): PAC on 3.9 ± 2.1, placebo 5.0 ± 2.5</p> <p>Levoglucosan mean \pm SD (ng/m³): PAC on 20.6 ± 19.9, placebo 13.2 ± 13.5</p>	<p>PM_{2.5} mean \pm SD: PAC on 0.87 ± 0.77, placebo 1.3 ± 0.65</p>	<p>PM_{2.5} percent reduction (mean \pm SD $\mu\text{g}/\text{m}^3$) PAC vs. placebo: 48% (3.4 ± 1.9 vs. 6.5 ± 2.7)</p> <p>Levoglucosan percent reduction (mean \pm SD ng/m³) PAC vs. placebo filter: 60% (11.8 ± 14.4 vs. 29.3 ± 67.1)</p>	<ul style="list-style-type: none"> - PACs reduced indoor PM_{2.5} by 48% (3.1 $\mu\text{g}/\text{m}^3$) and levoglucosan by 60% (17.5 ng/m³) compared to placebo PACs in woodsmoke impacted households - I/O ratio for PM_{2.5} was reduced from 1.3 to 0.87 comparing PAC use to placebo 	Moderate
Wheeler et al. 2014	RWC	<p>PM median (range) ($\mu\text{g}/\text{m}^3$): PAC on 7.66 (0.91, 65.28), placebo 5.9 (0.51, 35.66)</p> <p>PM_{2.5} median (range) ($\mu\text{g}/\text{m}^3$): PAC on 2.51 (0.42, 22.6), placebo 3.67 (0.34, 115.97)</p> <p>Levoglucosan median (range) (ng/m³): PAC on 0.139 (0.055, 3.258), placebo 0.096 (0.021, 1.458)</p>	<p>PM median (range): PAC on 0.42 (0.08, 2.29), placebo 1.42 (0.24, 19.72)</p> <p>PM_{2.5} median (range): PAC on 0.63 (0.08, 5.78), placebo 1.2 (0.03, 24.0)</p> <p>Levoglucosan median (range): PAC on 0.17 (0.00, 0.77), placebo 0.36 (0.00, 14.62)</p>	<p>PM percent reduction (median (range) $\mu\text{g}/\text{m}^3$) PAC vs. placebo: 63% (3.17 (0.9, 21.26) vs. 5.58 (2.6, 64.42))</p> <p>PM_{2.5} percent reduction (median (range) $\mu\text{g}/\text{m}^3$) PAC vs. placebo: 50% (1.92 (0.35, 11.28) vs. 3.87 (0.37, 30.19))</p> <p>Levoglucosan percent reduction (median (range) ng/m³) PAC vs. placebo: 32% (0.034 (undefined, 0.189) vs. 0.050 (undefined, 0.448))</p>	<ul style="list-style-type: none"> - PAC use reduced PM, PM_{2.5}, and levoglucosan levels by 63, 50, and 32% (median 1.7, 1.95 $\mu\text{g}/\text{m}^3$, and 0.016 ng/m³) compared to placebo respectively - I/O ratios were reduced for PM (1.42 to 0.42), PM_{2.5} (1.2 to 0.63), and Levoglucosan (0.36 to 0.17) comparing PAC use to placebo 	Moderate

Allen et al. 2011	RWC	<p>PM_{2.5} mean ± SD (µg/m³): PAC on 9.8 ± 4.2, placebo 10.8 ± 4.2</p> <p>Levoglucosan mean ± SD (ng/m³): PAC on 530 ± 358, placebo 613 ± 548</p>	PM _{2.5} mean ± SD: PAC on 0.2 ± 0.17, placebo 0.34 ± 0.17	<p>PM_{2.5} percent reduction (mean ± SD µg/m³) PAC vs. placebo: 59% (4.6 ± 2.6 vs. 11.2 ± 6.1)</p> <p>Levoglucosan percent reduction (mean ± SD ng/m³) PAC vs. placebo: 74% (33 ± 39 vs. 127 ± 191)</p>	<ul style="list-style-type: none"> - PAC intervention in homes with wood-burning stoves reduced indoor PM_{2.5} by 59% (6.6 µg/m³) and levoglucosan by 74% (94 ng/m³) compared to placebo PACs - I/O ratio for PM_{2.5} was reduced from 0.34 to 0.2 comparing PAC use to placebo 	Moderate
Hart et al. 2011	RWC	NR	NR	<p>PM_{2.5} percent reduction (mean (95%CI) µg/m³) PAC on vs. off:</p> <ul style="list-style-type: none"> - House A: 76% (3.3 (1.09, 5.51) vs. 13.98 (5.93, 22.03)) - House B: 76% (3.26 (2.23, 4.29) vs. 13.60 (8.10, 19.09)) <p>PM₁ percent reduction (mean (95% CI) µg/m³) PAC on vs. off:</p> <ul style="list-style-type: none"> - House A: 58% (3.72 (1.15, 6.28) vs. 5.85 (3.94, 13.8)) - House B: 55% (3.21 (0, 7.6) vs. 7.08 (0.83, 13.32)) <p>Particle # conc. percent range reduction PAC on vs. off:</p> <ul style="list-style-type: none"> - House A: 61% to 65% - Home B: 78% to 85% 	<ul style="list-style-type: none"> - PAC use in homes with wood-burning stoves reduced indoor PM_{2.5} mass concentrations by 76% (10.5 µg/m³) and particle number concentrations by 61–85% compared to when PACs were turned off; I/O ratios not reported 	Moderate

Abbreviations: **DIY**: do-it-yourself; **HEPA**: high-efficiency particulate air; **MERV**: minimum efficiency reporting values; **NR**: not reported; **PAC**: portable air cleaner; **PM₁₀**: particulate matter under 10.0 µm in diameter; **PM_{2.5}**: fine particulate matter under 2.5 µm in diameter; **PM_{0.1}**: ultrafine particulate matter under 1.0 µm in diameter; **PM_{x-y}**: particulate matter ranging in x-y µm in diameter; **BC**: black carbon; **BrC**: brown carbon; **RWC**: residential wood combustion; **CADR**: clean air delivery rate; **I/O**: indoor/outdoor ratio; **FFU**: fan filter unit.

#Percent reduction pre-post and or placebo-intervention

*Ratios above 1 indicate indoor source generation

& [Turner et al. 2024](#) and [Prathibha et al. 2024](#) reported air pollution data from the same Hoopa study. Analysis methods for air pollution data differed for select outcomes. Only air pollution data from [Prathibha et al. 2024](#) was considered in the air pollution summary findings. Air pollution data from [Turner et al. 2024](#) is presented to provide context for the health outcomes reported in this reference.

Table 4: Summary of human health outcomes

Reference	Combustion Episode	Type of Outcome	Outcomes	Summary of Findings	Study Quality
Wildfire References					
Turner et al. 2024	Wildfire and residential wood combustion (RWC)	Self-reported	<ul style="list-style-type: none"> - Physical (upper and lower respiratory, cardiovascular) symptoms - Mental/neurological (concentration, memory, sleep, depression, anxiety) symptoms - All-cause symptoms 	There were no differences in physical, mental or all-cause symptoms between periods of high and low air cleaner usage. Overall, there were no clear differences between DIY or commercial PAC.	Low
Residential Wood Combustion References					
Noonan et al. 2017	RWC	Self-reported	<ul style="list-style-type: none"> - PAQLQ score - Asthma symptoms (daytime/nighttime coughing or wheezing, activity limitations, use of asthma medication) - Spirometry measures (peak expiratory flow, diurnal peak flow variability) 	There were no differences in PAQLQ scores, asthma symptoms, or spirometry measures, compared to placebo.	Moderate
Kajbafzadeh et al. 2015	RWC	Cellular-level	<ul style="list-style-type: none"> - RHI - Systemic inflammation biomarkers (CRP, IL6, band cells) 	There were no differences in cellular-level outcomes between periods with or without HEPA filtration.	Moderate
Allen et al. 2011	RWC	Cellular-level	<ul style="list-style-type: none"> - Reactive hyperemia index (RHI) - Systemic inflammation biomarkers (C-reactive protein (CRP), interleukin-6 (IL6), band cells) - Oxidative stress markers (malondialdehyde, 8-isoprostane) 	RHI was 9.4% higher (95% CI=0.9,18) and CRP was 32.6% lower (95% CI=4.4,60.9) when HEPA filters were used, compared to placebo; there were no differences for other inflammation or oxidative stress markers. Effects were stronger amongst younger and male participants.	Moderate

Abbreviations: **CRP**: C-reactive protein; **DIY**: do-it-yourself; **HEPA**: high-efficiency particulate air; **IL6**: interleukin-6; **PAC**: portable air cleaner; **PAQLQ**: Pediatric Asthma Quality of Life Questionnaire; **RHI**: reactive hyperemia index; **RWC**: residential wood combustion.

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