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U.S. DEPARTMENT OF ENERGY

Efficacy of In-Room Air Cleaners during Wildfire Smoke

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Indoor Environment Group
Energy Technologies Area

BAAQMD Meeting July 7, 2022

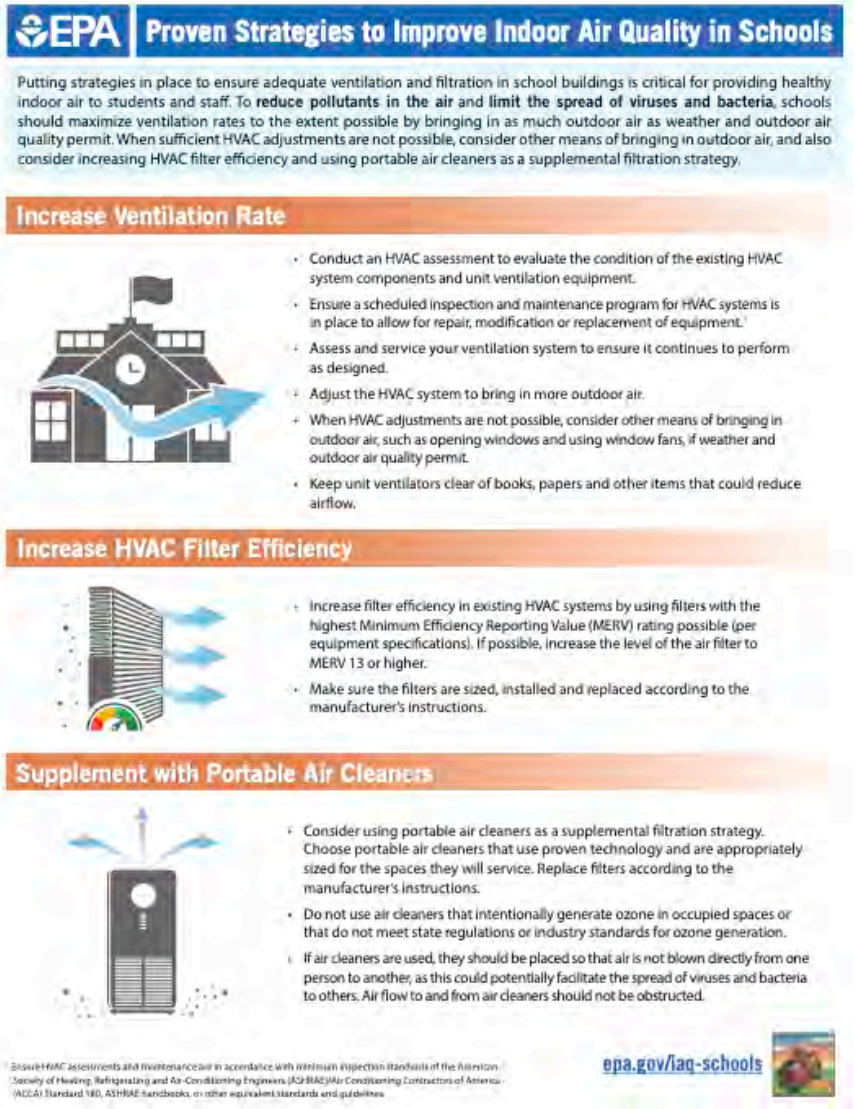
In-room air cleaners

- Portable air cleaners: commercial, DIY
- Form factor: wall unit, ceiling mount
- Fibrous filter, typically HEPA
- Some include other air cleaning technologies: activated carbon (AC), photocatalytic oxidation (PCO), germicidal ultraviolet (GUV), etc.

https://enverid.com/products/air-purifier/

https://kmph.com/news/local/air-purifiers-going-into-all-clovis-unified-classrooms

New guidance and resources on performance



EPA Proven Strategies to Improve Indoor Air Quality in Schools

Putting strategies in place to ensure adequate ventilation and filtration in school buildings is critical for providing healthy indoor air to students and staff. To **reduce pollutants in the air** and **limit the spread of viruses and bacteria**, schools should maximize ventilation rates to the extent possible by bringing in as much outdoor air as weather and outdoor air quality permit. When sufficient HVAC adjustments are not possible, consider other means of bringing in outdoor air, and also consider increasing HVAC filter efficiency and using portable air cleaners as a supplemental filtration strategy.

Increase Ventilation Rate

- Conduct an HVAC assessment to evaluate the condition of the existing HVAC system components and unit ventilation equipment.
- Ensure a scheduled inspection and maintenance program for HVAC systems is in place to allow for repair, modification or replacement of equipment.
- Assess and service your ventilation system to ensure it continues to perform as designed.
- Adjust the HVAC system to bring in more outdoor air.
- When HVAC adjustments are not possible, consider other means of bringing in outdoor air, such as opening windows and using window fans, if weather and outdoor air quality permit.
- Keep unit ventilators clear of books, papers and other items that could reduce airflow.

Increase HVAC Filter Efficiency

- Increase filter efficiency in existing HVAC systems by using filters with the highest Minimum Efficiency Reporting Value (MERV) rating possible (per equipment specifications). If possible, increase the level of the air filter to MERV 13 or higher.
- Make sure the filters are sized, installed and replaced according to the manufacturer's instructions.

Supplement with Portable Air Cleaners

- Consider using portable air cleaners as a supplemental filtration strategy. Choose portable air cleaners that use proven technology and are appropriately sized for the spaces they will service. Replace filters according to the manufacturer's instructions.
- Do not use air cleaners that intentionally generate ozone in occupied spaces or that do not meet state regulations or industry standards for ozone generation.
- If air cleaners are used, they should be placed so that air is not blown directly from one person to another, as this could potentially facilitate the spread of viruses and bacteria to others. Air flow to and from air cleaners should not be obstructed.

Ensure HVAC assessments and maintenance are in accordance with minimum inspection standards of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)/Air Conditioning Contractors of America (ACCA) Standard 180, ASHRAE handbooks, or other equivalent standards and guidelines.

epa.gov/iaq-schools

https://www.epa.gov/system/files/documents/2021-09/iaq_proven-strategies_infographic.pdf

UCDAVIS Western Cooling Efficiency Center

CASE STUDY August 2021

TESTING DIFFERENT CONFIGURATIONS OF DO-IT-YOURSELF PORTABLE AIR CLEANERS

This DIY air cleaner performs similarly to residential portable air cleaners in terms of estimated clean air delivered and costs approximately three times less.

Portable air cleaners are increasingly in demand to reduce concentrations of particulates and respiratory aerosols indoors. Researchers at the UC Davis Western Cooling Efficiency Center (WCEC) tested two types of Do-It-Yourself (DIY) portable air cleaners (standard box fans modified with added filtration on the suction side of the box fan) and documented the power draw, airflow, and noise for each configuration. Researchers calculated the clean air delivery rate based on filter test reports and reported energy efficiency and cost metrics for each configuration.

Note that while DIY portable air cleaners are a useful and easily accessible tool to reduce particulates in buildings, they should not be considered a substitute for ensuring adequate ventilation and filtration is provided by central building heating, ventilation, and air conditioning (HVAC) systems.

WESTERN COOLING EFFICIENCY CENTER wcec.ucdavis.edu UCDAVIS

https://energy.ucdavis.edu/wp-content/uploads/Case-Study_DIY-Portable-Air-Cleaners-083121.pdf

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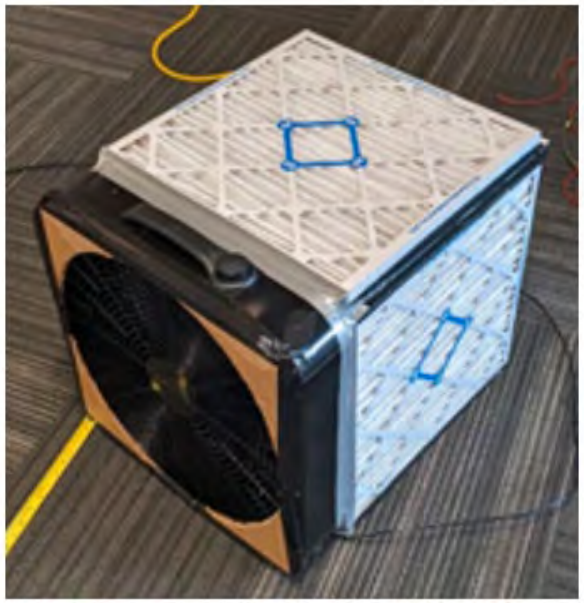
DIY box fan effectiveness and safety

Table 1 - DIY box fan filter test results. Best value highlighted in green.

Fan	Fan Intake	Speed	Power (W)	Airflow (CFM)	CADR	Noise (dB)	Face Velocity (fpm)	Energy Efficiency (CADR/ Watt)	Cost ($)	Cost ($) per unit of CADR
Lasko (A) + Shroud	4 Filter	1	70	306	165	53	34	2.19	$74.48	$0.24
Lasko (A) + Shroud	4 Filter	2	88	407	220	58	45	2.31	$74.48	$0.18
Lasko (A) + Shroud	4 Filter	3	102	443	239	61	49	2.17	$74.48	$0.17

Assumed 54% filtration efficiency for MERV 13 air filters. Estimated clean air delivery rate (CADR) and noise level similar to consumer products. Estimated energy efficiency slightly above ENERGY STAR 2 CADR / Watt requirement. Material costs = $75. https://energy.ucdavis.edu/wp-content/uploads/Case-Study_DIY-Portable-Air-Cleaners-083121.pdf

Additional resources from USEPA https://www.epa.gov/air-research/research-diy-air-cleaners-reduce-wildfire-smoke-indoors: UL Safety Report Findings

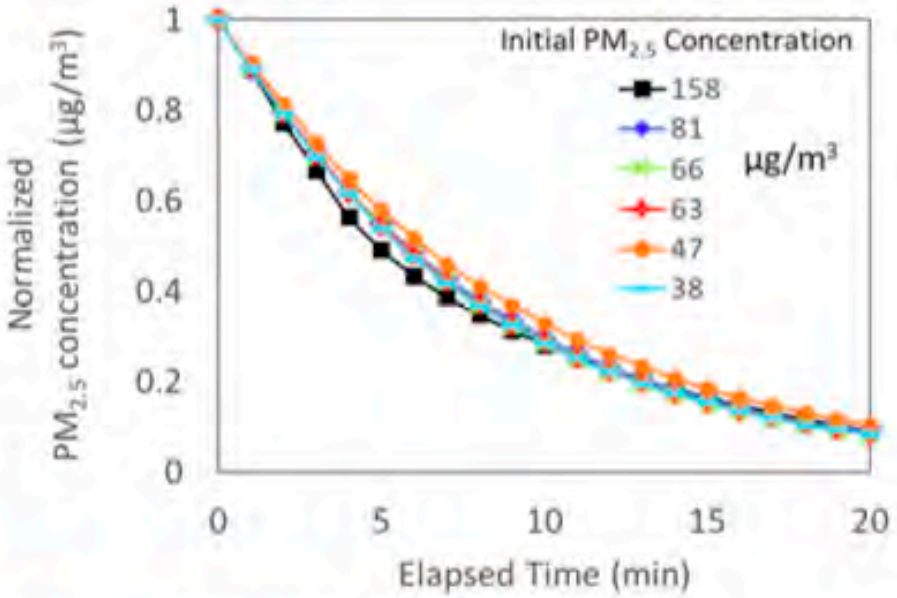


EPA ORD work in progress: DIY laboratory effectiveness

- Measuring CADR for simulated wildfire smoke (smoldering pine needles) in a 30 ft^3 chamber
- Completed 8 trial runs with Lasko box fan + Aerostar MERV 13 filters
- Repeatable results from $PM_{2.5}$ = 38 – 150 $\mu g/m^3$

Feature	DIY Air Cleaner	Commercial Air Cleaner
Price	~$30	~$100
CADR	113 ± 5	108
Noise (dB)	67 ± 1	55
Power (W)	77 ± 3	53

- Upcoming tests to focus on higher $PM_{2.5}$ concentrations, loaded filters, comparison to commercial units



Holder, A. Emerging Approaches to Cleaner Indoor Air During Wildfires. Presented at Smoke Impacts CA: 2020 Lessons - 2021 Actions, Virtual, April 20 - 21, 2021. https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=351926&Lab=CEMM&simplesearch=0&showcriteria=2&sortby=pubDate&searchall=holder&timstype=&datebeginpublishedpresented=08/03/2019

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Field study in 7 WA homes

- Field measurements of $PM_{2.5}$ infiltration factor and portable air cleaner effectiveness during Sep 16-18, 2020
  - Wildfire smoke from WA, OR, CA impacting Seattle, WA
  - 6 apartment units (~650 ft^2), 1 house (~1,900 ft^2)
  - 5 residences operated a portable air cleaner (auto-mode) in living room

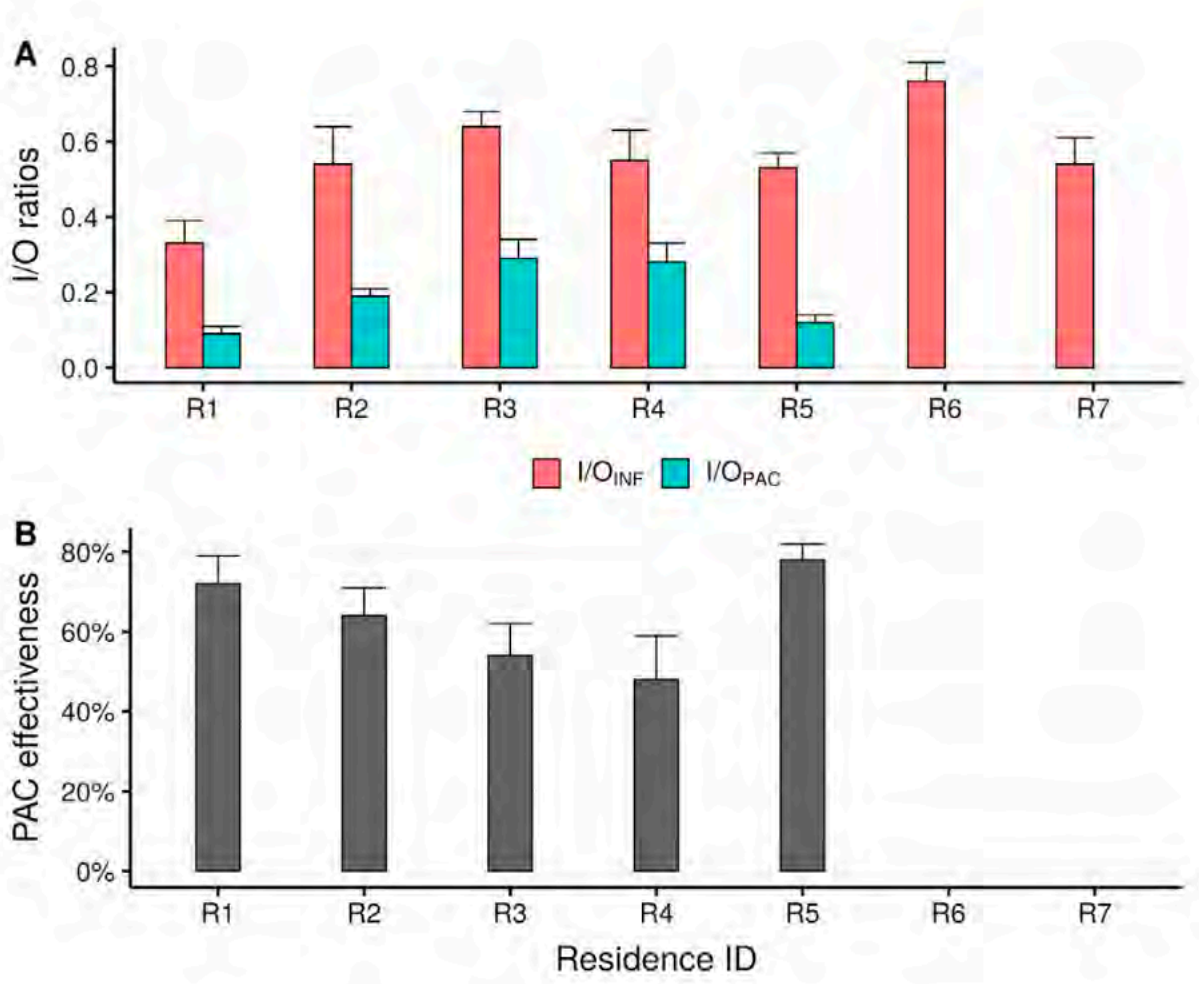

Fig. 3. (A) Measured mean (standard deviation) of $PM_{2.5}$ I/O_{INF} and I/O_{PAC} for each residence; (B) mean (standard deviation) of the portable air cleaner (PAC) effectiveness. I/O_{INF} represents infiltration factor; I/O_{PAC} represents indoor/outdoor ratio with a portable air cleaner on.

Xiang et al. (2021) https://doi.org/10.1016/j.scitotenv.2021.145642

Indoor Air 2017; 27: 191–204
wileyonlinelibrary.com/journal/ina

INDOOR AIR
doi:10.1111/ina.12285

Health benefits and costs of filtration interventions that reduce indoor exposure to PM2.5 during wildfires

Abstract Increases in hospital admissions and deaths are associated with increases in outdoor air particles during wildfires. This analysis estimates the health benefits expected if interventions had improved particle filtration in homes in Southern California during a 10-day period of wildfire smoke exposure. Economic benefits and intervention costs are also estimated. The six interventions implemented in all affected houses are projected to prevent 11% to 63% of the hospital admissions and 7% to 39% of the deaths attributable to wildfire particles. The fraction of the population with an admission attributable to wildfire smoke is small, thus, the costs of interventions in all homes far exceeds the economic benefits of reduced hospital admissions. However, the estimated economic value of the prevented deaths exceed or far exceed intervention costs for interventions that do not use portable air cleaners. For the interventions with portable air cleaner use, mortality-related economic benefits exceed intervention costs as long as the cost of the air cleaners, which have a multi-year life, are not attributed to the short wildfire period. Cost effectiveness is improved by intervening only in the homes of the elderly who experience most of the health effects of particles from wildfires.

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Key words: Benefits; Costs; Health; Filtration; Wildfires; Homes.

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2003 Southern California Wildfires

- Impacts on six counties over a 10-day period
  - PM2.5 levels (Wu 2006)
  - Hospital admission rates (Delfino 2009)
  - Effects on mortality (Kochi 2012)

Q: Can filtration substantially reduce wildfire-related hospitalizations and deaths? Are filtration interventions cost-effective?

Wu, et al. (2006) Exposure assessment of PM air pollution before, during, and after the 2003 southern CA wildfires, Atmos. Environ.
Delfino, et al. (2009) Relationship of respiratory & cardiovascular hospital admissions to southern CA wildfires 2003, Occup. Environ. Med.
Kochi, et al. (2012) Valuing mortality impacts of smoke exposure from major southern California wildfires, J. Forest Econ.

Filtration Interventions

- Mass balance models to estimate PM2.5 in homes with and without filtration interventions

1. Upgrade to high efficiency air filters (MERV 12*)
2. Change to Fan ON mode to run system continuously
3. 1 + 2
4. Buy an air cleaner (HEPA filter, 1 AER)
5. Buy an air cleaner + 1 + 2

* Reduced to MERV 9 because of air leakage bypass.

Fisk and Chan (2017) https://doi.org/10.1111/ina.12285

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Key Findings

- Filtration interventions in all 6.92 million homes exposed to 2003 southern California wildfires would have prevented 47 to 261 respiratory hospital admissions (11-63% reduction), and 9 to 52 premature deaths (7-39% reduction), related to PM2.5 exposures during the 10-day study period.
- Economic benefits from reduced hospitalization and premature deaths exceed intervention costs for all 6.92 million homes exposed to wildfire smoke, but are not sufficient to pay for portable air cleaners.
  - Estimated benefit-to-cost ratio range is about 2:1 using forced air system filtration interventions in all homes
  - For 22% of homes with age 65+ residents: benefit-to-cost = 16:1
- In 22% of homes with age 65+ residents, benefits from reduced hospitalization and premature deaths are sufficient to pay for purchase of portable air cleaners.

Fisk and Chan (2017) https://doi.org/10.1111/ina.12285

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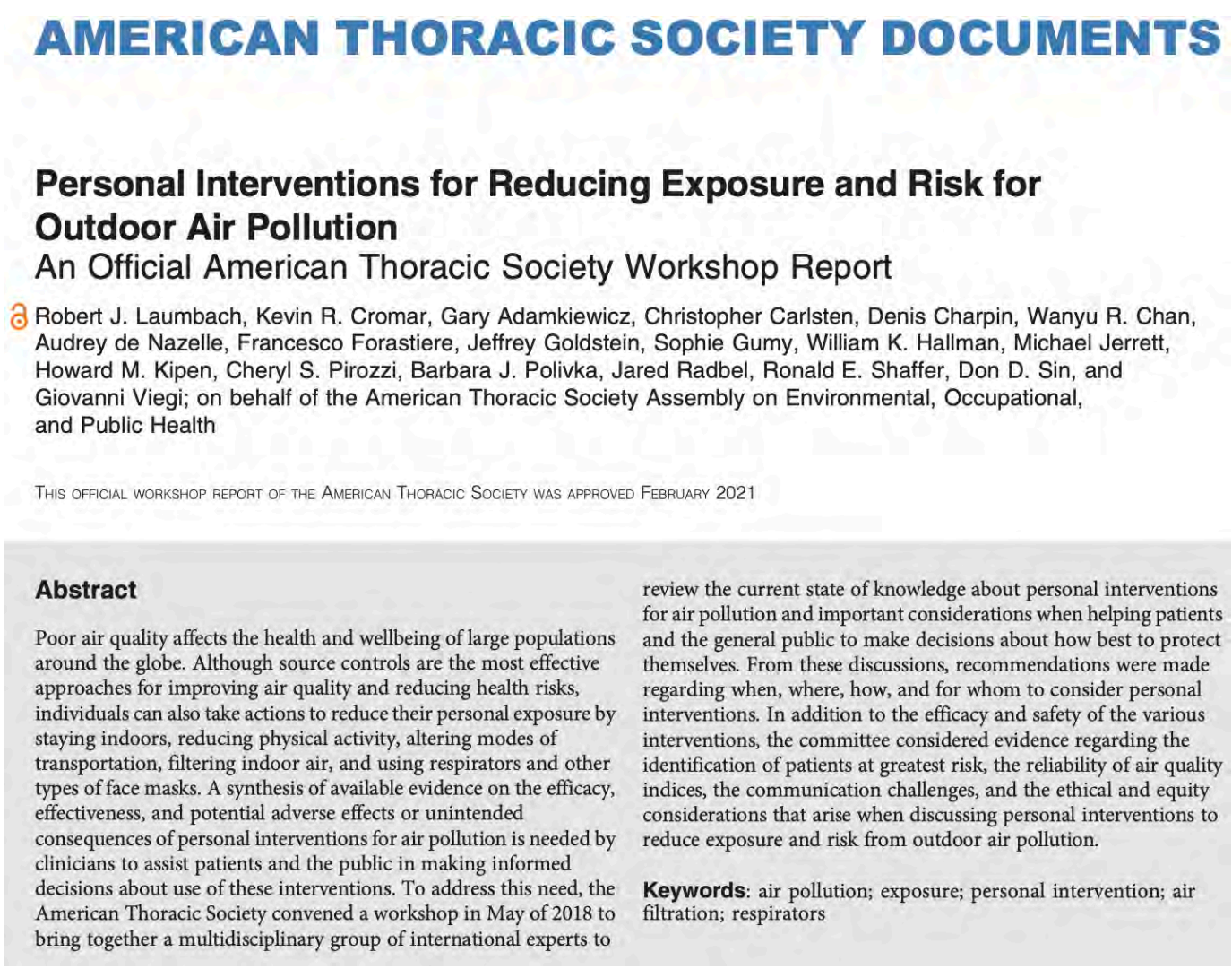
Does the use of indoor air cleaners protect against adverse health impacts from exposure to outdoor air pollution?

- There are relatively few studies of changes in health outcomes resulting from interventions to reduce indoor pollutant concentrations.
- Several small studies have measured changes in biomarkers believed to represent pathways that can lead to clinical outcomes.
- It is unclear whether further biomarker studies will clarify efficacy of portable air cleaners. Clinical trials investigating impacts on clinical outcomes are recommended.



AMERICAN THORACIC SOCIETY DOCUMENTS

Personal Interventions for Reducing Exposure and Risk for Outdoor Air Pollution

An Official American Thoracic Society Workshop Report

Robert J. Laumbach, Kevin R. Cromar, Gary Adamkiewicz, Christopher Carlsten, Denis Charpin, Wanyu R. Chan, Audrey de Nazelle, Francesco Forastiere, Jeffrey Goldstein, Sophie Gumy, William K. Hallman, Michael Jerrett, Howard M. Kipen, Cheryl S. Pirozzi, Barbara J. Polivka, Jared Radbel, Ronald E. Shaffer, Don D. Sin, and Giovanni Viegi; on behalf of the American Thoracic Society Assembly on Environmental, Occupational, and Public Health

THIS OFFICIAL WORKSHOP REPORT OF THE AMERICAN THORACIC SOCIETY WAS APPROVED FEBRUARY 2021

Abstract

Poor air quality affects the health and wellbeing of large populations around the globe. Although source controls are the most effective approaches for improving air quality and reducing health risks, individuals can also take actions to reduce their personal exposure by staying indoors, reducing physical activity, altering modes of transportation, filtering indoor air, and using respirators and other types of face masks. A synthesis of available evidence on the efficacy, effectiveness, and potential adverse effects or unintended consequences of personal interventions for air pollution is needed by clinicians to assist patients and the public in making informed decisions about use of these interventions. To address this need, the American Thoracic Society convened a workshop in May of 2018 to bring together a multidisciplinary group of international experts to review the current state of knowledge about personal interventions for air pollution and important considerations when helping patients and the general public to make decisions about how best to protect themselves. From these discussions, recommendations were made regarding when, where, how, and for whom to consider personal interventions. In addition to the efficacy and safety of the various interventions, the committee considered evidence regarding the identification of patients at greatest risk, the reliability of air quality indices, the communication challenges, and the ethical and equity considerations that arise when discussing personal interventions to reduce exposure and risk from outdoor air pollution.

Keywords: air pollution; exposure; personal intervention; air filtration; respirators

https://www.atsjournals.org/doi/10.1513/AnnalsATS.202104-421ST

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Improving IAQ Using In-Room Air Cleaners During Wildfire Smoke

- Focus on in-home exposure of vulnerable population
  - Health, age, other socioeconomic factors
  - Other factors: housing conditions, exposure outside of home
  - Education / outreach on operation, filter replacement
- Clean air centers and schools
  - Aside from effective filtration, other aspects (e.g., air distribution, thermal comfort, resilience from energy disruptions) also important
  - $PM_{2.5}$ and CO_2 monitoring; data sharing and communication

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Indoor Environment Group
Energy Technologies Area

BAAQMD Meeting July 7, 2022

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

AGENDA: 7

Authorization to use CARB SEP Funds and $1M Wildfire Mitigation Designated Reserves for School and Home Air Filtration Programs

Community Equity, Health and Justice Committee
July 7, 2022

Joshua Abraham
Acting Assistant Manager
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Requested Action

- Authorize the Interim Executive Officer/ APCO to allocate CARB Supplemental Environmental Project (SEP) funds and amend the Community Engagement Division Budget by $1 million using the Wildfire Mitigation Designation Reserves. These combined funding sources will be used in the following ways:

  1. Use of $231,000 for the purchase of air filters and replacement filters for low-income clients of state Asthma Mitigation Partners with asthma or other respiratory disease

  2. Execution of a $69,000 professional services contract with Regional Asthma Management Prevention (RAMP) (a project of the Public Health Institute)

  3. Execution of contract amendment with IQAir to use remaining $97,603.29 of CARB SEP funds and $294,600.95 of Wildfire Mitigation Designation Reserves for installation of air filtration and 5-year maintenance for four elementary schools in the Richmond - San Pablo area

Requested Action (cont.)

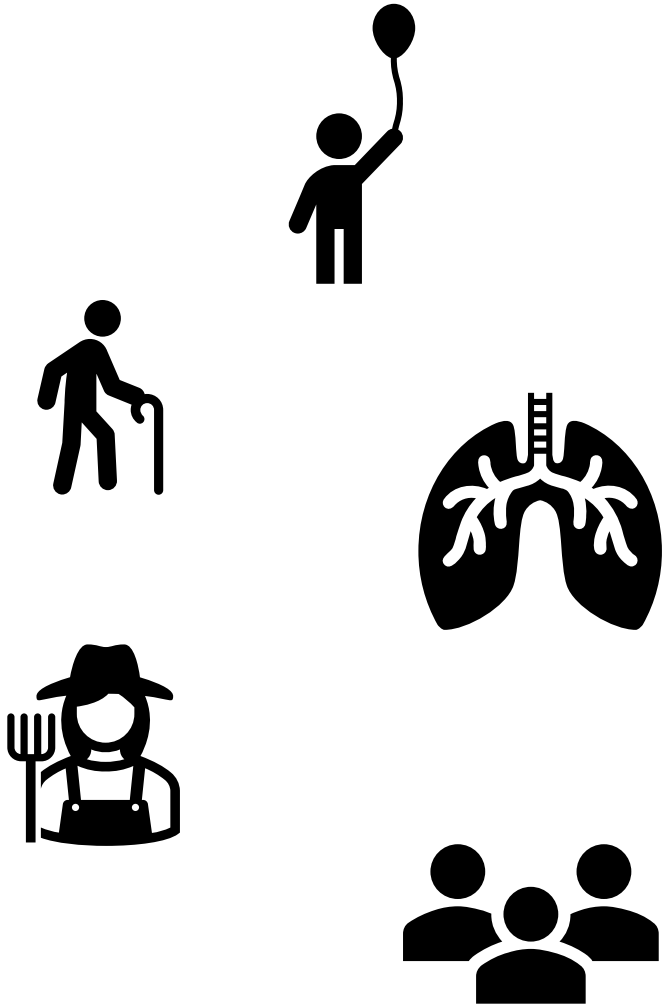
4. Use $300,000 to purchase air filtration units and replacement filters for federally qualified health centers to distribute to low-income clients with asthma or other respiratory disease in Assembly Bill (AB) 617 communities

5. Use $100,000 to purchase air filtration units and replacement filters for AB 617 communities and outdoor workers recruited by James Cary Smith Community Grantees and other community-based organizations

Background & Program Scope

- In September 2021:
  - Board approved Executive Officer/APCO to allocate an additional $1 million to the Wildfire Mitigation Designation and to reduce the Pandemic Reserves Designation by $1M.
- On June 30, 2022:
  - The Community Advisory Council unanimously approved and recommended staff's proposal to the CEHJ Committee.
- Staff’s Objective
  - Expand existing air filtration programs and equitably distribute air filtration units to more impacted communities.
  - Leverage existing partnerships with local communities.

Impact



- Children and youth
- Populations with pre-existing health conditions, respiratory disease
- Elders
- Outdoor workers
- Communities already impacted by cumulative health burdens

Consultation with Environmental Justice Leaders & Partners

What we heard:

- Localized focus on impacted communities, hard-to-reach populations
- Non-competitive funding
- Need for a comprehensive plan that integrates and leverages existing work (asset map)
- A way to distribute educational and resource information to communities in accessible ways
- Demonstrate how resources are getting to impacted communities

Existing Programs

RAMP Partnership

- Partner with Regional Asthma Management & Prevention ($250k) to provide air filters to low-income home visiting clients with poorly controlled asthma
- ~$143k remaining. Distributed 875 air filters.

Local Health Centers - *Pilot*

- Partner with Local Health Centers to distribute home air filtration units to low-income clients with asthma:
  - Ole Health (Napa) - *in progress*
  - West Oakland Health Council
  - Roots Community Clinic (East Oakland)
  - La Clinica (Vallejo)- *in progress*

Schools

- Install and maintain air filtration in heating, ventilation, and air conditioning (HVAC) systems at 12 elementary schools:
  - East and West Oakland
  - Bayview Hunters Point, San Francisco
  - Livermore
  - San Leandro
  - Pittsburg and Bay Point

Community Partners - *Pilot*

- Partner with Community-Based Organizations to distribute air filters to low-income residents. Distributed 293 air filters.
  - All Positives Possible (Vallejo)
  - Belle Haven Action (Menlo Park)
  - City of Millbrae
  - Healing Impacted Communities (Rodeo)
  - United Council (Pier 94, SF)

Proposal

RAMP Partnership ($300K)	Local Health Centers ($300K)	Schools ($300K)	Community-based organizations ($100K)
• Expand RAMP partnership to all clients with asthma or respiratory disease and to create educational materials and a case study of the partnership	• Expand outreach to additional local health center partners in AB 617 communities • Low-income clients with asthma or respiratory disease	• Expand to four elementary schools in Richmond – San Pablo area with remaining CARB SEP grant and wildfire mitigation reserve funds	• Expand outreach to JCS Community Grantees to apply to distribute to residents in AB 617 communities • West Oakland and Richmond/ North Richmond/ San Pablo: identify Resiliency Hubs • Outdoor workers in Santa Clara County

Local Health Centers & Community Partners

Eligibility:

- Local Health Centers: Low-income individuals and individuals diagnosed with asthma and/ or other respiratory lung disease or a referral
- Community Partners: Recruit recipients from AB 617 communities

Partner Role and Responsibility

- Ensure eligibility, place orders with Air District
- Store and distribute air filtration units and factsheet on air filter
- Collect information about recipients: date of delivery, City and Zip Code of recipient; (optional: age, race/ ethnicity and primary language of recipient)

Air District Role

- Purchase and schedule delivery of air filters from selected vendors
- Provide factsheet in multiple languages and general support
- Collect and analyze data

Next Steps

July

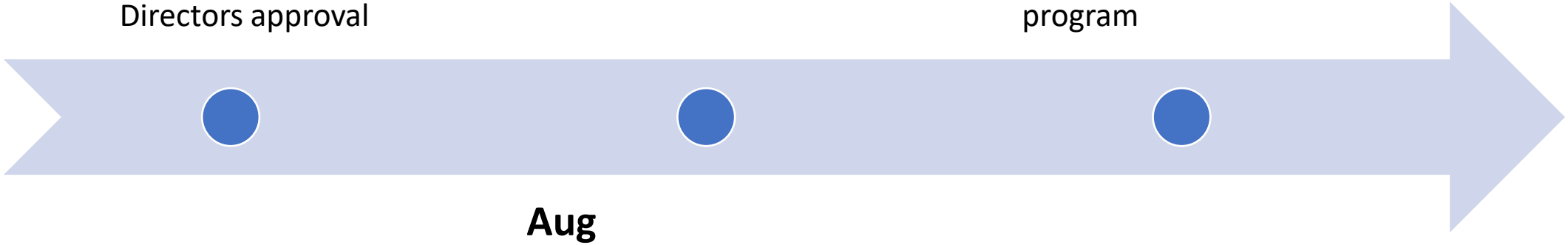
- CEHJ and Board of Directors approval

Aug

- Launch Strategies-set up partnerships and assist with order for air filters

September

- Track progress and assess program



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Questions?