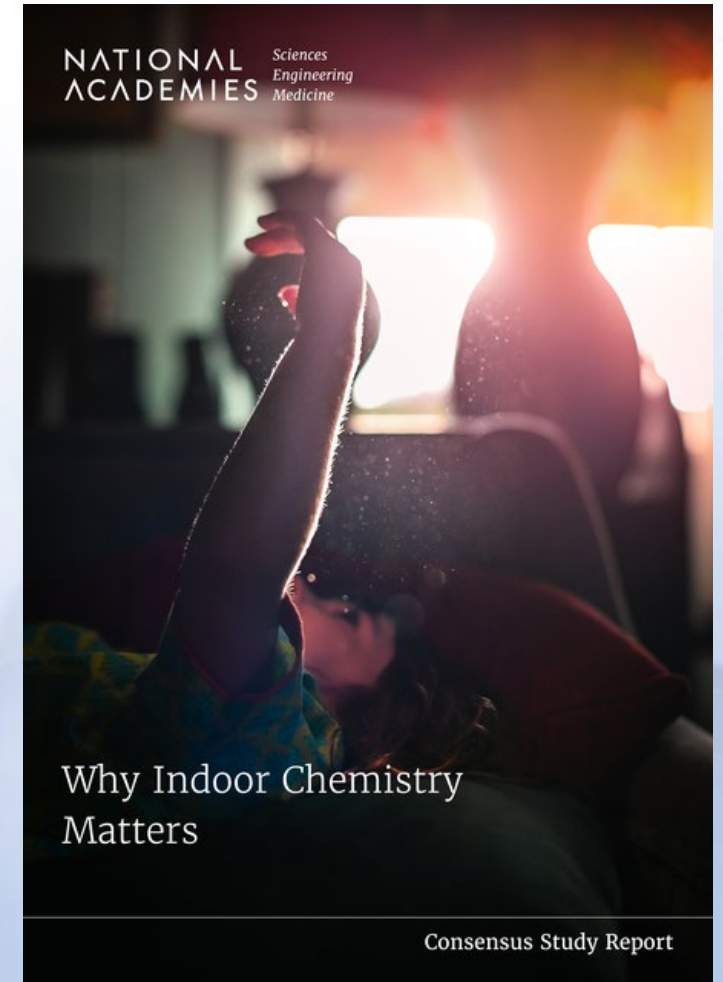


# Indoor air guidance development at EPA

## Why Indoor Chemistry Matters – Workshop 3

Vito Ilacqua, PhD

4/10/2024



This presentation was administratively reviewed and has been approved for presentation as an Environmental Protection Agency document.

It does not necessarily reflect the views of the Environmental Protection Agency. No official endorsement should be inferred.

This presentation includes photographs of commercially-available products. The photographs are included for purposes of illustration only and are not intended to imply that EPA approves or endorses the product or its manufacturer. EPA does not endorse the purchase or sale of any commercial products or services.

Data presented herein did not undergo a formal quality assurance review as outlined in "U.S. EPA Office of Research and Development's Quality Management Plan for Scientific Research". If these data are included in future EPA reports or other publications, they will be subjected to this review.

- Science in guidance development
- Examples of guidance development
  - Air cleaners
  - Indoor air and COVID-19
  - Flooded homes website
  - Vacuum cleaners
- Challenges and opportunities
  - Interpretability
  - Engaging intermediaries
  - Feedback collection
  - AI and future guidance

# Framework for EPA indoor air guidance



CONTACT US

- Guidance: **Authoritative advice** aimed at resolving **a problem or difficulty**
- Indoor air: air in indoor residential, educational, office environments
  - excluding specialized workplaces


## GOALS

- Reduce undesirable **health effects**, or at least **exposures**
- Promote desirable health and well-being outcomes

## MINIMUM CHARACTERISTICS



- **Non-regulatory application**, regardless of any enforceable requirements
  - Intended to influence policy and systems which guide activity
  - or individual actions in the general public
- Must be **supported by scientific evidence** and unbiased by private interest
- Practically feasible (time and money)



**Indoor Air Quality (IAQ)**



**Radon is a health hazard with a simple solution**  
Test. Fix. Save a life.  
Test your home today!  
[Find a Radon Test Kit](#)

**Did You Know...**  
We spend about 90% of our time indoors. Indoor Air Quality affects everyone, especially the most vulnerable - children, the elderly, and people with health conditions like asthma and heart disease. [Take steps to address the most common types of IAQ concerns.](#)

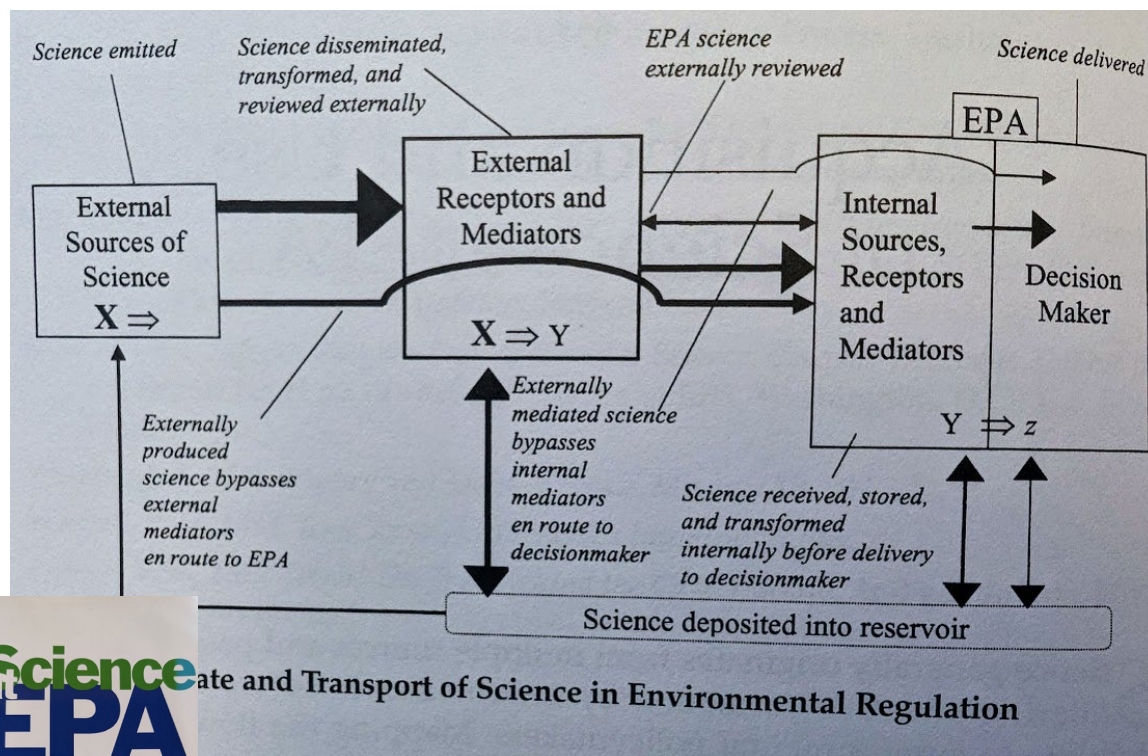
Learn about IAQ	Protect IAQ in Buildings	Related Topics
 <ul style="list-style-type: none"><li>• <a href="#">Learn about IAQ</a></li><li>• <a href="#">Air Sensor Technology and IAQ</a></li><li>• <a href="#">Air Cleaners and Filters</a></li><li>• <a href="#">Climate Change and IAQ</a></li><li>• <a href="#">Emergencies and IAQ</a></li><li>• <a href="#">Webinars, Meetings and Updates</a></li><li>• <a href="#">Wildfire Smoke Preparedness Grant Program</a></li></ul>	 <ul style="list-style-type: none"><li>• <a href="#">IAQ by Building Type</a></li><li>• <a href="#">Homes</a></li><li>• <a href="#">Schools</a></li><li>• <a href="#">Offices &amp; Other Large Buildings</a></li><li>• <a href="#">Clean Air in Buildings Challenge</a></li></ul>	<ul style="list-style-type: none"><li>• <a href="#">Asthma</a></li><li>• <a href="#">Mold</a></li><li>• <a href="#">IAQ in Schools</a></li><li>• <a href="#">Radon</a></li><li>• <a href="#">Indoor airPLUS</a></li><li>• <a href="#">Indoor Air and Coronavirus (COVID-19)</a></li><li>• <a href="#">Frequent Questions about Indoor Air and Coronavirus (COVID-19)</a></li></ul>

Network and Collaborate	Tour the IAQ House	Resources
 <ul style="list-style-type: none"><li>• <a href="#">Network and Collaborate about IAQ</a></li><li>• <a href="#">Interagency Committee on Indoor Air Quality (ICIAQ)</a></li><li>• <a href="#">Asthma Community Network</a></li><li>• <a href="#">Radon Leaders Saving Lives</a></li></ul>	 <ul style="list-style-type: none"><li>• <a href="#">Learn how to protect the air in your home</a></li></ul>	<ul style="list-style-type: none"><li>• <a href="#">EPA Regional Office and State IAQ Information</a></li><li>• <a href="#">Frequently Asked Questions about IAQ</a></li><li>• <a href="#">Publications (En Español)</a></li><li>• <a href="#">Media Materials &amp; Public Service Announcements</a></li><li>• <a href="#">U.S. Agencies and Hotlines</a></li><li>• <a href="#">Read CDC's guidance on ventilation in buildings</a></li><li>• <a href="#">Secondhand Smoke and E-cigarette Aerosols</a></li><li>• <a href="#">Indoor Air Quality in Everyday Life</a></li><li>• <a href="#">Subscribe to Indoor Air Quality Email Updates</a></li></ul>

# Regulatory vs. non-regulatory use of science



- The process of developing regulations may be better known

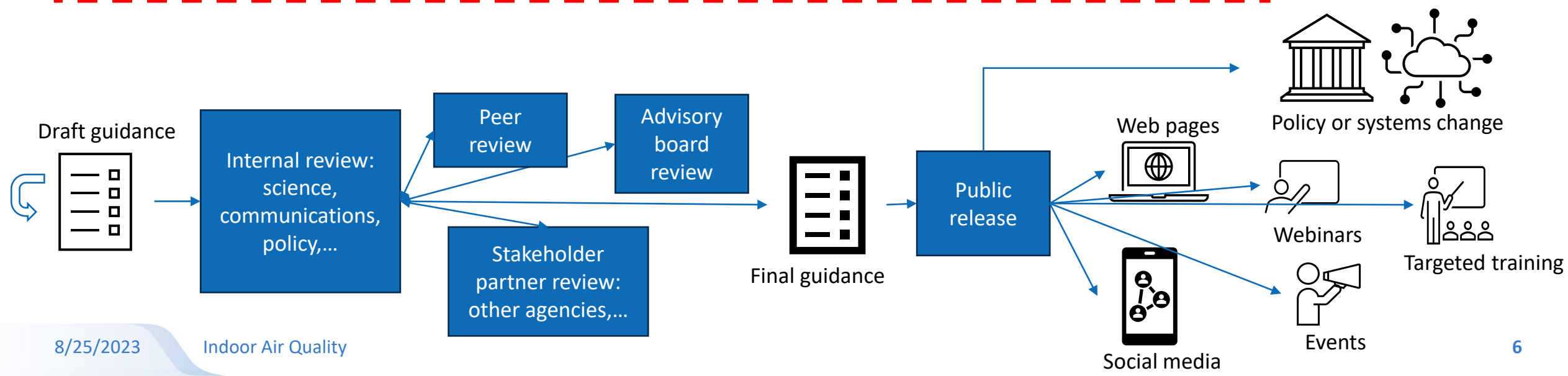
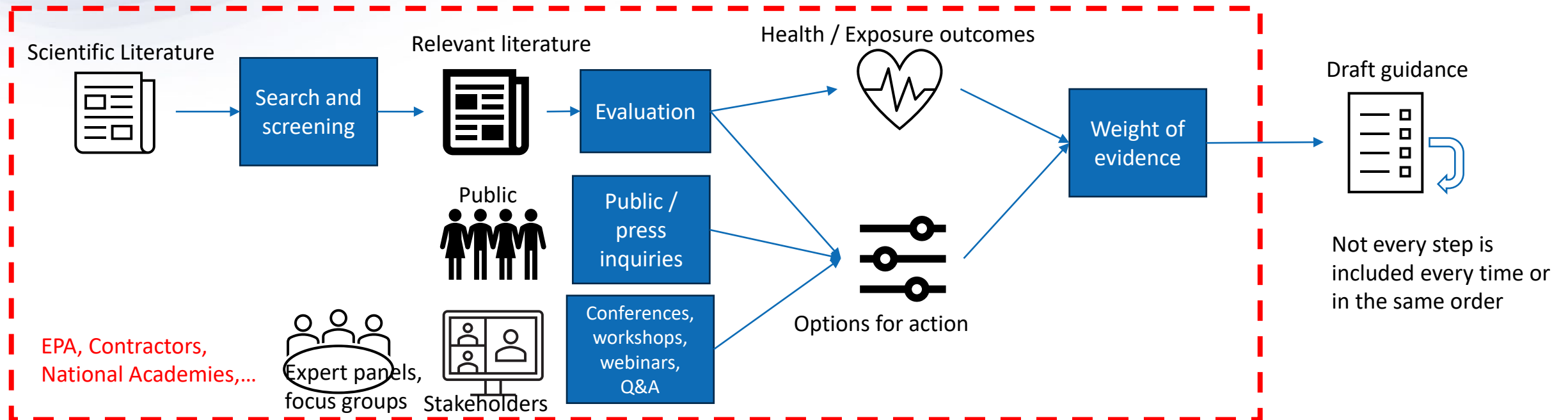


- There are significant differences in the development of non-regulatory guidance, e.g.
  - Decision makers are outside EPA (in the public)
  - Risk assessment, cost-benefit information not mandated (usually considered if available)
  - Federal Register notice not required
- But many parallels in the way science is used

*"Sometimes important scientific assumptions, uncertainties, and debates are not communicated to [decision makers]"*



# Idealized process of guidance development



# EPA IED Strategic Framework

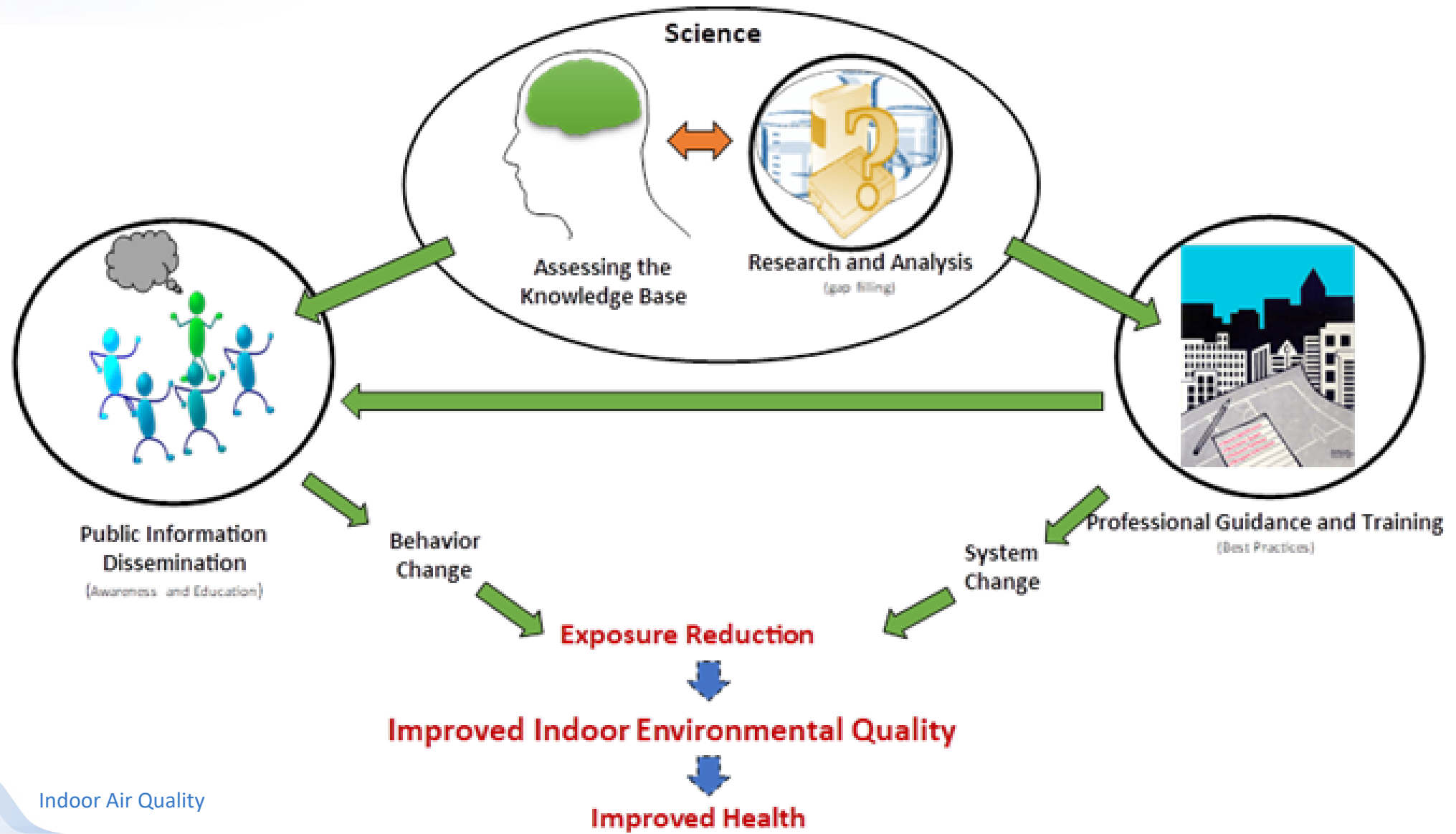


Guidance from research to practice - and vice-versa



- Feedback during guidance development
  - Improve acceptance, value, effectiveness
  - Through focus groups, partner advocacy and community organizations
  - Resource intensive
- After guidance release
  - Measure effectiveness
  - Adapt guidance
  - Identify new research gaps
- Direct collection through surveys limited by Paperwork Reduction Act of 1995
  - agencies must get OMB approval before systematically requesting or collecting many types of information from the public
- Indirect evidence of effectiveness through market research, or partner organizations
  - Asthma Community Network, state programs,...

# Guidance development - Public Health framework





# Science Translation



- Fundamentally, developing guidance is a process of knowledge transfer
- Similarities with Education:
  - Propagate information from the few to the many (and vice-versa?)
  - People with strong interest in a subject engaging with an audience with varying degrees of interest
- Translation is a better description
- *“Translation is the process of turning observations in the laboratory, clinic and community into interventions that improve the health of individuals and the public” (NIH-NCAT)*



# Epistemological framework of guidance development



What does it mean to be “supported by scientific evidence”?

- Correspondence theory (Plato, Aquinas, Russell): *A statement is true if it corresponds to facts*
  - Insistence on empirical evidence
  - No guidance developed if lacking specific IAQ studies, preferably field rather than lab studies
- Coherence theory (Shankara, Leibniz, Kuhn): *A statement is true if it fits with other accepted statements*
  - Consensus seeking approach; watch out when crossing discipline boundaries
  - Guidance generally not developed if unsettled debates among researchers or agencies (RH and COVID; CO<sub>2</sub> measurements,...)
- Pragmatic theory / constructivism (James, Dewey, Rorty): *A statement is true if it works; if it passes socially accepted process*
  - Emphasis on actionable statements, best practices. CBPR is prized (when available)
  - Guidance focuses on practical steps, rather than general understanding. It must be able to stand if challenged in courtroom; it should account for differences in goals, values

Based on Velasquez, 2005

# Paradigm

## Strategies for Indoor Air Quality



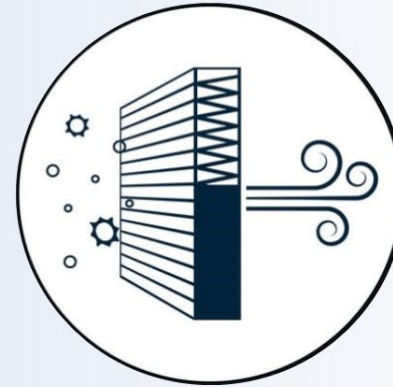
### SOURCE CONTROL

First, manage the sources of pollutants either by removing them from the building or isolating them from people through physical barriers, air pressure relationships, or by controlling the timing of their use.



### VENTILATION

Second, dilute pollutants and remove them from the building through ventilation.



### FILTRATION

Third, use supplemental filtration to help remove pollutants from the air. Avoid air cleaning devices that produce ozone.

# Summarizing the science

- A resource for public health professionals, building professionals, and others who seek scientific information about the effects of IAQ on people's health or work performance; Supported by EPA
- Provides information summarizing the state of scientific knowledge about the relationships between people's health and productivity and the IAQ conditions or associated building characteristics in which the people work or reside
- The IAQ-SFRB provides concise summary information that is well-supported by scientific research. The summary information is based upon the published findings of research

## VOCs from Indoor Chemical Reactions and Health

Indoor chemical reactions in office buildings occur spontaneously between oxidants such as ozone and various common indoor chemicals in indoor air or on indoor surfaces. The products of these chemical reactions, only some of which have been identified, have been hypothesized to cause sensory irritation of eyes and airways or skin irritation. Overall, however, the current evidence is too sparse to draw conclusions about the health consequences of indoor chemical reactions.

[Read more](#)

## Discover the Science on Indoor Air Quality



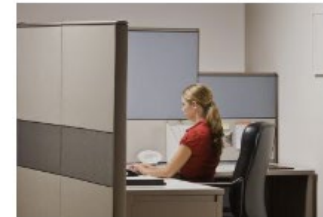
Building Ventilation



Dampness and Mold



Volatile Organic Compounds



Human Performance



National-Level Opportunities



Air Cleaning



Climate Change



IAQ in Schools



Airborne Infections

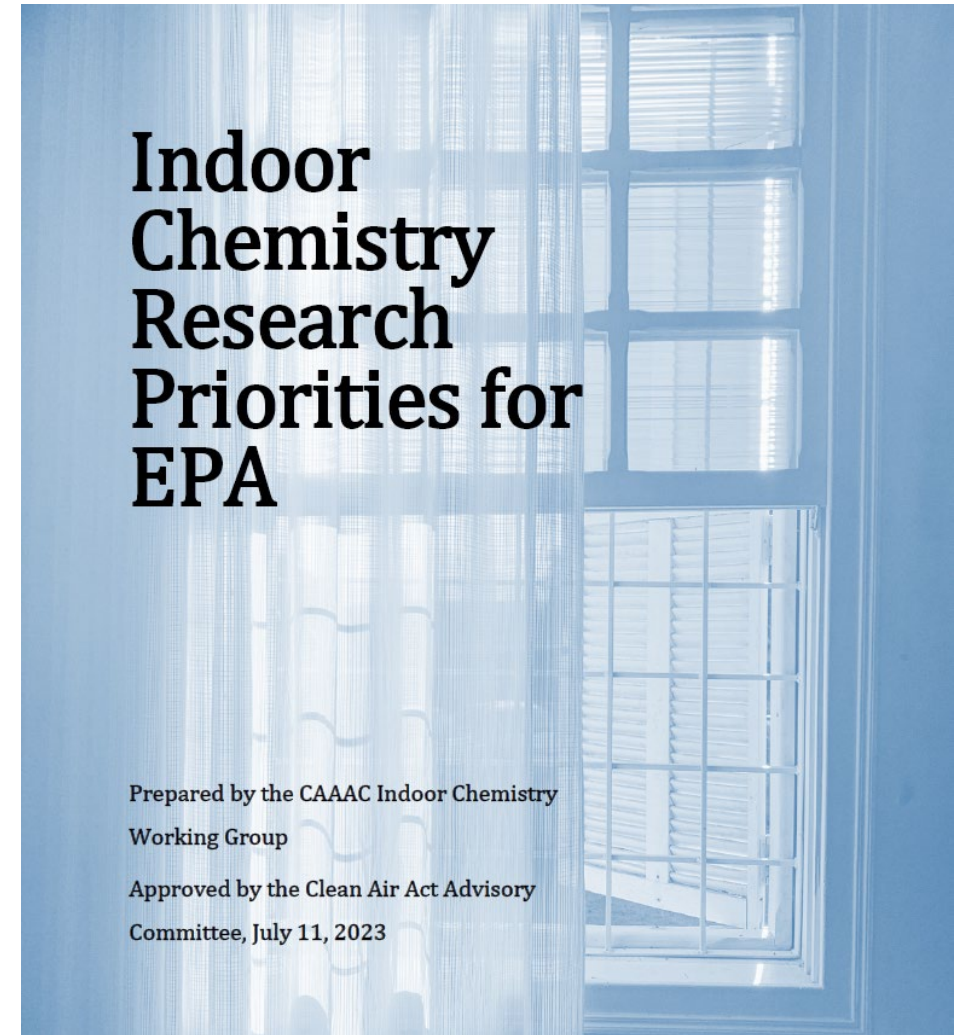


# Review – advisory boards



## Clean Air Act Advisory Committee Recommendations

- Examined 43 recommendations from NASEM report and screened those feasible for short-term and suitability to EPA guidance
- Overarching Recommendations
  - Enhanced exposure assessment: products, behaviors, market data
  - Prioritize research on health effects (toxicology and epidemiology)
  - Dissemination for decisions:
    - Standard writing committees
    - Practitioner conferences
    - Social and mass media

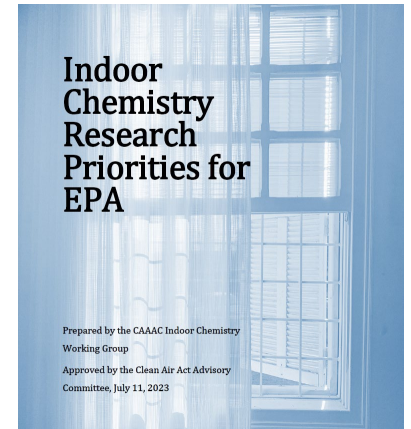


# Clean Air Act Advisory Committee Recommendations (2)



## Based on NASEM “Why Indoor Chemistry Matters” report

- Addressing human behavior
  - Chemistry of human occupancy. Characterize the secondary products from common activities
  - Deeper understanding of behavior and activity patterns. E.g. laundering, hand washing, window/door opening, ...Detailed data to improve modeling.
  - Improve models through better integration of behavioral data
  - Update National Human Activity Pattern Survey to capture activities in indoor environments
- Health Disparities and Environmental Justice
  - Include EJ community in the variety of indoor environments studied
  - Harmonize measures of exposure disparities. Standard datasets to support community and policy decisions. Expand data in concert with NHANES data
  - Methodological and technological tools to simplify exposure measurements, especially mixtures and co-exposures



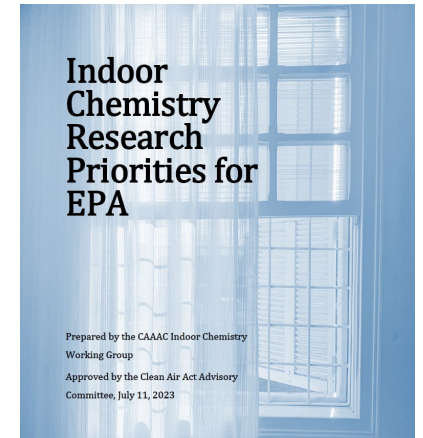


# Clean Air Act Advisory Committee Recommendations (3)



Based on NASEM “Why Indoor Chemistry Matters” report

- Air Cleaners
  - Develop testing approaches that consider both efficacy and byproduct formation, in real-world representative environments
  - Develop standardized consensus test methods that would enable certification
  - Field experiments to understand the fundamental chemistry of emerging air cleaning technologies, and mold or smoke remediation schemes.
- Priority contaminants of concern
  - Particulate matter – mass, composition, and systemic uptake
  - Biologicals: infectious aerosols; non-infectious aerosols (toxins, allergens, asthma triggers...)
  - Chemicals
    - Reactive Oxygen Species: ozone, alkyl radicals, peroxides,  $\text{NO}_2$ ,...Chemical transformations, concentration limits, affordable sensors
    - Aldehydes: formaldehyde, acrolein, acetaldehyde,... Explore effects of more species, develop affordable sensors, reduce emission rates





# Examples of indoor air guidance

# Air cleaners Guidance

## Example 1



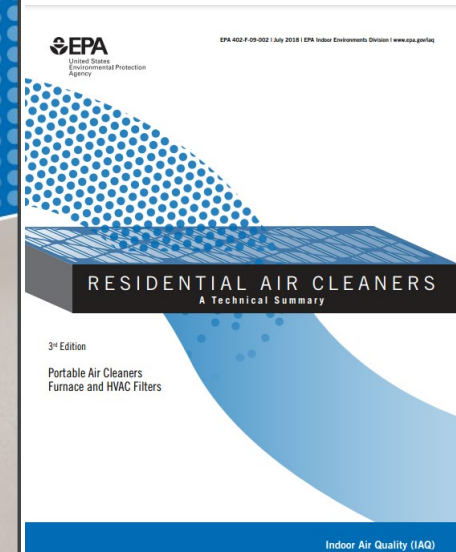
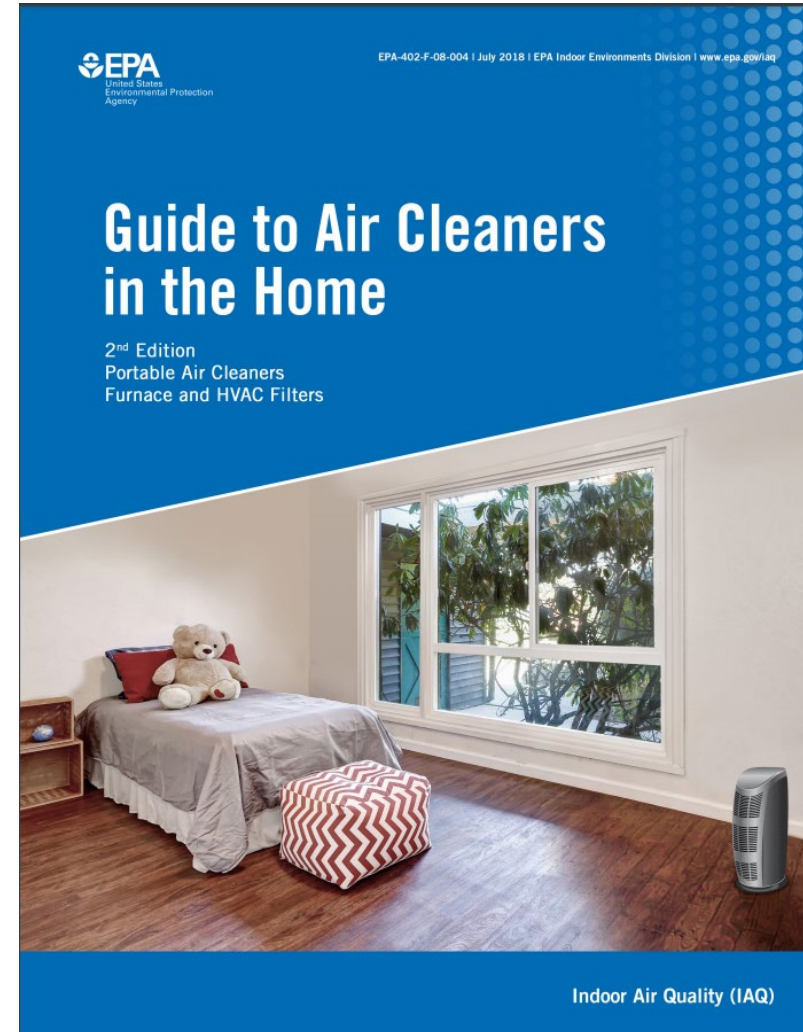
Major update to previous guidance in 2018



- Performed by EPA (Office of Air & Radiation and Office of Research & Development) along with expert contractors



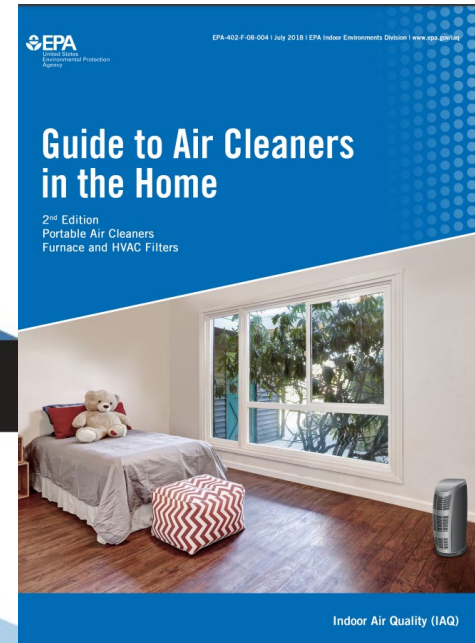
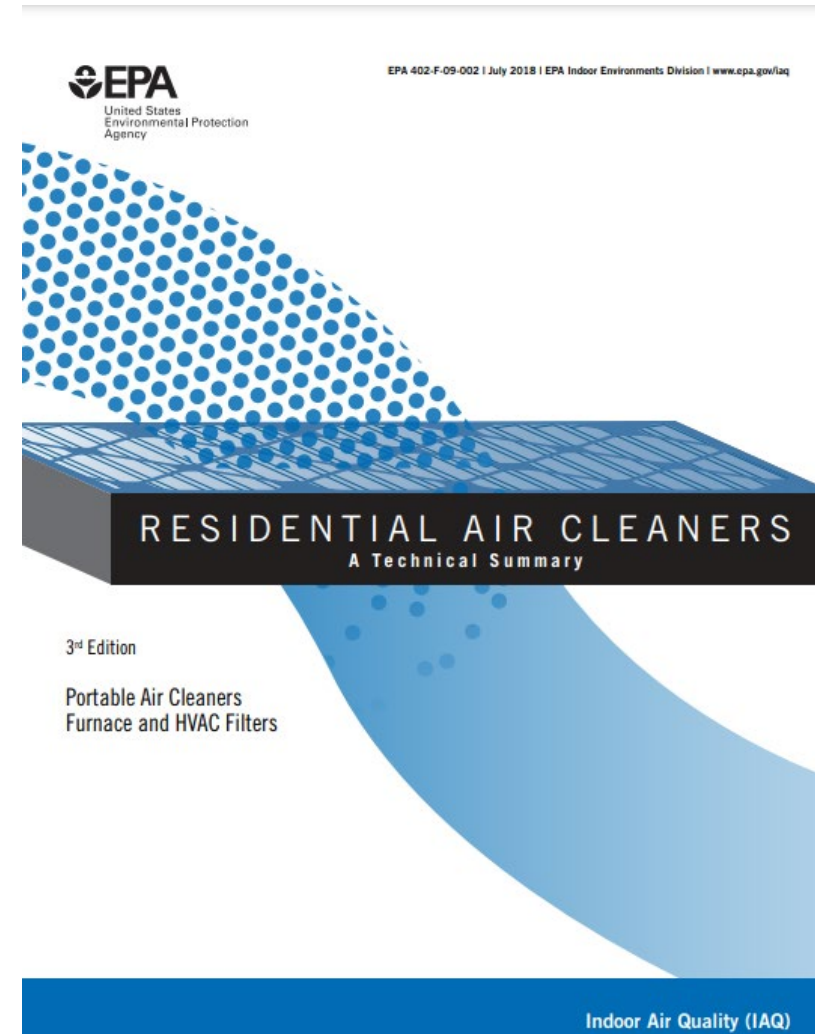
- Literature review of peer reviewed publications (159 references)
- Peer review: selected panel of 8 reviewers to cover a range of expertise; general and specific questions
- General public guide (and web pages) plus technical guide



# Air cleaners Guidance (2)



- Some specific questions:
- **Do portable air cleaners and furnace/HVAC filters used in homes have the potential to improve my indoor air quality?** Unequivocally yes
- **Can portable air cleaners and furnace/HVAC filters potentially have a positive impact on health?** Possibly. Usually small subclinical improvements, but good exposure data was limited
- **How do I choose a portable air cleaner that can remove volatile organic compounds (VOCs)?**
- **Where should I put a portable air cleaner?**



# Air cleaners guidance (3)

## Public interest



Google Trends

air cleaner  
Search term

air purifier  
Search term

+ Add comparison

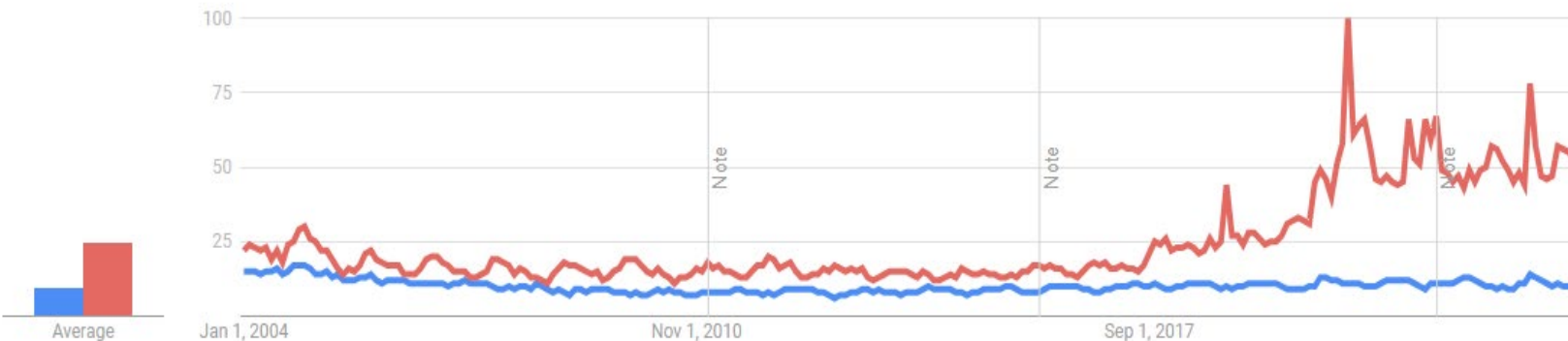
United States

2004 - present

All categories

Web Search

Interest over time ?



### Air Cleaners and Filter in the Home

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

Pageviews

Summary: FY2022 - FY2024

Month	FY22	FY23	FY24
Oct		5705	3709
Nov		5299	4473
Dec		4641	3676
Jan		5747	4043
Feb		5238	3620
Mar		4713	2832
Apr		3926	
May		3895	
Jun		7868	
Jul		4291	
Aug	6,131	3854	
Sep	5,789	3548	
Ttotal	11,920	58,725	22,353



# COVID-19 and indoor Air guidance

## Example 2

- Atypical guidance
  - Speed of development
  - Evolving science
  - Disagreement (initially) among sources of guidance and among researchers
  - Availability of empirical research
- Developed within the Agency, updated frequently
- Mix of Q&As (simpler, faster) and traditional webpages (more complex, more review)
  - Eventually 14 Q&As and 8 pages
- Rapidly reflecting questions from the public
  - Will air purifiers help?
  - What about evaporative coolers or whole-house fans?



### Coronavirus

CONTACT US

Coronavirus Home

Disinfectants

Indoor Air

Drinking Water and Wastewater

Frequent Questions

## Indoor Air and Coronavirus (COVID-19)

Spread of COVID-19 occurs via airborne particles and droplets. People who are infected with COVID can release particles and droplets of respiratory fluids that contain the SARS-CoV-2 virus into the air when they exhale (e.g., quiet breathing, speaking, singing, exercise, coughing, sneezing). The droplets or aerosol particles vary across a wide range of sizes – from visible to microscopic. Once infectious droplets and particles are exhaled, they move outward from the person (the source). These droplets carry the virus and transmit infection. Indoors, the very fine droplets and particles will continue to spread through the air in the room or space and can accumulate.

Since COVID-19 is transmitted through contact with respiratory fluids carrying the infectious SARS-CoV-2 virus, a person can be exposed by an infected person coughing or speaking near them. They can also be exposed by inhaling aerosol particles that are spreading away from the infected person. Transmission of COVID-19 from inhalation of virus in the air can occur at distances greater than six feet. Particles from an infected person can move throughout an entire room or indoor space. The particles can also linger in the air after a person has left the room – they can remain airborne for hours in some cases. Someone can also be exposed via splashes and sprays of respiratory fluids directly onto their mucous membranes. Spread may also sometimes occur through contact with contaminated surfaces, though this route is now considered less likely. See [Science and Technical Resources related to Indoor Air and Coronavirus \(COVID-19\)](#) or [Indoor Air and COVID-19 Key References and Publications](#) for technical information.

Though the risk of infection by breathing in particles carrying the virus generally decreases with distance from infected people and with time, some circumstances increase the risk of infection:

- Being indoors rather than outdoors, particularly in indoor environments where ventilation with outside air

### Frequent Questions

- [Read Frequent Questions about Indoor Air and Coronavirus \(COVID-19\)](#).
- [Explore all EPA Frequent Questions related to Coronavirus \(COVID-19\)](#).

Indoor Air and COVID-19 & Information in Other Languages

## Healthy Indoor Environments in Schools During the COVID-19 Pandemic and Beyond

The EPA [Indoor Air Quality \(IAQ\) Tools for Schools Program](#) helps support stakeholders who are working to ensure that schools are healthy places to learn and work. The Program, while utilizing the latest science, provides customizable resources and guidance, hosts web-based



# COVID-19 and indoor Air guidance (2)



- Initial dissonance between WHO, other health organizations and aerosol research, IAQ models, epidemiology, ...
- Key consultations with people straddling these fields
- Unusual technical reference page to support the guidance
  - Need to communicate with unusual audiences
- Formal partnership and cross reviews later caught up



## It is Time to Address Airborne Transmission of COVID-19

Lidia Morawska<sup>1\*</sup>, Donald K. Milton<sup>2</sup>



International Laboratory for Air Quality and Health, WHO Collaborating Centre, Queensland University of Technology, 2 George Street, Brisbane, QLD 4001 Australia. Email: [lmorawska@qut.edu.au](mailto:lmorawska@qut.edu.au)

<sup>2</sup>Institute for Applied Environmental Health, University of Maryland School of Public Health, 255 Campus Dr, College Park, Maryland, USA. Email: [dmilton@umid.edu](mailto:dmilton@umid.edu)

Corresponding author: Lidia Morawska, Email: [lmorawska@qut.edu.au](mailto:lmorawska@qut.edu.au)

**Keywords:** airborne transmission; airborne infection spread; coronavirus; COVID-19; SARS-CoV-2 virus.



© The Author(s) 2020. Published by Oxford University Press for the Infectious Diseases Society of America. All rights reserved. For permissions, e-mail: [rnals.permissions@oup.com](mailto:rnals.permissions@oup.com).



United States Environmental Protection Agency

ARCHIVED VERSION

Environmental Topics

Laws & Regulations

About EPA

Search EPA.gov

Related Topics: [Coronavirus](#)

CONTACT US

SHARE



## Indoor Air and COVID-19 Key References and Publications

This page lists some of the technical publications addressing the science related to transmission of SARS-CoV-2 through aerosol in indoor environments. This is an area of active research that is fast developing. References will be updated periodically.

Multiple scientific journal articles have been published related to the issue of potential airborne transmission of SARS-CoV-2 through aerosols (also referred to as droplet nuclei). The rationale for consideration is based on multiple, growing, lines of evidence: 1) Reports of measurement of the virus in the air, including beyond the distance recommended for droplet transmission, 2) Physically-based models of emissions of virus-laden aerosols and their dynamics, 3) Evidence of airborne transmission for the closely-related coronaviruses that caused the SARS and MERS outbreaks 4) Epidemiological evidence suggestive of possible airborne transmission, though other routes cannot be excluded.

The relative importance of this potential route of SARS-CoV2 transmission in comparison to others (close-contact, fomites) has not been established at this point. This increasing weight of evidence supports the use of precautions against transmission of SARS-CoV-2 in indoor environments as an addition to other measures already known to limit it.

### Topics on this page:

- [General](#)
- [Reports of Measurements in Aerosols](#)
- [Physically-based Modeling of Aerosol Dynamics](#)
- [Evidence of Airborne Transmission for SARS and MERS](#)
- [Epidemiological Evidence Suggestive of Transmission Through Aerosol](#)
- [Other](#)

## General

- Morawska et al. 2020. [How can airborne transmission of COVID-19 indoors be minimized?](#) Environ Int. PMID 32521345.
- Anderson et al. 2020. [Consideration of the Aerosol Transmission for COVID-19 and Public Health](#). Risk Analysis.
- Morawska and Milton. [It is Time to Address Airborne Transmission of COVID-19](#). Clinical Infectious Diseases, ciaa939. [EXIT](#)
- Allen and Marr. 2020. [Re-thinking the Potential for Airborne Transmission of SARS-CoV-2](#).
- Tellier et al. 2019. [Recognition of aerosol transmission of infectious agents: a commentary](#). BMC infectious diseases, 19(1), 101.

# COVID-19 and indoor Air guidance (3)



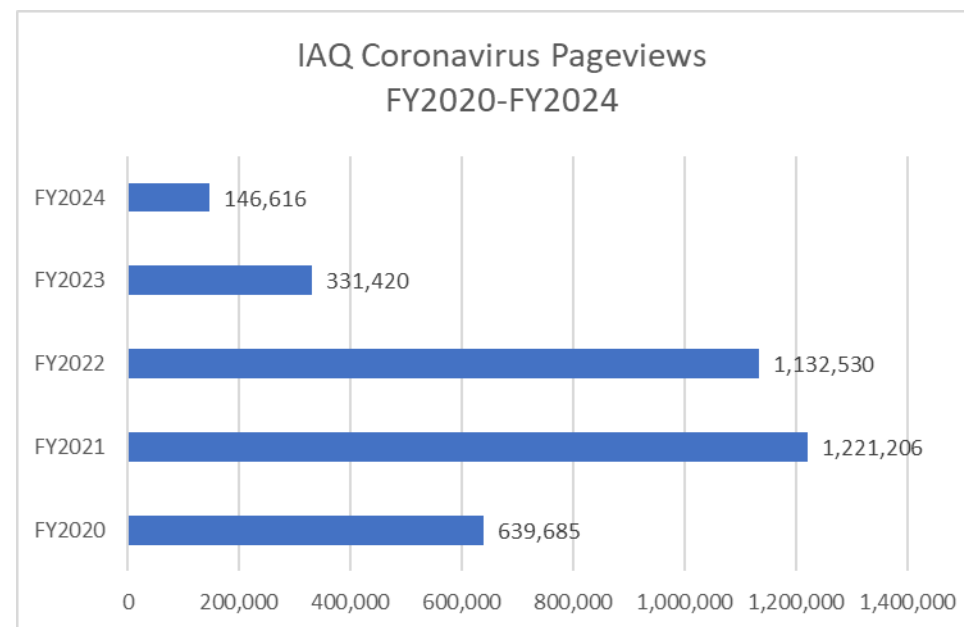
## Public interest



Indoor Air Quality

## January 2024 data

1.	Indoor Air and Coronavirus (COVID-19)   US EPA	15,825
1.	About List N: Disinfectants for Coronavirus (COVID-19)   US EPA	15,129
1.	Coronavirus and Drinking Water and Wastewater   US EPA	5,489
1.	Air Cleaners, HVAC Filters, and Coronavirus (COVID-19)   US EPA	4,299
1.	Indoor Air in Homes and Coronavirus (COVID-19)   US EPA	4,086
1.	What's the difference between products that disinfect, sanitize, and clean surfaces?   US EPA	3,496
1.	Cleaning and Disinfecting: Best Practices During the COVID-19 Pandemic   US EPA	3,367
1.	Disinfectant Use and Coronavirus (COVID-19)   US EPA	3,135
1.	List N Advanced Search Page: Disinfectants for Coronavirus (COVID-19)   US EPA	2,311
1.	Will an air cleaner or air purifier help protect me and my family from COVID-19 in my home?   US EPA	2,082



# COVID-19 and indoor Air guidance (4)



## Webinars

- 6 science webinars addressing COVID-related questions
- 14 webinars dedicated to schools

**Indoor Environments**

**SARS-CoV-2 in Indoor Air: Principles and Scenarios**

Thursday, July 16th, 1:00 – 2:30 p.m. EDT

**Dr. Linsey Marr**  
Charles P. Lunsford Professor  
of Civil and Environmental  
Engineering, Virginia Tech

**Dr. Richard Corsi**  
Dean, College of Engineering  
and Computer Science,  
Portland State University

## Navigating the Landscape of Air Cleaning Technologies for COVID-19



**Elliott Gall, Ph.D.**  
Department of Mechanical  
and Materials Engineering  
Portland State University



**Brent Stephens, Ph.D.**  
Department of Civil  
and Environmental  
Illinois Institute of Technology

Wednesday, June 16, 2021  
1:00 p.m. – 3:00 p.m. EDT

## Using CO<sub>2</sub> Monitoring to Manage Ventilation in Buildings



**Andrew K. Persily, Ph.D.**  
National Institute of Standards and Technology



## Indoor Air Quality in K–12 Schools: Addressing the Concept of Layered Risk Amidst COVID-19

*Recorded on Thursday, November 19, 2020*



# Flooded homes Guidance



## Example 3

See <https://www.epa.gov/indoor-air-quality-iaq/report-flood-related-cleaning>

- Indoor Air Quality and other hazards (Pb, asbestos, microbiological)
- How can residents safely get back in to clean up?
- Development of guidance can integrate differences between the technical and social inputs into risk communication

- *Safely Clean, Decontaminate, and Reoccupy Flood-Damaged House; 103 pages:*

Use a combination of wet and dry cleaning methods as appropriate. Wet cleaning methods include washing with water and a cleaner, steam cleaning, cleaning with foaming detergent, hot water extraction, low pressure flushing, and high pressure washing. Dry cleaning methods include

- What information do flood survivors find useful? What are their values and perceptions? How do they vary across social and cultural groups?



# Flooded homes Guidance (2)



- Risk communication using Strategic Action Learning Tools (SALT)
- Website with text (mobile friendly), videos, empathetic language
- Human-centered design
  1. Establish design principle – to make the website a trusted source of information that meets the user where they are after a flood
  2. Hold focus groups – external and internal to EPA. What questions should be asked when engaging communities?
  3. Review scripts – technical review and social science review (respect, behavior change,...)
  4. Interview survivors and volunteers
  5. Sort topics and draft website
  6. Usability testing of prototype





# Flooded homes Guidance (3)

## Lessons learned

### Key to success

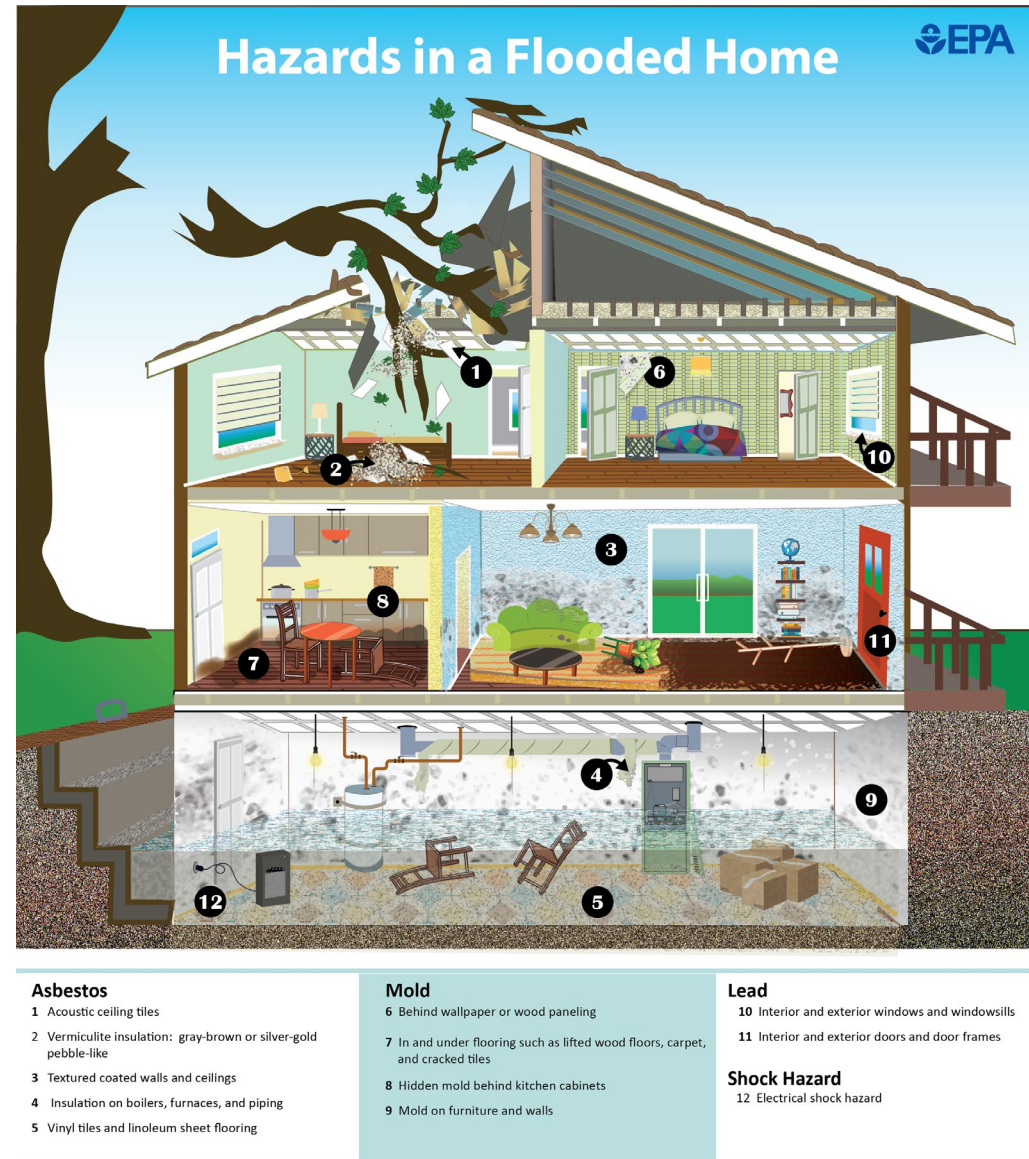
- Interdisciplinary team
- Open mindset
- Accept imperfection
- Check assumptions

### Biggest challenges

- Recruitment takes a lot of time
- Virtual interviews, usability testing

### Next time

- Combine technical & social science script reviews
- Add in community reviews





# Guidance on hold: Vacuuming



## Example 4

- Similar in goals scope, and process to air cleaners guidance. Summer 2018
- Relevant literature: 169 peer reviewed publications
- Some specific questions:
- **Will vacuuming help if I have allergies/asthma?**
  - Maybe. Conflicting evidence about exposure reduction. Unclear health benefits
- **Will vacuuming help with [insert issue here – mold, pollen, cat dander, etc]?**
  - Possibly. Wide range of product performance; some allergens showing reductions but not consistently between allergens, studies, and metrics (per unit mass; per surface area)
  - Successful interventions when part of a comprehensive approach targeting sources
- **How often should I vacuum?**
  - Very different protocols compared in the literature (daily to monthly frequencies)
  - Inconsistent evidence for a variety of metrics (re-suspended PM<sub>10</sub>, allergen loading in carpets,...)
  - Possibly improvements at impractical frequencies (daily, in depth)



Fundamental lack of methodological and outcome coherence in the literature; irreducible variability (at the time) in protocols, device performance, covariates

Revisit these conclusions as literature grows

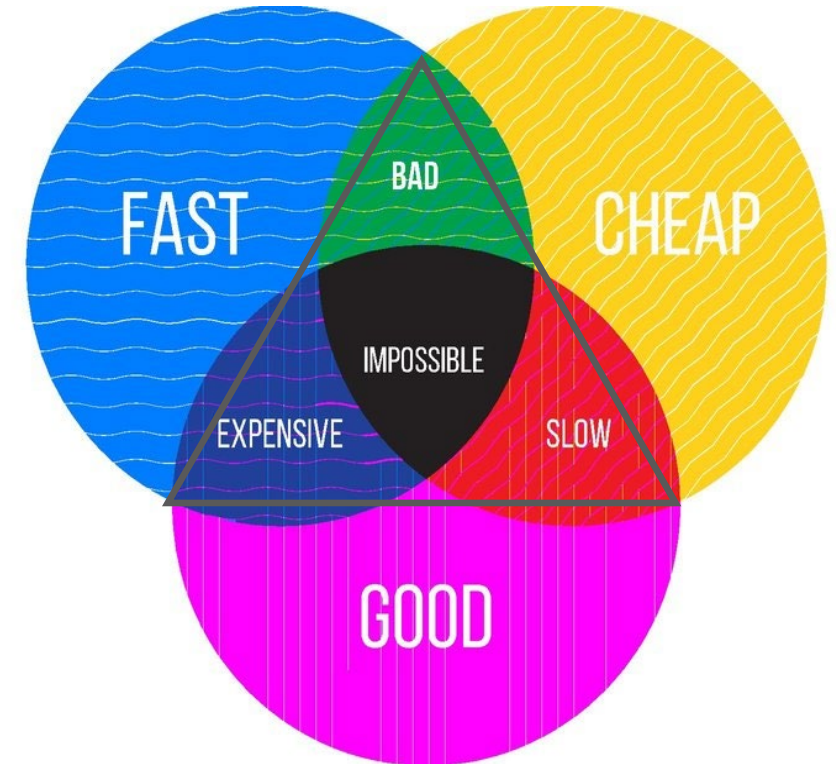


# Challenges and opportunities

# What can we do better?



1. Communicate the evolving nature of our knowledge
  - Communicating uncertainty: pros and cons
2. Increase precision of reaching audience
  - Especially indirectly, through third parties
3. Invest in gathering feedback on effectiveness of guidance, during development and after release
  - Is it relevant? Is it accessible?
  - Does it translate into behavior change / exposure reduction / health benefit?



# Interpretability

- Who is the guidance for?
- *“More than 47 percent[...] of U.S. adults have difficulty locating, matching, and integrating information in written texts with accuracy and consistency [...] have literacy skills that test below high school level”.*
  - *“The majority of these adults are native-born English speakers”*
- The target of public health benefit and the guidance user/reader may not be the same
  - Hub and spoke website designs; general + technical guidance



- We should not equate inability to interpret guidance directly to inability to access guidance
  - Social support mechanisms may be available to overcome the barrier
  - Professional intermediaries (health care professionals, HVAC technicians, ...) may have more access and trust



# Engaging Intermediaries



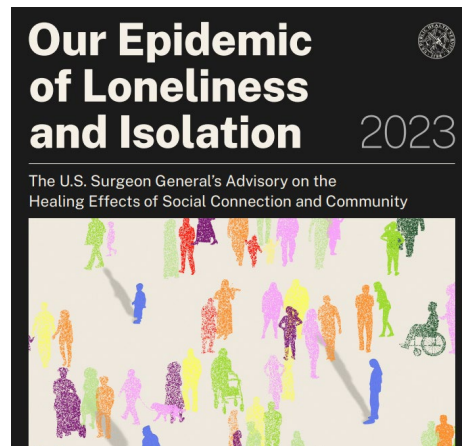
- Are Indoor Air Quality messages reaching those who can effectively promote it?
  - Are we communicating effectively and through the right channels?
  - *“Making a message actionable requires talking to people who actually take the action”* (L. Burton)
- HVAC technicians
  - Training and development
  - Does IAQ fit in the business model of HVAC service industry?
- Health care professionals
  - Do we see IAQ or environmental health in the general health screening?
- Community based organizations
  - Significant EPA research and outreach investment
  - How is the loneliness and isolation epidemic affecting these and other socially-based communications of IAQ messages?



## Environmental Health: A Position Paper From the American College of Physicians FREE

Authors: [Ryan Crowley, BSJ](#), [Suja Mathew, MD](#), and [David Hilden, MD, MPH](#) [Health and Environmental Policy Committee of the American College of Physicians](#) | [AUTHOR, ARTICLE, & DISCLOSURE INFORMATION](#)

Publication: *Annals of Internal Medicine* • Volume 175, Number 11  
<https://doi.org/10.7326/M22-1864>



# Engaging Product Manufacturers

## Air cleaner design



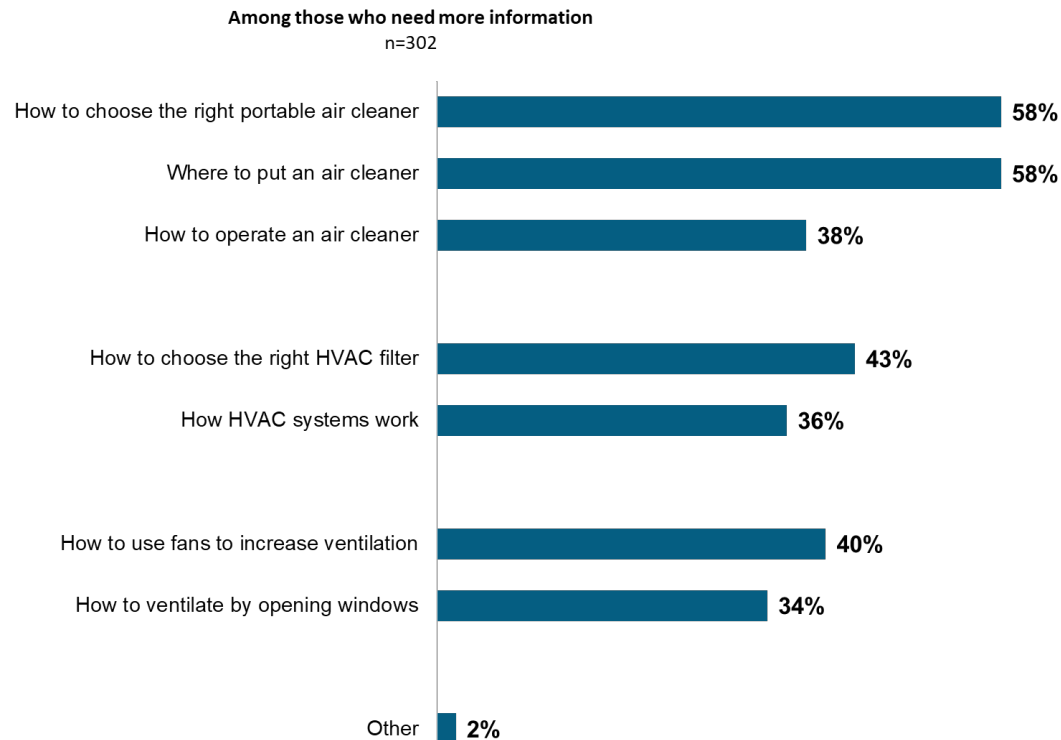
- **Thinking of public health at the product design stage**
  - Engage with public health agencies, or researchers
  - How can public health agencies be more accessible?
- Example: Multi-stage portable air cleaners
  - Marketing reasons
  - Energy efficiency
  - Noise reduction
- Reactive species may be useful for biologicals or odor control
- Ozone penetration factor across building envelope:  $54\% \pm 10\%$  (Zhao and Stephens Indoor Air, 2015)
- Time the air spends inside an air cleaner:  $\sim 1$  s
- ROS and radicals often have much shorter half-lives
- Reactive species could be directed to quenching surfaces
- Yet, many devices place reactive stage **last**, releasing reactive species ( $O_3$ ,  $OH$ , ...) into a room



# Feedback collection

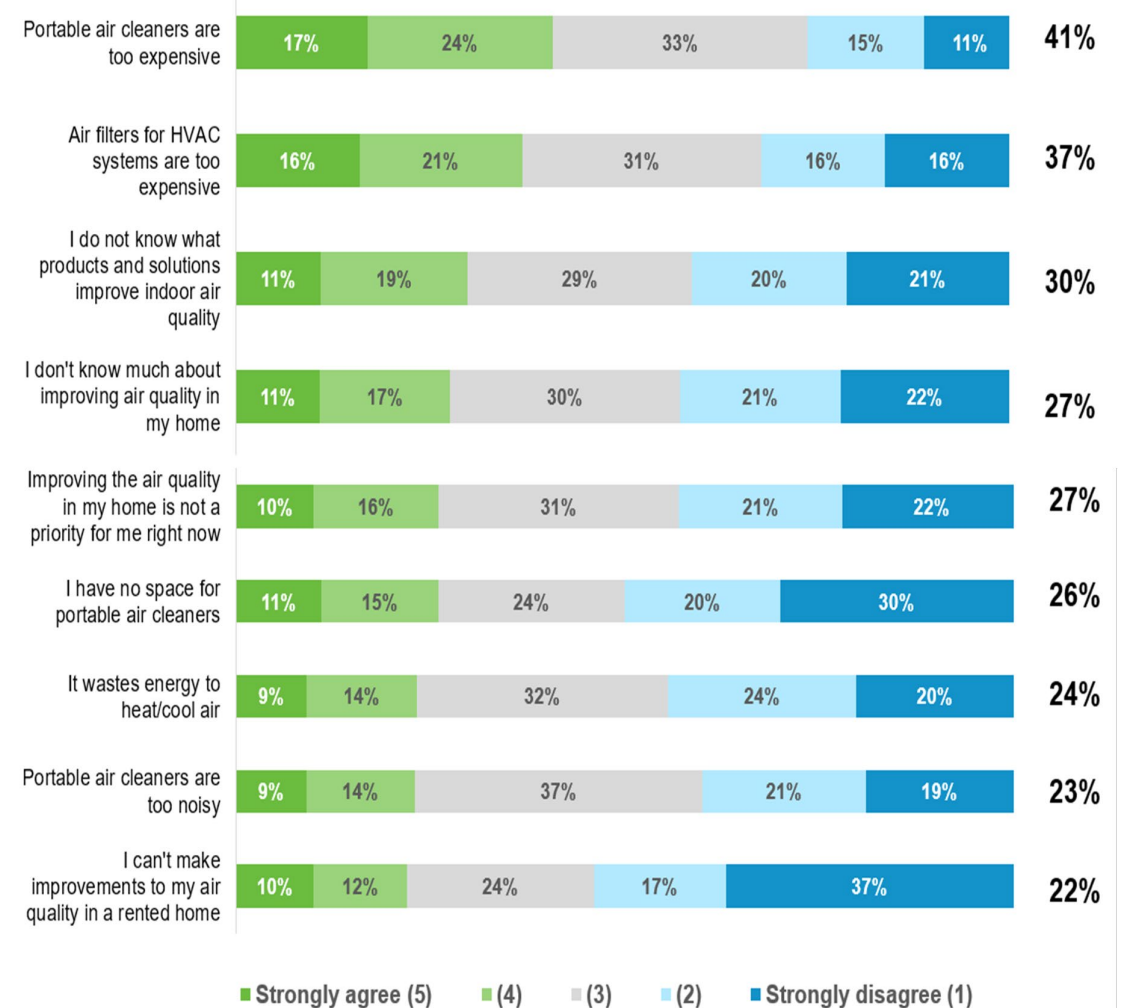
## Survey data

- Joint 18-question survey with CDC in August 2022
- exploring perceptions of IAQ in their home and awareness of IAQ improvement strategies
- Respondents (n=1,011) randomly sampled from a national opt-in, non-representative, cross-sectional panel



Indoor Air Quality

### Among 20% who found it difficult to improve IAQ in their homes Total Agree



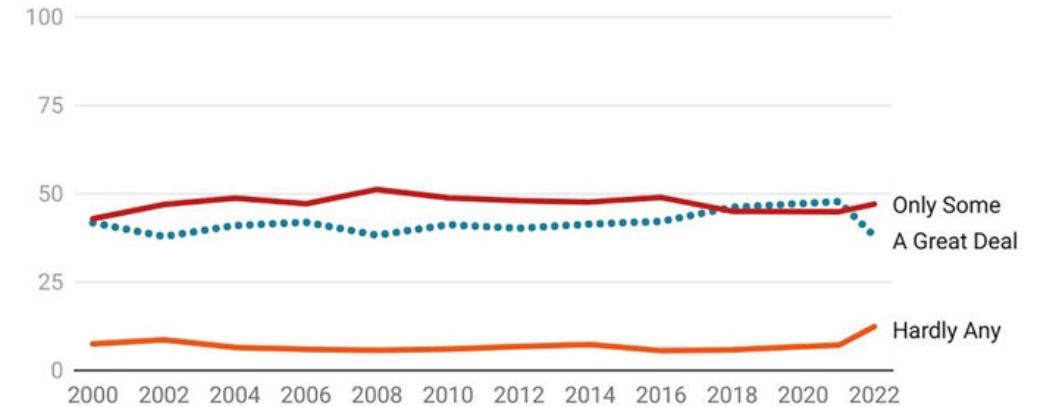
# Other Challenges



- Trust in the scientific community
- Trust in government as a source of information
- Political polarization shaping perception of public health guidance
- Lack of accepted standards for safety and performance of IAQ
- Relative abundance of reliable guidance vs. interested, ambiguous, or misinformed messages
- Add your own preferred challenge...
- *“When you argue with reality, you lose – but only 100% of the time” (Byron Katie)*

## Overall Confidence in the Scientific Community

Percent of adults.



Question: "I am going to name some institutions [scientific community] in this country. As far as the people running these institutions are concerned, would you say you have a great deal of confidence, only some confidence, or hardly any confidence at all in them?"

Source: General Social Survey (GSS), last conducted in 2022.

*Truth is so obscure in these times, and falsehood so established, that, unless we love the truth, we cannot know it.*

(B. Pascal, Pensees XIV, 864, circa 1660s)



# Artificial Intelligence



## The future of guidance development?

### Why does indoor air chemistry matter?

**ChatGPT 3.5** \*Training data pre-NASEM report\* :

Indoor air chemistry matters for several reasons:

Human Health: The quality of indoor air can have a significant impact on human health. Many indoor air pollutants, such as volatile organic compounds (VOCs), particulate matter, carbon monoxide, and nitrogen dioxide, can cause or exacerbate respiratory problems, allergies, asthma, and other health issues.[...].

Comfort and Well-being: Indoor air chemistry affects the comfort and well-being of occupants. Poor indoor air quality can lead to unpleasant odors, discomfort, headaches, fatigue, and reduced productivity. [...]

Building Materials and Furnishings: [...]

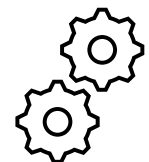
Indoor Air Pollution Sources: Indoor air chemistry helps in identifying and understanding the sources of indoor air pollution. Sources can include cooking activities, tobacco smoke, household cleaning products, [...].

Ventilation and Air Quality Control: Indoor air chemistry influences the effectiveness of ventilation and air quality control strategies. For example, chemical reactions between indoor pollutants and outdoor air can affect the efficiency of filtration systems and air purifiers. Understanding indoor air chemistry can inform the selection and optimization of ventilation and air purification technologies to improve indoor air quality.

Environmental Impact: Indoor air chemistry is linked to outdoor air quality and environmental pollution[...]

Overall, understanding indoor air chemistry is essential for promoting occupant health, comfort, and well-being, as well as for designing sustainable and energy-efficient indoor environments.

- Large Language Models (LLMs) have proven their skills at language manipulation – one essential component of guidance development
  - Analogy with D. Kahneman's System 1
  - The content they provide ultimately depends on their training data - Models GIGO
  - Models trained on peer-reviewed literature only for content and audience-specific set for language skills?
  - Modulation of language for specific audiences
- Similar considerations for image generators
- LLMs lack a physical (and chemical) model of the world (PWM) – unsuitable for inference
  - Integrated LLMs and PWM: Digital Agents
    - Artificial General Intelligence



## Can you explain Indoor Air Quality in a way an 8-year old would understand?

**ChatGPT 3.5:** Sure! Imagine your home is like a big bubble that you live inside. Just like how you want the air outside to be clean and fresh, you also want the air inside your home to be clean and healthy to breathe.

Think of all the things in your home that might make the air not so clean. Maybe when you cook, there's steam and smells. Or when you paint or use cleaning sprays, there are tiny things called "chemicals" that go into the air. [...]

Now, imagine there are special detectives called "scientists" who check the air inside your home to make sure it's healthy. They look for things that could make you cough, sneeze, or feel yucky. These scientists help your family find ways to keep [...]

So, indoor air quality is all about making sure the air inside your home is nice and clean, just like the fresh air outside, so you can feel happy and healthy!

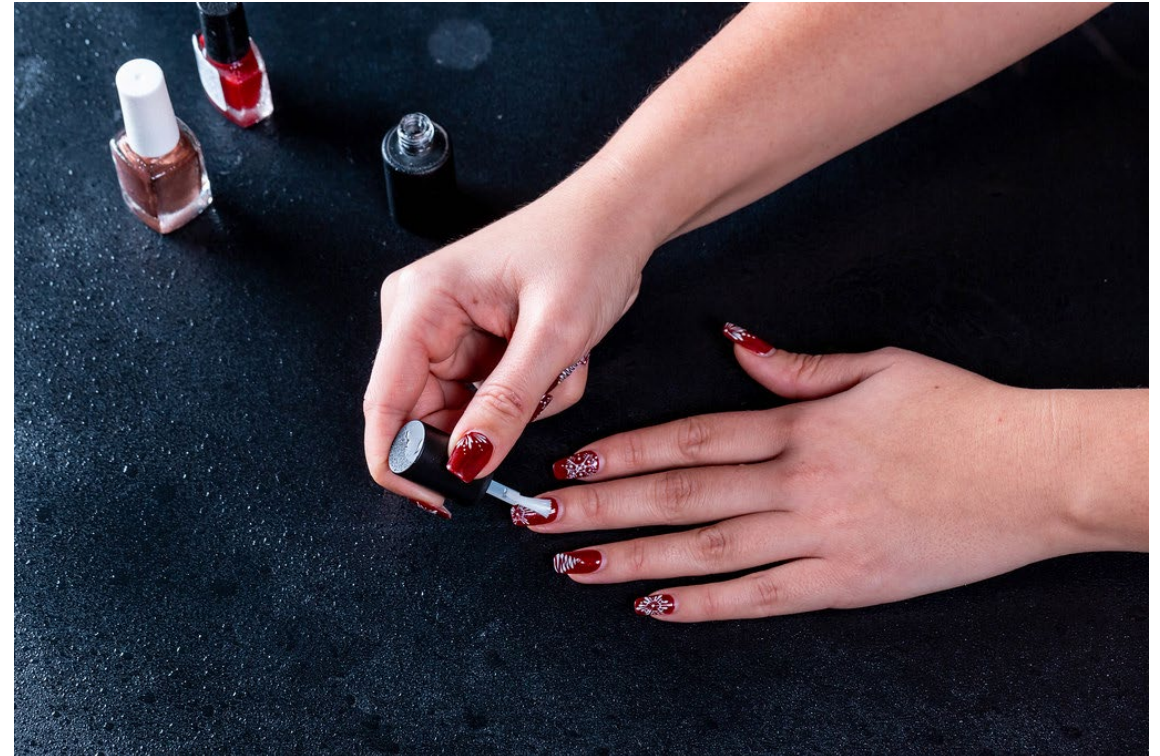


### **Explain to my teenage daughter why she should open the window when painting her nails**

**ChatGPT 3.5 :** Hey there! So, you know how much you love painting your nails, right? It's fun to try out different colors and styles. But have you ever noticed that nail polish smell? That's actually a bunch of chemicals called volatile organic compounds (VOCs) that can be harmful if you breathe in too much of them.

When you're painting your nails, those chemicals can build up in the air inside your room. That's why it's a good idea to crack open a window or paint your nails in a well-ventilated area[...]

I know it might seem like a small thing, but taking this little step can make a big difference in keeping the air in your room healthier. [...] So next time you're painting your nails, just remember to give yourself and your lungs some fresh air by opening a window!





## **Explain to my scientist father why I don't need to open the window when painting my nails**

**ChatGPT 3.5:** Hey Dad, I know you're all about science and making sure everything we do is safe and healthy. So, let me explain why I don't think I need to open the window when painting my nails.

First off, the chemicals in nail polish, like volatile organic compounds (VOCs), can indeed be harmful if you're exposed to high levels of them for a long time. However, when I'm painting my nails, I'm only using a small amount of nail polish for a short period.

Most modern nail polishes also contain fewer harmful chemicals than they used to, thanks to advances in cosmetic science. They often have lower levels of VOCs and other potentially harmful ingredients.

Additionally, our house has decent ventilation, with air circulation from the heating and cooling system and occasional openings of doors and windows throughout the day. This helps to dilute any chemicals in the air, including those from nail polish, without the need for me to specifically open a window just for that purpose.

I understand your concern for my health, and I appreciate it, but in this case, I believe the risk is minimal given the circumstances. If you have any other suggestions for ensuring safety while painting my nails, I'm all ears.





- IAQ Guidance development follows **general science translation** principles. Specific steps may vary, but always include:
  - grounding statements in **empirical, independent evidence** of exposure or health benefits
  - **multiple levels of review**, from different perspectives
  - **actionable steps** from the perspective of the target audience
- It is really hard to meet all principles of translation science in any single guidance with finite resources
- There are significant challenges and opportunities for improvement
  - Gathering feedback on message and effects
  - Reach, train, and learn from service practitioners, other professionals, manufacturers, policy makers, system leaders and implementers, and communities
  - Present and future application of AI

●●●●●●●●  
**Thank you!**

Special thanks to Laureen Burton for ideas and discussion

<https://www.epa.gov/indoor-air-quality-iaq>  
[llacqua.vito@epa.gov](mailto:llacqua.vito@epa.gov)