**Indoor Air: The Forgotten Frontier of Environmental Law**

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Abstract

Poor indoor air quality poses a pervasive and serious threat to human health. The wide range of indoor pollutants and environments, as well as uncertainty about chemical interactions and risks, complicates potential responses. Although the COVID-19 pandemic and episodes of widespread wildfire smoke have underscored the importance of indoor air quality, government attention to the problem has been limited and ad hoc. Federal, state, and local governments should undertake a systematic effort to improve IAQ using a combination of voluntary guidelines, procedural regulations, and substantive standards. Voluntary guidelines can inform action by other government actors, industry, and consumers, and serve as a foundation for mandatory standards. Procedural requirements can direct attention to an issue, generate information, and catalyze action based on that information. Finally, substantive requirements can focus on key indoor pollutants and settings where regulation would be both impactful and feasible.

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Poor indoor air quality (IAQ) poses a pervasive and serious threat to human health. Various indoor pollutants—chemical and biological—cause respiratory illness, cardiovascular disease, cancer, and death for millions annually.[[2]](#footnote-3) In recent years, the COVID-19 pandemic and episodes of widespread wildfire smoke have underscored the importance of indoor air quality. Nonetheless, government attention to the problem has been limited. In the workplace, the Occupational Safety and Health Administration (OSHA) has set ventilation requirements for specific industries and relatively weak standards for a subset of air contaminants.[[3]](#footnote-4) Beyond the workplace, the U.S. Environmental Protection Agency (EPA) interprets its air pollution regulatory authority under the Clean Air Act to extend only to outdoor air.[[4]](#footnote-5) State regulation varies widely, ranging from essentially no oversight in some states to regulation of specific pollutants or specific types of buildings, such as schools, in others.[[5]](#footnote-6) Comprehensive indoor air quality protection is lacking.

Nonetheless, ongoing initiatives here and in other countries suggest potential pathways for tackling this important and complex problem. A suite of complementary approaches, including voluntary guidelines, procedural requirements, and substantive mandates, can yield improvements in IAQ and consequent benefits for human health and well-being.

Part I of this Article discusses the health risks associated with poor IAQ, increased attention to the issue, and available methods for improving IAQ. Part II of this Article describes the limited patchwork of federal, state, and local law relating to IAQ. Although these laws are complemented by nonbinding, nongovernmental standards, the problem of poor IAQ remains neglected. Part III explores obstacles to more robust oversight of IAQ and considers approaches taken by other countries to regulating IAQ. Finally, Part IV sketches out a suite of complementary approaches for improving IAQ in the U.S.

# I. Background

Americans spend 87% of their time in buildings.[[6]](#footnote-7) As climate change increasingly drives people indoors to shelter from smoke, heat, and other weather extremes, this percentage will likely rise.[[7]](#footnote-8) Because people spend most of their time indoors, indoor air quality and other aspects of the indoor environment are critical to human health.[[8]](#footnote-9) Indoor air pollution is one of the top environmental risks to public health in the United States[[9]](#footnote-10) and is responsible for approximately 3.2 million deaths per year worldwide.[[10]](#footnote-11)

## A. Health Risks of Poor IAQ

Building materials, furnishings, personal care products, and activities such as cooking and cleaning release thousands of chemicals into the indoor environment.[[11]](#footnote-12) Indoor air pollution also originates from outside air that infiltrates a building through openings or is drawn into a building through air intakes.[[12]](#footnote-13) Pollutant concentrations tend to be much higher in indoor air than outdoor air.[[13]](#footnote-14) Unfortunately, characterizing the health risks posed by indoor air pollution is difficult. Information is often lacking regarding the identity, properties, concentration, and toxicity of chemicals in a building, as well as the reactions between them.[[14]](#footnote-15) Additional uncertainties surround the cumulative and long-term effects of exposure to mixtures of chemicals.[[15]](#footnote-16) Variations in the type, quality, and use of indoor spaces further complicate risk analyses.[[16]](#footnote-17)

Indoor air pollutants include radon, particulate matter, carbon monoxide, nitrogen dioxide, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and tobacco smoke.[[17]](#footnote-18) Radon, a naturally occurring gas that enters buildings primarily through the soil, increases the risk of lung cancer.[[18]](#footnote-19) Fine particulate matter (PM2.5), which can cause cancer, respiratory illness, cardiovascular disease, and impairment of the immune system,[[19]](#footnote-20) comes from outdoor sources, such as wildfires and vehicle traffic, and indoor sources, such as kerosene heaters, gas stoves, and cooking.[[20]](#footnote-21) Indoor combustion processes also can generate carbon monoxide (CO), which is fatal at high concentrations.[[21]](#footnote-22) Nitrogen dioxide, often generated in significant amounts by gas stoves, has been linked to asthma, chronic obstructive pulmonary disease, lung cancer, and preterm birth.[[22]](#footnote-23) VOCs, released by building materials, paints, furniture, cleaning products and personal care products, contribute to respiratory ailments, heart disease, cancer, and multiple chemical sensitivity.[[23]](#footnote-24) Other organic chemicals classified as hazardous air pollutants, such as benzene and formaldehyde, can reach significant levels indoors as a result of their release from building materials and household products.[[24]](#footnote-25) Many SVOCs used as flame retardants, plasticizers, and pesticides are known or suspected endocrine disruptors, carcinogens, and neurological, reproductive, and developmental toxins.[[25]](#footnote-26) Smoking is also a significant source of hazardous air pollutants and fine particulates in indoor air.[[26]](#footnote-27) Ultimately, indoor air pollution harms human health and impairs academic and workplace performance.[[27]](#footnote-28)

Assessing risk to building occupants is challenging even for well-recognized indoor pollutants. Consider fine particulate matter, which is a major contributor to human morbidity and mortality.[[28]](#footnote-29) Fine particulate matter includes particles that vary tremendously in chemical composition and size, ranging between 0.01 and 2.5 microns.[[29]](#footnote-30) Concentrations differ with time and location, and chemical composition may change depending on temperature, humidity, and the presence of other substances.[[30]](#footnote-31) Human exposure, moreover, depends on not only pollutant concentrations but also location and individual behavior.[[31]](#footnote-32) Risks to individual health hinge further on age, health, cumulative exposures, susceptibility, and other factors.[[32]](#footnote-33)

## B. Increased Attention to IAQ

Developments in recent years have only underscored IAQ’s importance. First, the COVID-19 pandemic served as a jolting reminder that biological agents—viruses, bacteria, and fungi—are important contributors to poor IAQ.[[33]](#footnote-34) Second, repeated episodes of widespread wildfire smoke in 2023 forced Americans to stay indoors and to seek ways to keep smoke and other pollutants out.[[34]](#footnote-35) Although the pandemic pushed people outdoors while wildfire smoke drove people indoors, both redirected society’s attention to IAQ.[[35]](#footnote-36) This heightened attention nevertheless has failed to generate a meaningful regulatory response.

COVID-19 spreads primarily through the inhalation of fine droplets or aerosol particles containing the SARS-CoV-2 virus.[[36]](#footnote-37) Increasing indoor air ventilation has been a critical tool for keeping these droplets and particles from becoming concentrated in poorly ventilated spaces.[[37]](#footnote-38) Recognizing the importance of IAQ in reducing the spread of COVID-19, the federal government launched the Clean Air in Buildings Challenge in March 2022.[[38]](#footnote-39) This initiative called on building owners and operators to assess IAQ and improve ventilation and air filtration.[[39]](#footnote-40) Similarly, the October 2022 White House Summit on Indoor Air Quality aimed to share and encourage best practices in combating infectious disease spread.[[40]](#footnote-41)

Yet even with the heightened attention to improved ventilation, actual improvements in IAQ have been underwhelming or difficult to measure.[[41]](#footnote-42) For example, the federal government allocated $122 billion for COVID-19 response in schools, including improvements in classroom ventilation and air quality.[[42]](#footnote-43) Only about one-third of school districts used any of these funds to upgrade heating, ventilation, and air conditioning (HVAC) systems, and a significant portion of funds was spent on unproven or ineffective products.[[43]](#footnote-44)

Increasing wildfires and wildfire smoke have also drawn attention to indoor air quality. Across the U.S., wildfire smoke has stalled or reversed decades of improvement in outdoor air quality.[[44]](#footnote-45) During wildfire smoke episodes, public health officials typically advise the public to go indoors and close windows and doors.[[45]](#footnote-46) Sealing buildings off to keep out wildfire smoke, however, might only worsen IAQ.[[46]](#footnote-47) Indeed, decades-long efforts to keep out smog and conserve energy through building design produced poorly ventilated indoor environments where contaminants can concentrate.[[47]](#footnote-48) Rather than focusing on healthy air, ventilation standards sought to “bring[] in just enough outdoor air to ensure that buildings did not stink.”[[48]](#footnote-49)

As climate change worsens, hotter days and increased wildfire smoke could drive people indoors even more and prompt further efforts to reduce ventilation of outdoor air.[[49]](#footnote-50) Other responses to climate change, including weatherization of homes and portable generator use during power outages, also may worsen IAQ.[[50]](#footnote-51) In many areas, sea level rise and more frequent floods and heavy rainfall events will increase dampness and facilitate the growth of mold, bacteria, and fungi.[[51]](#footnote-52)

## C. Methods of Control

Weak management of IAQ is not due to a lack of technical tools. Methods for controlling indoor air pollution fall into three categories: source management, engineering controls, and administrative controls.[[52]](#footnote-53)

Source management—preventing or limiting pollutants from entering indoor air—is often the most direct and effective means of indoor air pollution control.[[53]](#footnote-54) Source management may include encapsulating materials that release pollutants, removing or substituting for such materials, or isolating pollutants by space or time of use.[[54]](#footnote-55)

Engineering controls reduce indoor air pollution through mechanical or structural means.[[55]](#footnote-56) Engineering controls include HVAC systems, which dilute indoor pollution with outdoor air and filter out some contaminants; local exhaust systems, which remove pollutants emitted by point sources before their widespread dispersal; and air cleaning devices, which filter or adsorb contaminants from the air.[[56]](#footnote-57) Ventilation is the primary means of controlling IAQ in most buildings.[[57]](#footnote-58) However, “no single ventilation rate . . . will assure adequate indoor air quality,”[[58]](#footnote-59) as the efficacy of ventilation also depends on the concentration of outdoor contaminants and ventilation system design.[[59]](#footnote-60) Indeed, if outdoor air is polluted, increased ventilation with outdoor air will reduce IAQ.[[60]](#footnote-61) Nonetheless, experts generally recommend ventilation rates above current standards and well above the rates typically found in indoor environments.[[61]](#footnote-62)

Administrative controls rely on the conduct of building occupants to reduce pollution levels or exposure.[[62]](#footnote-63) Administrative controls include work arrangements to reduce chemical use or time of exposure; educating building occupants about ways to promote IAQ; and housekeeping practices to reduce the entry and spread of pollutants in buildings.[[63]](#footnote-64) Masks and other personal protective equipment, which depend on individual compliance, offer an additional approach to limiting pollution exposure, particularly where other methods prove inadequate.[[64]](#footnote-65)

The effectiveness of a specific control technique may depend on the contaminant. For example, filtration is fairly effective at removing particulates but not carbon monoxide.[[65]](#footnote-66) Carbon monoxide and other combustion products are best managed by properly maintaining and operating combustion equipment.[[66]](#footnote-67)

Poor IAQ poses a widespread and serious threat to human health. Although various tools can ameliorate the threat, existing laws and policies have failed to effectively deploy them.

# II. Existing Law

No federal agency has overarching responsibility for IAQ.[[67]](#footnote-68) Rather, a patchwork of federal, state, and local standards relates to IAQ.[[68]](#footnote-69) This patchwork includes nonregulatory guidance from EPA, regulation of workplace hazards by OSHA, and ad hoc regulation of specific pollutants or specific indoor environments by states.[[69]](#footnote-70) Nongovernmental organizations have also promulgated standards for building design and operation that have been incorporated into building codes and green building programs.[[70]](#footnote-71)

## A. Federal Law

### 1. EPA

Environmental law has historically neglected IAQ. EPA has long interpreted its Clean Air Act authority over air pollution to cover only air outdoors.[[71]](#footnote-72) Under the Toxic Substances Control Act, EPA can regulate chemical substances that pose unreasonable risks to health or the environment, including chemicals that contribute to indoor air pollution.[[72]](#footnote-73) However, various difficulties in exercising this authority—including the cumbersome nature of a chemical-by-chemical approach and the potential for regulators to disregard health and environmental risks—have led to its relatively feeble and infrequent use.[[73]](#footnote-74) Instead, EPA has focused on research, assistance, guidance, and voluntary programs.[[74]](#footnote-75)

The Radon Gas and Indoor Air Quality Research Act authorizes EPA to research—but not regulate—IAQ and to assess federal actions to mitigate associated health risks.[[75]](#footnote-76) Data gathered by EPA supports various agency initiatives, such as the Environmental Air Quality Tools for Schools program, which assists schools in addressing IAQ problems, and the Partnership for Clean Indoor Air, which aims to reduce pollution from the burning of biomass fuels indoors.[[76]](#footnote-77)

Furthermore, as part of the federal Clean Air in Buildings Challenge,[[77]](#footnote-78) EPA issued a best practice guide for improving IAQ. The guide makes recommendations in four areas: creating a clean indoor air action plan, optimizing fresh air ventilation, enhancing air filtration and cleaning, and engaging the building community.[[78]](#footnote-79) EPA’s guide offers “basic principles” and general recommendations while noting that “the best combination of actions for a building will vary by space and location.”[[79]](#footnote-80)

EPA also has developed a voluntary labeling program for new residential construction, Indoor airPLUS.[[80]](#footnote-81) To be certified under the program, homes must meet Energy Star standards for energy efficiency and incorporate specified design and construction features, including additional moisture control, construction materials with reduced chemical content, whole-house and spot ventilation, and improved air filtration.[[81]](#footnote-82) Homes that verifiably meet program requirements can be marketed as Indoor airPLUS-certified.[[82]](#footnote-83) While the features in certified homes are intended to promote healthier indoor environments, good IAQ depends on their maintenance and use as well as other factors.[[83]](#footnote-84) As of 2023, only 74,000 homes had been certified under the program.[[84]](#footnote-85) Indoor airPLUS version 2, finalized in 2024, aims to broaden participation and increase IAQ protections.[[85]](#footnote-86) Version 2 offers an additional certification tier, Indoor airPLUS Gold, which would requires Energy Star certification as well as further steps to improve IAQ.[[86]](#footnote-87)

### 2. OSHA

OSHA, the primary federal regulator of workplace safety,[[87]](#footnote-88) has established ventilation and exposure standards that offer limited protection of IAQ in the workplace.[[88]](#footnote-89)

OSHA has the authority to promulgate standards requiring conditions or practices “reasonably necessary or appropriate to provide safe or healthful employment and places of employment.”[[89]](#footnote-90) When “promulgating standards dealing with toxic materials or harmful physical agents,” OSHA “shall set the standard which most adequately assures, to the extent feasible, on the basis of the best available evidence, that no employee will suffer material impairment of health or functional capacity” even with regular exposure during the employee’s working life.[[90]](#footnote-91) Employers must comply with any specific standards set by OSHA as well as the General Duty Clause of the Occupational Safety and Health Act.[[91]](#footnote-92) This provision requires employers to “furnish . . . employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm” to employees.[[92]](#footnote-93)

In theory, employers can be held liable for poor IAQ under the General Duty Clause.[[93]](#footnote-94) Violations of the General Duty Clause require a showing that “1) the employer failed to keep his/her workplace free of a ‘hazard’; 2) the hazard was ‘recognized’ either by the cited employer individually or by the employer's industry generally; 3) the recognized hazard was causing or was likely to cause death or serious physical harm; and 4) there was a feasible means available that would eliminate or materially reduce the hazard.”[[94]](#footnote-95) However, OSHA appears unlikely to apply the General Duty Clause to instances of poor IAQ. Noting that normal workplace exposure to the main chemicals in tobacco smoke would not exceed permissible exposure limits, OSHA previously declined to apply the Clause to environmental tobacco smoke.[[95]](#footnote-96)

In terms of specific standards, OSHA has not set overarching IAQ standards per se but has established standards for ventilation and some indoor air contaminants.[[96]](#footnote-97) Unfortunately, the agency’s limits for contaminant exposure, known as permissible exposure limits (PELs), were adopted five decades ago and for the most part offer minimal protection.[[97]](#footnote-98) PELs are “much higher (several orders of magnitude in some cases) than several other non-regulatory exposure limits issued by the state of California and the U.S. EPA.”[[98]](#footnote-99)

OSHA itself has recognized the need to update its standards—many of which are relevant to IAQ—yet struggled to keep up. In 1988, it noted:

OSHA has issued only 24 substance-specific health regulations since its creation. It has not been able to review the many thousands of currently unregulated chemicals in the workplace nor to keep up with reviewing the several thousand new chemicals introduced since its creation. It has not been able to fully review the literature to determine if lower limits are needed for many of the approximately 400 substances it now regulates.[[99]](#footnote-100)

Even today, OSHA acknowledges “that many of its permissible exposure levels (PELs) are outdated and inadequate for ensuring protection of worker health.”[[100]](#footnote-101)

In a 1989 rule that sought to establish new or revised PELs en masse for over 400 substances, OSHA relied heavily on recommendations by other entities.[[101]](#footnote-102) The Eleventh Circuit struck down the rule, holding that OSHA failed to assess each regulated substance individually and to make its own determination that each substance created a significant risk of material health impairment.[[102]](#footnote-103)

OSHA subsequently made an unsuccessful effort to regulate IAQ more directly. In 1994, OSHA proposed IAQ regulations focused primarily on tobacco smoke in the workplace.[[103]](#footnote-104) The proposal opted for a general ventilation standard rather than regulating contaminants on a chemical-by-chemical basis.[[104]](#footnote-105) Employers in nonindustrial work environments would have been required to develop and implement IAQ compliance plans.[[105]](#footnote-106) Substantive requirements included: operation of HVAC systems to provide at least the minimum outside air ventilation rate required by the building code; monitoring for CO2 in occupied spaces as a “gross surrogate indicator of air quality”; and measures to restrict entry of outdoor air pollutants and control indoor pollution sources.[[106]](#footnote-107) Opposition from the tobacco industry ultimately forced OSHA to withdraw the proposal.[[107]](#footnote-108)

### 3. Other Federal Agencies

Other federal agencies having limited authority over matters affecting IAQ include the Consumer Product Safety Commission (CPSC) and Centers for Disease Control and Prevention (CDC).

#### a. CPSC

The CPSC, under its authority to regulate “consumer products,” has taken a few actions to reduce contaminants in indoor air, such as banning the use of urea formaldehyde foam insulation in schools and residences and banning asbestos in wall patching compounds and artificial fireplace embers.[[108]](#footnote-109) However, the agency’s regulatory authority is relatively weak, as reflected in judicial invalidation of its ban on urea formaldehyde foam insulation.[[109]](#footnote-110) Controversy surrounding the CPSC’s 2023 request for information about the health hazards associated with gas stove emissions underscores the agency’s difficulties in attempting to regulate consumer products.[[110]](#footnote-111)

As an initial matter, the agency’s authority is limited to “consumer products,” a term that does not include houses.[[111]](#footnote-112) Moreover, the agency cannot regulate the use of consumer products, other than through notices or warnings.[[112]](#footnote-113) In areas within its jurisdiction, the CPSC must rely on voluntary safety standards if compliance with such standards is likely and “would eliminate or adequately reduce the risk of injury addressed.”[[113]](#footnote-114) If voluntary standards are inadequate, the agency may resort to mandatory product safety standards that are “reasonably necessary to prevent or reduce an unreasonable risk of injury associated with such product.”[[114]](#footnote-115) Such standards must impose “the least burdensome requirement which prevents or adequately reduces the risk of injury.”[[115]](#footnote-116) These fairly rigorous requirements can discourage the CPSC from issuing mandatory safety standards.[[116]](#footnote-117)

#### b. CDC

The COVID-19 pandemic highlighted the CDC’s potential role in protecting IAQ. The Public Health Service Act authorizes the issuance of regulations “necessary to prevent the introduction, transmission, or spread of communicable diseases . . . .”[[117]](#footnote-118) Under this authority, the CDC can take “reasonably necessary” measures to prevent the interstate spread of communicable disease upon a determination that measures taken by state authorities are insufficient to prevent such spread.[[118]](#footnote-119) Before the COVID-19 pandemic, the CDC wielded this authority mainly to quarantine individuals who might spread contagious diseases.[[119]](#footnote-120) However, during the COVID-19 pandemic, the agency invoked this authority to issue an eviction moratorium—a move swiftly invalidated by the Supreme Court.[[120]](#footnote-121) The CDC’s more recent guidance on improving ventilation in buildings aims primarily at reducing the spread of respiratory infections but offers broader IAQ benefits as well.[[121]](#footnote-122)

\* \* \*

Other federal actions to promote IAQ generally involve incentives and guidance rather than direct regulation. These actions include: funding research on reducing airborne disease transmission in buildings; funding state and local governments, schools, and other entities to undertake IAQ improvements through the American Rescue Plan and Inflation Reduction Act; and establishing IAQ requirements in federal buildings.[[122]](#footnote-123) Recent proposed legislation has also shied away from regulation. For example, the Airborne Act, proposed in 2022, would have offered a tax credit for conducting an IAQ assessment and implementing an air filter or HVAC upgrade.[[123]](#footnote-124)

## B. State & Local Law

State regulation of IAQ varies widely. Some states regulate specific indoor air contaminants or specific building categories.[[124]](#footnote-125) Bans on smoking in bars, restaurants, and worksites constitute perhaps the most prominent state efforts to improve IAQ.[[125]](#footnote-126) A few states, including New Jersey and California, have adopted broader IAQ regulations —though even these are hardly comprehensive.[[126]](#footnote-127) New Jersey regulates existing buildings occupied by public employees during regular working hours, including public schools.[[127]](#footnote-128) Employers must establish and follow a preventive maintenance schedule for HVAC systems, check HVAC systems if CO2 levels exceed 1000 parts per million, use ventilation when housekeeping and maintenance activities could result in chemical exposures above applicable PELs, and implement control measures when general ventilation is inadequate to limit contaminant levels below PELs.[[128]](#footnote-129)

California’s IAQ standards aim at preventing harmful exposures to dusts, fumes, mists, vapors, and gases in public and private workplaces.[[129]](#footnote-130) The standards require the maintenance and operation of HVAC systems to provide the minimum ventilation specified by the state building code.[[130]](#footnote-131) HVAC systems must be inspected annually and operated continuously during working hours.[[131]](#footnote-132) Employers must also provide protection from wildfire smoke, other than in enclosed buildings in which the air is filtered by a mechanical ventilation system.[[132]](#footnote-133) Other California regulations that affect IAQ include limits on formaldehyde emissions from wood products,[[133]](#footnote-134) limits on ozone emitted by indoor air cleaning devices,[[134]](#footnote-135) and a temporary requirement that employers increase outdoor air supply or improve mechanical filtration to hinder COVID-19 transmission.[[135]](#footnote-136)

Local governments can also regulate IAQ through building code provisions and rules directly governing IAQ. Montgomery County, Maryland prohibits the emission of indoor air pollutants beyond a person’s property line in a manner that creates indoor air pollution.[[136]](#footnote-137) The ordinance also establishes a process for filing complaints, testing, investigation, and enforcement.[[137]](#footnote-138) A few municipalities have enacted ordinances that require landlords to test for radon.[[138]](#footnote-139) Furthermore, New York City has proposed laws that would require the creation of air quality standards for schools and municipal buildings.[[139]](#footnote-140) The proposal would also establish pilot programs to analyze air quality in private buildings, with mandatory participation for owners or developers who receive financial assistance from the city.[[140]](#footnote-141)

Characterizing the legal environment of IAQ as a “patchwork,” the Johns Hopkins Center for Health Security compiled a Model State Indoor Air Quality Act.[[141]](#footnote-142) The model law is intended to encourage state and local governments to “respond to the public health risks of poor IAQ related to airborne infectious disease agents and other contaminants through enhanced measures applicable to public buildings.”[[142]](#footnote-143) Buildings are classified according to the level of risk of exposures to contaminants.[[143]](#footnote-144) States can mandate indoor air contaminant testing and public posting of test results, and building owners are encouraged to conduct IAQ assessments.[[144]](#footnote-145) The model law also empowers building occupants to file IAQ complaints with the state for evaluation, investigation, and inspection.[[145]](#footnote-146)

## C. Nongovernmental Standards

Building standards developed by nongovernmental organizations also influence IAQ. ASHRAE (formerly the American Society of Heating, Refrigerating and Air-Conditioning Engineers) and the US Green Building Council, through its Leadership in Energy and Environmental Design (LEED) rating system, have developed two of the leading standards.[[146]](#footnote-147) The World Health Organization has also published voluntary IAQ guidelines.[[147]](#footnote-148)

### 1. ASHRAE

ASHRAE’s standards for ventilation rates, air filtration efficiency, and air cleaners have been adopted into most U.S. building codes.[[148]](#footnote-149) Model building codes and green building programs have also incorporated these standards.[[149]](#footnote-150) However, state and local building codes may not be updated until several years after ASHRAE’s standards are revised.[[150]](#footnote-151) In addition, whereas adoption of ASHRAE’s standards into building codes is largely voluntary, state and local governments face powerful incentives to incorporate energy conservation standards into building codes, even at the expense of IAQ.[[151]](#footnote-152)

ASHRAE Standard 62.1 sets out “minimum requirements” to promote “acceptable” IAQ in commercial, institutional, and high-rise residential buildings.[[152]](#footnote-153) Acceptable IAQ is defined as “air in which there are no known contaminants at harmful concentrations . . . and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction.”[[153]](#footnote-154) To achieve acceptable IAQ, Standard 62.1 prescribes minimum ventilation rates and standards for HVAC system construction, building design, and other features.[[154]](#footnote-155) With respect to mechanical air filtration, for example, Standard 62.1 prescribes a minimum efficiency reporting value (MERV) of 8.[[155]](#footnote-156) This degree of control filters out larger particles that foul up HVAC equipment but removes only a small fraction of fine particulate matter.[[156]](#footnote-157) Standard 62.1 “is intended for regulatory application to new buildings” and as guidance for existing buildings,[[157]](#footnote-158) but does not comprehensively address all factors relevant to good IAQ.[[158]](#footnote-159)

ASHRAE Standard 62.2 similarly prescribes standards to achieve acceptable IAQ in residential buildings through dwelling-unit ventilation, local mechanical exhaust, and source control.[[159]](#footnote-160) Minimum ventilation requirements from this standard have been incorporated into California’s Title 24 standards for building energy efficiency, the LEED rating system, and EPA’s Indoor airPlus program.[[160]](#footnote-161)

ASHRAE explicitly cautions that compliance with its standards does not ensure health, comfort, or good IAQ.[[161]](#footnote-162) As an initial matter, the ASHRAE standards generally govern building design, not operation.[[162]](#footnote-163) Moreover, while Standards 62.1 and 62.2 take health impacts into consideration, the standards are not intended to guarantee specific levels of human health protection.[[163]](#footnote-164) Indeed, the standards were not formulated with disease transmission in mind.[[164]](#footnote-165) In response to the COVID-19 pandemic, ASHRAE promulgated a separate standard specifically focused on reducing disease transmission risk indoors.[[165]](#footnote-166) Standard 241 Control of Infectious Aerosols, applicable to new and existing buildings during times of heightened infection risk, specifies requirements for equivalent clean air flow rate, taking into account outdoor air circulation, indoor air filtration, and air cleaners such as germicidal ultraviolet light.[[166]](#footnote-167) Notably, the ventilation rates specified in Standard 241 are generally several factors greater than those required by Standard 62.1—the IAQ standard applicable to new buildings.[[167]](#footnote-168)

Ventilation requirements aside, the ASHRAE standards also include an alternative, performance-based approach aimed at controlling contaminant concentrations rather than mandating airflow.[[168]](#footnote-169) This approach, known as the IAQ Procedure, relies on mass balance analysis as well as subjective evaluations by building occupants to determine whether standards are met.[[169]](#footnote-170) Unlike ventilation standards, this approach focuses on actual indoor air pollution levels.[[170]](#footnote-171) While the IAQ Procedure does not require monitoring of actual contaminant concentrations once a building is occupied, it may require difficult-to-gather information on pollution sources and contaminant limits.[[171]](#footnote-172)

### 2. LEED

The U.S. Green Building Council's LEED system is a widely used, voluntary rating system that considers a building’s design, construction, operation, and maintenance.[[172]](#footnote-173) The system awards points for incorporating elements that reduce contributions to climate change, enhance human health, and promote environmental sustainability.[[173]](#footnote-174) New or existing buildings achieve LEED certification by satisfying prerequisites and earning points through a verification and review process.[[174]](#footnote-175)

Indoor environmental quality—including IAQ—is a basic component of the LEED rating system.[[175]](#footnote-176) Meeting minimum IAQ standards—defined largely by reference to ASHRAE Standard 62.1 “or a local equivalent”—is a prerequisite for certification.[[176]](#footnote-177) In addition, a building can earn points by filtering air or increasing ventilation above minimum standards, using materials that emit low levels of VOCs, developing and implementing an IAQ management plan, or assessing IAQ after construction or during occupancy.[[177]](#footnote-178) LEED certification does not necessarily ensure safe IAQ,[[178]](#footnote-179) however, as a building can earn the highest level of certification without earning any points in indoor environmental quality.[[179]](#footnote-180)

### 3. WHO Guidelines

The World Health Organization (WHO) published indoor air quality guidelines for dampness, mold, benzene, carbon monoxide, formaldehyde, naphthalene, nitrogen dioxide, polycyclic aromatic hydrocarbons, radon, trichloroethylene, and tetrachloroethylene in 2010.[[180]](#footnote-181) Developed through systematic expert reviews of scientific evidence linking pollutant exposure with health impacts, these guidelines identify “acceptable levels of population exposure.”[[181]](#footnote-182) Their primary objective “is to provide a uniform basis for the protection of public health from adverse effects of indoor exposure to air pollution.”[[182]](#footnote-183) In other words, the guidelines are based solely on anticipated health effects and do not consider the costs of implementing the guidelines.[[183]](#footnote-184) The guidelines’ intended audience includes public health professionals and those “involved in the design and use of buildings, indoor materials and products.”[[184]](#footnote-185) While not intended to be adopted as standards—which might factor in the acceptability of risks or the costs of meeting mandatory standards—the WHO guidelines are incorporated into some national guidelines and could serve as a basis for legally enforceable standards.[[185]](#footnote-186)

# III. Developing an IAQ Strategy

While the COVID-19 pandemic and 2023 wildfires directed attention to the widespread and serious problem of poor IAQ, multiple factors have hindered development of robust federal or state responses. An effective approach to improving IAQ should account for these factors. In addition, efforts to improve IAQ in other countries can serve as reference points for designing IAQ measures in the United States.

## A. Barriers

### 1. Lack of Obvious Externalities

Negative externalities serve as a prominent justification for government regulation.[[186]](#footnote-187) For example, the Clean Air Act aims to reduce adverse impacts of outdoor air pollution on neighboring communities and ecosystems as well as downwind states.[[187]](#footnote-188) Indoor air pollution, by contrast, involves fewer obvious externalities: IAQ in one building typically has little effect on IAQ in another building, and individuals exercise some control over air quality in their homes.[[188]](#footnote-189) However, several characteristics of the problem call for public intervention. First, homeowners may lack sufficient information and resources to make and implement informed decisions about IAQ.[[189]](#footnote-190) Additionally, some sources of indoor air pollution, such as chemicals in building materials or radon-containing soil, may be more difficult for homeowners to remediate.[[190]](#footnote-191) Furthermore, many factors that influence IAQ, including outdoor air pollution, lie outside the control of a building’s occupants.[[191]](#footnote-192) In commercial and public buildings, indoor air pollution squarely presents a public health issue, as visitors, employees, and other occupants typically have little or no control over IAQ.[[192]](#footnote-193) Ultimately, these barriers to private action on indoor air pollution make a compelling case for public action.

### 2. Low Visibility

Inattention to indoor air pollution can be attributed in part to the largely invisible nature of the problem.[[193]](#footnote-194) Outdoor air pollution is often manifested in smoke or smog that is impossible to ignore.[[194]](#footnote-195) Indoor air pollution, in contrast, is often invisible and odorless.[[195]](#footnote-196) Building occupants who suffer adverse effects may not attribute them to indoor air pollution. Symptoms of poor IAQ, which include eye, nose, and throat irritation, headaches, and fatigue, vary widely and may be mistaken for symptoms of allergies, colds, or stress.[[196]](#footnote-197) Linking symptoms to specific pollutants or exposures is often difficult if not impossible.[[197]](#footnote-198) Longer-term risks, such as increased rates of cancer or heart disease from exposure to VOCs, may not be immediately apparent—or apparent at all—to building occupants.[[198]](#footnote-199) Against the backdrop of limited appreciation of IAQ, the COVID-19 pandemic and recent wildfires boosted awareness of the importance of IAQ, and information campaigns, IAQ monitors, and the like can maintain and heighten that awareness.

### 3. Privacy Concerns

Regulating IAQ in public spaces raises minimal privacy concerns. Health inspectors and fire officials routinely monitor and inspect schools, restaurants, and other public spaces to protect building users and the public.[[199]](#footnote-200) When entering public spaces, people generally assume they will experience healthy indoor air. State initiatives to improve IAQ in public buildings reflect such expectations as well as a relative lack of privacy concerns.[[200]](#footnote-201)

Regulating IAQ in the home, in contrast, raises more serious worries about privacy and government intrusion. The Fourth Amendment protects Americans from unreasonable searches and seizures by the government.[[201]](#footnote-202) Although administrative inspections of homes and businesses require probable cause or consent, the Supreme Court has recognized that less is required in the civil context than for a criminal search warrant.[[202]](#footnote-203) In the words of one commentator’s summary of the relevant jurisprudence, “courts evaluating administrative searches need only balance the government's interest in conducting the search against the degree of intrusion on the affected individual's privacy to determine whether the search is reasonable.”[[203]](#footnote-204) Nonetheless, even if constitutionally permissible, government inspections or monitoring of IAQ in homes would be politically difficult.

As a technical matter, monitoring IAQ in the home is increasingly feasible. Inexpensive monitors that generate real-time data have become widely available and are incorporated into many thermostat systems sold today.[[204]](#footnote-205) These monitors can detect a handful of indoor pollutants: PM2.5, VOCs, carbon monoxide, and carbon dioxide.[[205]](#footnote-206) Testing indicates that some low-cost monitors intended for home use can detect PM2.5 and CO2 within a reasonably accurate range.[[206]](#footnote-207) Overall, low-cost IAQ monitors do vary widely in terms of their accuracy, reliability, and durability.[[207]](#footnote-208) As EPA cautions, “there are currently no widely accepted performance criteria used to standardize how measurements are made by low-cost air pollutant monitors, or what thresholds limits are used to determine the alert cues used for the various low-cost air pollutant monitors.”[[208]](#footnote-209) Although data from low-cost monitors may not be sufficiently accurate for regulatory use, they are reliable enough to help identify emission sources, notify building occupants, and prompt responses that reduce indoor air pollution.[[209]](#footnote-210) For example, smart ventilation systems can adjust ventilation rates in response to air quality conditions or contaminant levels.[[210]](#footnote-211) Such technological advances suggest that voluntary uptake of indoor air monitors and smart ventilation controls can be a foundational element of IAQ strategies.

### 4. Complexity and Perceived Cost

IAQ is a complex matter. Indoor air pollution is comprised of numerous and diverse substances generated by multiple sources and processes, and pollutants’ composition and concentration vary over space and time and from one building to another.[[211]](#footnote-212) Individuals’ intake rates and susceptibility to contaminants also differ.[[212]](#footnote-213) Further, indoor chemical reactions and transformations are not always well understood, compounding the challenges of characterizing and reducing exposure.[[213]](#footnote-214) All of this suggests that improving IAQ will require further research and multiple approaches, rather than any single prescription.

The costs of improving IAQ depend on the circumstances contributing to poor IAQ and the relevant control methods. Some indoor air pollution can be readily addressed by ceasing the pollution-causing activity or by opening a window. In contrast, installing or upgrading HVAC or exhaust systems may require substantial expenditures.[[214]](#footnote-215) Yet for many buildings, the benefits of improved IAQ can justify even substantial expenditures. In the commercial building sector, these benefits include health benefits, increased worker productivity, and energy savings.[[215]](#footnote-216) As a general matter, the public health and productivity benefits of improved IAQ would “likely far outweigh the investment costs in achieving clean [indoor air].”[[216]](#footnote-217)

### 5. Commerce Clause Limits

The federal government or the states could seek to regulate IAQ. Whereas state authority to regulate IAQ would fall squarely within states’ general police power,[[217]](#footnote-218) federal regulation would rely heavily on Congress’ power to regulate interstate commerce.[[218]](#footnote-219) Regulation of consumer products and other items in commerce that affect IAQ, such as building materials, lies clearly within federal authority.[[219]](#footnote-220) Regulation of some indoor environments may be trickier, however. Federal regulation of IAQ in federally owned or financed buildings could rely on the Property Clause, Commerce Clause, or Necessary and Proper Clause.[[220]](#footnote-221) Federal regulation of IAQ in workplaces, akin to OSHA workplace safety regulation, would also be constitutionally secure.[[221]](#footnote-222) However, federal regulation of private residences may be limited to specific circumstances. Such regulation might be implemented upon the sale of residences, for example.[[222]](#footnote-223) Working from home also constitutes commercial activity that might serve as a basis for federal regulation.[[223]](#footnote-224)

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While various factors have hindered better management of indoor air pollution, none poses an insurmountable barrier to improving IAQ.

## B. Comparative IAQ Regulation

Notwithstanding the barriers to IAQ regulation, some countries have adopted policies to improve IAQ beyond workplace settings. IAQ management outside the U.S. relies primarily on source controls (including bans on smoking in public buildings and limitations on materials that emit toxic chemicals), building code ventilation requirements, or voluntary guidelines.[[224]](#footnote-225) Recognizing the difficulty of monitoring and enforcing air quality standards in homes and other indoor spaces, these policies rarely mandate the achievement of specific IAQ levels.[[225]](#footnote-226) Instead, nations typically express pollutant concentration limits as guidelines.[[226]](#footnote-227) Canada’s IAQ policies suggest the potential benefits and limitations of voluntary guidelines. IAQ laws in Japan, South Korea, Taiwan, and Belgium exemplify mandates that go beyond voluntary guidelines. In addition, proposed regulation in the European Union illustrates one approach to the phase-in of IAQ mandates.

### 1. Canada

Health Canada, a Canadian federal agency, issues voluntary IAQ guidelines pursuant to the Canada Environmental Protection Act.[[227]](#footnote-228) Based on its own risk assessments, the agency generates Residential IAQ Guidelines consisting of 1-hour and 8-hour recommended exposure limits for indoor air contaminants.[[228]](#footnote-229) Health Canada has developed quantitative guidelines for 11 contaminants as well as guidance to reduce exposure to other contaminants when quantitative exposure limits are not feasible.[[229]](#footnote-230) In 2012, for example, the agency replaced its quantitative guidelines for PM2.5 with a recommendation that PM2.5 levels be kept as low as possible because it had determined “there is no apparent threshold for the health effects of PM2.5.”[[230]](#footnote-231)

Health Canada also has published Indoor Air Reference Levels for certain pollutants that lack recommended exposure limits.[[231]](#footnote-232) To identify the reference levels, which are meant to reflect acceptable levels of risk based on long-term exposure, the agency relies heavily on assessments developed by other health and environmental organizations.[[232]](#footnote-233)

Health Canada’s IAQ guidelines, guidance, and reference levels are voluntary.[[233]](#footnote-234) However, they serve as benchmarks for government risk assessments and provide guidance for managers of public spaces.[[234]](#footnote-235) They also have been incorporated into building codes and product standards and are communicated to the public and professionals.[[235]](#footnote-236)

### 2. Japan

Japan has established both generally applicable IAQ guidelines and specific standards applicable to large buildings. Japan’s Ministry of Health, Labour and Welfare established individual IAQ guidelines for 13 VOCs between 1997 and 2002, as well as a provisional target for total VOCs.[[236]](#footnote-237) These guidelines apply generally to indoor spaces, including housing, but not to industrial plants.[[237]](#footnote-238) Average indoor air concentrations of many of these VOCs fell substantially after the guidelines were issued.[[238]](#footnote-239)

Apart from these guidelines, Japan has established IAQ requirements for designated categories of buildings of a specified square footage, including stores, offices, and schools.[[239]](#footnote-240) Operators of these buildings must measure suspended particles, CO, and CO2 levels every two months to ensure that their concentration does not exceed specified thresholds.[[240]](#footnote-241) The law also requires monitoring for compliance with humidity, temperature, and airflow standards.[[241]](#footnote-242) A building manager must report air quality assessment results to the government and prepare a remediation plan if air quality standards are not met.[[242]](#footnote-243) Government reports indicate that regulated buildings are only occasionally failing to meet standards for airflow, suspended particles, and CO but are exceeding standards for CO2, temperature, and humidity over 20% of the time.[[243]](#footnote-244)

### 3. South Korea

South Korea likewise regulates IAQ in designated building categories, backed by more powerful enforcement tools. The nation’s Indoor Air Quality Control Act requires “public use facilities” of a prescribed size to meet IAQ standards for pollutants identified by the Ministry of the Environment.[[244]](#footnote-245) Facilities subject to these requirements include business facilities, medical institutions, libraries, movie theaters, superstores, performance halls, and subway stations.[[245]](#footnote-246) Newly built multi-family housing and mass transit vehicles are also governed by the statute.[[246]](#footnote-247) Regulated indoor air pollutants include total particulates (PM10), PM2.5, CO2, CO, formaldehyde, and total bacteria.[[247]](#footnote-248) The government may enforce IAQ standards by ordering ventilation or other measures and penalizing violators with fines and prison time of up to a year.[[248]](#footnote-249) The statute also requires public use facility owners to measure IAQ and regulates construction materials in new public use facilities and multifamily housing.[[249]](#footnote-250) Other laws aimed at improving IAQ include a mandate that builders of apartment buildings of more than 500 units report on compliance with requirements for source controls, ventilation controls, and removal controls.[[250]](#footnote-251)

### 4. Taiwan

Taiwan adopted a regulatory program similar to South Korea’s in 2011 and has gradually expanded the premises to which its standards apply.[[251]](#footnote-252) Taiwan’s Indoor Air Quality Act standards initially applied to colleges, government offices, transit systems, shopping malls, and medical institutions, and now also applies to cinemas, stores, and performance halls.[[252]](#footnote-253) Regulated premises must meet IAQ standards, prepare and implement IAQ management plans, regularly test IAQ, and make test results publicly available.[[253]](#footnote-254) Standards have been established for CO2, CO, formaldehyde, total VOCs, bacteria, fungi, PM10, PM2.5, and ozone.[[254]](#footnote-255) Government officials may conduct inspections and IAQ analyses, and violations are subject to corrective orders and civil penalties.[[255]](#footnote-256) To complement the regulatory regime, Taiwan established a voluntary program that allows building operators to earn and publicize a certification that they have achieved “good” or “excellent” IAQ if they meet specified standards for designated pollutants.[[256]](#footnote-257)

### 5. Belgium

In the wake of the COVID-19 pandemic, Belgium established a relatively limited scheme of IAQ regulation. The regulations, which are largely procedural, apply to enclosed spaces open to the public, such as bars, gyms, restaurants, and workspaces open to the public, but not to residences or office meeting rooms.[[257]](#footnote-258) Regulated entities must display real-time measurements of CO2, prepare risk analyses, and obtain air quality certifications.[[258]](#footnote-259) The scheme also establishes air quality targets, or “reference levels,” measured in terms of ventilation flow rates or CO2 concentrations.[[259]](#footnote-260) The reference levels serve as guidance to facilitate assessments of IAQ.[[260]](#footnote-261)

### 6. European Union

Although European regulators historically have devoted scant attention to IAQ, the European Parliament included several provisions focused on IAQ in its 2023 proposed revisions to the Energy Performance of Buildings Directive (EPBD).[[261]](#footnote-262) Proposed Article 11a would require Member States to “set requirements for the implementation of adequate indoor environmental quality standards in buildings in order to maintain a healthy indoor climate.”[[262]](#footnote-263) Indoor environmental quality is defined to include indoor air quality and other parameters affecting the health and well-being of building occupants.[[263]](#footnote-264) The proposal would also mandate the measurement of various indoor environmental quality indicators, including CO2 levels and ventilation rate.[[264]](#footnote-265) The proposed standards would apply to new buildings and those undergoing major renovation.[[265]](#footnote-266) Aimed at decarbonizing the European Union building stock by 2050, the EPBD revisions in many instances would require renovations to improve energy performance.[[266]](#footnote-267) As a result, the indoor environmental quality standards would increasingly apply to existing buildings.[[267]](#footnote-268)

# IV. A Pathway for Improving IAQ

Improving IAQ should be envisioned as a pathway that incorporates multiple policy options. These options include voluntary guidelines, procedural regulations, and substantive standards. Over time, these options can build off of each other, bridge policy gaps, and collectively form an increasingly comprehensive approach to addressing indoor air pollution.

## A. Voluntary Guidelines

One important step would be for federal or state regulators to issue voluntary IAQ guidelines, as Canada has done.[[268]](#footnote-269) A significant advantage of this approach is that agencies sometimes can issue guidelines without new statutory authority.[[269]](#footnote-270) At the federal level, the Radon Gas and Indoor Air Quality Research Act authorizes EPA to research indoor air pollution and disseminate information on indoor air pollution and methods for reducing it.[[270]](#footnote-271) EPA might issue voluntary IAQ guidelines based on this information dissemination authority.[[271]](#footnote-272) In fact, EPA published a voluntary indoor exposure standard for radon[[272]](#footnote-273) under the Indoor Radon Abatement Act of 1988—although that statute specifically directs EPA to publish action levels indicating the health risks associated with radon exposure.[[273]](#footnote-274) EPA’s voluntary radon standard has since been incorporated into binding standards and testing protocols.[[274]](#footnote-275)

An approach centered on voluntary guidelines might resemble the Indoor Air Act of 1994,[[275]](#footnote-276) which passed the U.S. House and Senate but did not survive the legislative reconciliation process.[[276]](#footnote-277) The bill would have required EPA to compile a list of common significant indoor air health risks and develop voluntary guidelines for identifying, reducing, and preventing such risks.[[277]](#footnote-278) The bill also would have mandated that EPA publish and disseminate the list, guidelines, and indoor health advisories describing health effects.[[278]](#footnote-279)

Though voluntary in nature, guidelines can inform product safety standards, agency program implementation, building codes, building certification programs, and consumer behavior.[[279]](#footnote-280) Voluntary standards may be especially appropriate where private actors lack information on steps to improve IAQ.[[280]](#footnote-281) Furthermore, they can prompt at least some level of health protection when mandatory standards are politically infeasible.[[281]](#footnote-282) In the current political environment, mandatory federal IAQ standards would likely face an uphill struggle, especially in light of historical norms of state and local control of building safety standards and land use.[[282]](#footnote-283)

Of course, guidelines may have limited impact because compliance with them is voluntary. States, facing political pressure to avoid stringent regulation, may resist incorporating IAQ standards into already complicated building codes.[[283]](#footnote-284) Likewise, companies may have little incentive to follow recommended guidelines in the absence of consumer demand for healthy IAQ.[[284]](#footnote-285) Nonetheless, widespread acceptance of ASHRAE’s standards for ventilation and HVAC system design suggests a potential pathway for making voluntary guidelines effective. As it updates and issues new standards, ASHRAE should account for or incorporate government IAQ guidelines.[[285]](#footnote-286) ASHRAE could also tighten its IAQ standards on its own. In addition, certification schemes can encourage building managers to make IAQ improvements, which often pay for themselves in terms of productivity gains and reduced absenteeism.[[286]](#footnote-287)

## B. Procedural Regulation

Another option, inspired by regulation in Belgium and other countries, would institute procedural requirements aimed at improving IAQ. Helpfully, the Model State Indoor Air Quality Act offers language that state legislatures or Congress can reference in establishing a procedural IAQ scheme.[[287]](#footnote-288) Such a scheme could require owners and operators of regulated indoor environments to measure pollution levels or ventilation rates or test for IAQ and make results available to building occupants or the public.[[288]](#footnote-289) It could also require risk analyses, IAQ management plans, and air quality certifications.[[289]](#footnote-290) Officially promulgated reference levels for measured pollutants would facilitate interpretation and use of test results by interested parties and the public.[[290]](#footnote-291)

The Boston Public Schools’ (BPS) use of IAQ sensors illustrates how procedural requirements might work. BPS installed IAQ sensors in all school classrooms to measure CO2, CO, PM10, PM2.5, temperature, and humidity.[[291]](#footnote-292) Information from the sensors is reported on the web in real-time, and a response plan prescribes steps to optimize air quality and ventilation in light of the information gathered.[[292]](#footnote-293) Steps that have been taken include adjustments to ventilation systems, installation of new ventilation systems, increased circulation of fresh air during events with high emissions, reduction of bus and vehicle idling near schools, and use of green cleaners.[[293]](#footnote-294)

Procedural requirements direct attention to an issue and generate information that can empower action. Technological advances have made information on IAQ increasingly available at reasonable cost, potentially catalyzing action by building operators (such as improving ventilation systems), tenants (such as relocating to a building with better air quality), and individual occupants (such as opening a window).[[294]](#footnote-295) In environmental contexts, this sort of information-based approach has had a greater influence on behavior and decision making by government agencies and commercial entities than lay individuals.[[295]](#footnote-296) Motivating individual action generally has proven more difficult because individuals “remain largely unaware of or fail to understand the information subject to disclosure.”[[296]](#footnote-297) Unfortunately, this insight suggests that IAQ disclosure requirements may have limited impact in the very context—i.e., residential dwellings—in which such requirements may be most politically necessary. It also points to the importance of ensuring disclosures are clear and coupled with educational outreach and incentives for individual action.

## C. Substantive Regulation

Substantive IAQ regulation in other countries offers potential models for regulation and suggests its feasibility. The architects of substantive regulation will have to make fundamental choices regarding the indoor environments and pollutants to regulate, as well as regulatory tools to use.

### 1. Which Indoor Environments

Indoor air pollution encompasses a wide range of indoor environments, including industrial workplaces, offices, schools, multifamily residential buildings, and single-family homes.[[297]](#footnote-298) This variety of indoor environments—and the differences between them—points toward a tailored rather than a uniform approach to addressing IAQ issues.[[298]](#footnote-299) Existing legal regimes already single out industrial workplaces and schools for regulation.[[299]](#footnote-300) Yet the standards applicable to industrial workplaces are relatively weak, inasmuch as they assume a healthy workforce and balance worker health and safety against potential interference with industrial processes.[[300]](#footnote-301) Many states set standards specific to school buildings, reflecting children’s sensitivity to indoor air pollution and the amount of time students spend in schools.[[301]](#footnote-302) Beyond industrial workplaces and schools, substantive regulations might also focus on larger facilities used by the public in significant numbers, as in Japan, South Korea, and Taiwan, or even multifamily residential buildings.[[302]](#footnote-303)

A tiered regulatory approach could account for the differing feasibility, effectiveness, and impact of substantive IAQ regulation in varying environments. The most stringent protections should apply in schools, hospitals, senior living facilities, and other buildings with large numbers of users who are especially susceptible to poor IAQ.[[303]](#footnote-304) More modest protections might apply in workplaces and public buildings, whose users are generally less vulnerable to poor IAQ. In comparison to private residences, workplaces and public buildings involve lesser privacy concerns, and their owners and operators are more likely to have the capacity to undertake capital-intensive IAQ improvements.[[304]](#footnote-305) In private residences, more limited and less intrusive protections could apply.[[305]](#footnote-306) Regulations that are relatively easy to implement, such as product bans, might be especially suited to protect occupants of these buildings.

### 2. Which Pollutants

The diverse range of indoor air pollutants poses a serious challenge for defining, measuring, and regulating IAQ.[[306]](#footnote-307) Monitoring or regulating all indoor pollutants is simply impossible.[[307]](#footnote-308) Instead, oversight should focus on a small handful of common pollutants that are more readily measured and pose significant health risks. Many states already require dwellings, schools, and other buildings to have carbon monoxide detectors.[[308]](#footnote-309) Other countries’ indoor air standards, which single out CO2, PM10, PM2.5, and a few other pollutants, offer a useful starting point for developing further oversight in the U.S.[[309]](#footnote-310)

Monitoring requirements focused specifically on carbon monoxide, CO2, and PM2.5 can generate a general snapshot of IAQ at reasonable cost.[[310]](#footnote-311) Carbon monoxide monitoring can readily identify life-threatening CO levels resulting from incomplete combustion.[[311]](#footnote-312) CO2 concentrations serve as a proxy for ventilation rates and emissions linked to people, such as bioeffluents and respiratory viruses, whose levels are not easily monitored.[[312]](#footnote-313) Indeed, the use of CO2 measurements to gauge disease transmission risk during the COVID-19 pandemic, as well as Belgium’s mandate to measure and display real-time CO2 measurements, reflects the utility of elevated CO2 concentrations in identifying inadequate ventilation in occupied buildings.[[313]](#footnote-314) Elevated PM2.5 levels can reveal not only inadequate ventilation and poor air filtration but also health risks from PM2.5 exposure itself.[[314]](#footnote-315)

Beyond CO, CO2, and PM2.5, carcinogens, toxins, and other hazardous substances might also be subject to indoor air regulation.[[315]](#footnote-316) Regulations already govern the use or concentration of a few substances, such as formaldehyde, in specified products.[[316]](#footnote-317) Many hazardous substances, however, are unregulated.[[317]](#footnote-318) Product-focused standards, which might be applied to building materials, gas stoves, and other consumer products that emit such substances, “are relatively simple to devise and administer” but offer only a piecemeal approach to indoor air pollution.[[318]](#footnote-319)

### 3. Which Tools

Architects of environmental regulation can draw upon a wide range of policy options for improving environmental quality, including ambient standards, design standards, product bans, and subsidies.[[319]](#footnote-320)

Regulation of outdoor air pollution under the Clean Air Act relies heavily on the National Ambient Air Quality Standards, which drive the development of emission limits, permitting systems, and other regulatory requirements aimed at achieving the ambient standards.[[320]](#footnote-321) In theory, ambient standards for indoor air pollution could incorporate thresholds and guidelines for indoor air pollution promulgated by Health Canada, the World Health Organization, ASHRAE, or other entities.[[321]](#footnote-322) However, establishing indoor standards analogous to the Clean Air Act’s ambient standards would face serious practical challenges, including: a multitude of pollutants with varying and synergistic effects and lack of health data on many of them, variations in individual behavior and individual susceptibility to pollutants, a diversity of building stock as well as varying conditions within individual buildings, and difficulty in measuring ambient concentrations of specific chemicals at high spatial and temporal resolution.[[322]](#footnote-323)

In addition, setting ambient standards would represent only an initial step in improving IAQ. Under the Clean Air Act, outdoor ambient pollution standards are achieved almost exclusively through a combination of state and federal regulation of emissions from major stationary sources and motor vehicles.[[323]](#footnote-324) Regulation concentrates on a relatively small number of polluters, such as power plant operators and motor vehicle manufacturers, for whom pollution reduction is relatively feasible and effective.[[324]](#footnote-325) Taking a similar approach would be unlikely to improve IAQ. Building owners, operators, and occupants are more numerous and have a more limited capacity to address indoor air pollution, which arises from multiple and varied sources.[[325]](#footnote-326) Furthermore, implementing and achieving indoor ambient standards could require steps that raise privacy and property rights concerns.[[326]](#footnote-327)

Design standards, which either specify a pollution control technology or allow entities to choose any technology that meets a quantitative or qualitative standard, would be easier to implement and potentially more effective in improving IAQ than ambient standards.[[327]](#footnote-328) Design standards could include building code requirements governing air filtration efficiency, ventilation rates, ventilation and exhaust equipment, and the like. Through dilution and filtration, each such standard can reduce concentrations of multiple pollutants—as opposed to ambient standards, which take a more tedious pollutant-by-pollutant approach.[[328]](#footnote-329)

Design standards should be accompanied by operating, maintenance, and inspection standards that help ensure actual and effective use of mandated equipment. Recommended steps for reducing COVID-19 transmission in schools—such as opening windows and adjusting HVAC settings to bring in more outdoor air and installing air filters with a MERV rating of 13 or higher on centralized HVAC systems—offer examples of complementary design and operating standards.[[329]](#footnote-330)

Product regulation might include prohibitions or restrictions on the use of specified products or building materials that contribute to indoor air pollution. Such regulation can effectively reduce some significant sources of indoor air pollution, as demonstrated by indoor smoking bans and limits on formaldehyde-emitting building materials and furniture.[[330]](#footnote-331) However, regulating all products that contribute to poor IAQ is not feasible, nor would such regulation solve the problem alone.[[331]](#footnote-332) Lack of information about the thousands of chemicals in indoor products and their potential health effects will confound a purely product-based approach to improving IAQ.[[332]](#footnote-333)

Finally, subsidies—though not imposing substantive mandates—can help pay for improvements aimed at bettering IAQ. Federal aid for schools to reopen and operate safely as the COVID-19 pandemic eased offers one example, as some federal funding was used to upgrade ventilation systems or install air cleaners.[[333]](#footnote-334) Another example involves tax subsidies for building electrification, which are aimed primarily at reducing carbon emissions but also offer indoor air benefits as gas cooktops and wood stoves are replaced.[[334]](#footnote-335) Although subsidies can involve significant public expenditures, they represent potentially important tools for generating public health benefits and improving IAQ, particularly when regulation may be infeasible or ineffective.

# Conclusion

Poor IAQ is an overlooked yet serious threat to the health of millions of Americans. The wide range of pollutants and indoor environments, as well as uncertainty about chemical interactions and risks, complicate potential responses. Building operators and homeowners nonetheless have a number of effective tools for improving IAQ but often lack awareness, resources, or incentives to address the problem. Federal, state, and local governments have taken piecemeal and ad hoc approaches that have yielded only modest impacts. Instead, they should undertake a more systematic effort to improve IAQ using a combination of voluntary guidelines, procedural regulations, and substantive standards. Voluntary guidelines can inform action by other government actors, industry, and consumers, and serve as a foundation for mandatory standards. Procedural requirements can direct attention to an issue, generate information, and catalyze action based on that information. Finally, substantive requirements can initially focus on key indoor pollutants and settings where regulation would be both impactful and feasible as a technical and political matter.

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2. *See infra* Part I.A. [↑](#footnote-ref-3)
3. *See infra* Part II.A.2. [↑](#footnote-ref-4)
4. *See infra* note 70. [↑](#footnote-ref-5)
5. *See infra* Part II.B. [↑](#footnote-ref-6)
6. Neil E. Klepeis et al., *The National Human Activity Pattern Survey (NHAPS): Resources for Assessing Exposure to Environmental Pollutants*, 11 J. Exposure Sci. & Env’t Epidemiology 231, 239, 248 (2001) (reporting that Americans spend 86.9% of time in buildings and another 5.5% of time in enclosed vehicles). [↑](#footnote-ref-7)
7. Arden Rowell, *Indoor Environmental Law*, 54 Env’t L. 327, 329 (2024). [↑](#footnote-ref-8)
8. *Id.* at 345–46. [↑](#footnote-ref-9)
9. EPA, Why Indoor Air Quality Is Important to Schools, <https://www.epa.gov/iaq-schools/why-indoor-air-quality-important-schools> [https://perma.cc/LA62-X9AY] (noting comparative risk studies by EPA’s Science Advisory Board) (Nov. 28, 2023). [↑](#footnote-ref-10)
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61. Allen & Macomber, *supra* note 12, at 61, 87 (recommending ventilation rate in commercial buildings of 30 cubic feet per minute per person (cfm), as compared to “bare-minimum” industry standard of 20 cfm); Allen & Macomber, *supra* note 12, at 155 (recommending 4-6 air changes per hour (ACH), above the 0.5 ACH typically found in homes and the 1.5 ACH typically found in schools). [↑](#footnote-ref-62)
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70. *See infra* Part II.C. [↑](#footnote-ref-71)
71. Rowell, *supra* note 6, at 329–30 & n.6; 40 C.F.R. § 49.123 (defining “air pollutant” as “any air pollution agent . . . that is emitted into or otherwise enters the ambient air” and “ambient air” as “that portion of the atmosphere, external to buildings, to which the general public has access”). Whether Congress intended the CAA to cover indoor air is uncertain. Kirsch & Myers, *supra* note 16, § 17A.03[2]. [↑](#footnote-ref-72)
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74. *See infra* text accompanying notes 74-85. [↑](#footnote-ref-75)
75. Radon Gas and Indoor Air Quality Research Act, Pub. L. No. 99-499, Sec. 403. As part of its COVID-19 pandemic response, EPA issued a request for information to assist in developing and implementing technical assistance to support IAQ improvements in the nation’s buildings. EPA, Request for Information: Better Indoor Air Quality Management To Help Reduce COVID-19 and Other Disease Transmission in Buildings: Technical Assistance Needs and Priorities to Improve Public Health, 87 Fed. Reg. 60396 (2022). [↑](#footnote-ref-76)
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77. *See supra* text accompanying notes 37-38. [↑](#footnote-ref-78)
78. EPA, Clean Air in Buildings Challenge (2022), *available at* <https://www.epa.gov/indoor-air-quality-iaq/clean-air-buildings-challenge> [https://perma.cc/F529-YHE6]. [↑](#footnote-ref-79)
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81. EPA, Indoor airPlus Construction Specifications Version 1 (Rev. 04) (2018); EPA, Step Up to Indoor airPLUS (2017), *available at* <https://www.epa.gov/sites/default/files/2017-08/documents/epa_indoor_airplus_builder_brochure_release_nocrops_508.pdf> [https://perma.cc/5L2U-K9VU]. The program’s IAQ-related requirements are relatively modest. For example, whole-dwelling ventilation must meet the requirements of ASHRAE 62.2, a standard discussed further below. *See infra* Part II.C.1. In addition, HVAC systems must incorporate filters with a rating of at least MERV 8, which remove most larger particles—but not the fine particulate matter that poses greater health concerns. EPA, Indoor airPLUS Technical Bulletin: Filtration (2019). [↑](#footnote-ref-82)
82. EPA, Step Up to Indoor airPLUS (2017). [↑](#footnote-ref-83)
83. EPA, Indoor airPLUS, <https://www.epa.gov/indoorairplus/if-i-buy-home-indoor-airplus-am-i-guaranteed-home-has-good-indoor-air-quality> [https://perma.cc/W8V7-3SBL]. [↑](#footnote-ref-84)
84. Email from Amelia Nguyen (EPA), Feb. 26, 2024 (on file with author). [↑](#footnote-ref-85)
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87. About OSHA, <https://www.osha.gov/aboutosha>; Randy S. Rabinowitz & Mark M. Hager, *Designing Health and Safety: Workplace Hazard Regulation in the United States and Canada*, 33 Cornell Int’l L.J. 373, 375-76 (2000). [↑](#footnote-ref-88)
88. OSHA, Indoor Air Quality in Commercial and Institutional Buildings 9 (2011). [↑](#footnote-ref-89)
89. 29 U.S.C. § 652(8); *see also* 29 U.S.C. § 655(b) (authorizing OSHA to promulgate occupational safety and health standards). [↑](#footnote-ref-90)
90. 29 U.S.C. § 655(b)(5). [↑](#footnote-ref-91)
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92. 29 U.S.C. § 654(a). [↑](#footnote-ref-93)
93. *See* OSHA, Indoor Air Quality: Frequently Asked Questions. [↑](#footnote-ref-94)
94. Memorandum from R. Davis Layne, Deputy Assistant Secretary, OSHA Policy on Indoor Air Quality: Office Temperature/Humidity and Environmental Tobacco Smoke, Feb. 24, 2003, https://www.osha.gov/laws-regs/standardinterpretations/2003-02-24. [↑](#footnote-ref-95)
95. *Id.* [↑](#footnote-ref-96)
96. OSHA, Indoor Air Quality, https://www.osha.gov/indoor-air-quality; 29 C.F.R. § 1910.94 (setting out ventilation requirements); 29 C.F.R. § 1910.1000 (setting out limits for exposure to air contaminants) [↑](#footnote-ref-97)
97. OSHA, Air Contaminants, 53 Fed. Reg. 20960, 20962 (1988). The initial PELs incorporated standards recommended by the American Council of Governmental Industrial Hygienists in 1968 and adopted by the Department of Labor for government contractors, as well as consensus standards recommended by the American National Standards Institute. 53 Fed. Reg. at 20962. [↑](#footnote-ref-98)
98. Andrew Persily, *Challenges in Developing Ventilation and Indoor Air Quality Standards: The Story of ASHRAE Standard 62*, 91 Building & Env’t 61, 66 (2015) . Public health standards are generally more protective than occupational standards because they assume continuous and involuntary exposure, focus specifically on health concerns and seek to protect sensitive populations. EPA, Report to Congress on Indoor Air Quality Volume II: Assessment and Control of Indoor Air Pollution 7–22 (1989)*;see also* Persily, *supra*, at 65 (observing, with respect to threshold limit values for industrial workplace exposure set by American Council of Governmental Industrial Hygienists, that such values “are based on protecting healthy, adult workers from health effects from exposures over eight-hour workdays” and “are not applicable to non-industrial environments, e.g., offices, schools and residences, or to the general population including children, the elderly and those with pre-existing health conditions”). [↑](#footnote-ref-99)
99. 53 Fed. Reg. at 20963. [↑](#footnote-ref-100)
100. OSHA, Permissible Exposure Limits—Annotated Tables, https://www.osha.gov/annotated-pels. [↑](#footnote-ref-101)
101. 53 Fed. Reg. at 20963–65 (referring to recommendations by the American Conference of Government Industrial Hygienists and the National Institute for Occupational Safety and Health); AFL-CIO v. OSHA, 965 F.2d 962, 969 (11th Cir. 1992). [↑](#footnote-ref-102)
102. 965 F.2d at 975–82. Since that time, OSHA has not undertaken a comprehensive update of existing PELs, most of which were adopted in 1971. Kirsch & Myers, *supra* note 16, § 17A.03[3]. [↑](#footnote-ref-103)
103. OSHA, Indoor Air Quality, 59 Fed. Reg. 15968 (1994). [↑](#footnote-ref-104)
104. *Id.* at 16026–28. [↑](#footnote-ref-105)
105. *Id.* at 16025–26; Dickson, *supra* note 72, at 20, 55. [↑](#footnote-ref-106)
106. OSHA, 59 Fed. Reg. at 16027–29. [↑](#footnote-ref-107)
107. Katherine Bryan-Jones & Lisa A. Bero, *Tobacco Industry Efforts to Defeat the Occupational Safety and Health Administration Indoor Air Quality Rule*, 93 Am. J. Pub Health 585 (2003). In announcing the withdrawal, OSHA noted that “a great many state and local governments and private employers have taken action to curtail smoking in public areas and in workplaces” and that “the portion of the proposal not related to environmental tobacco smoke (ETS) received little attention during the rulemaking proceedings.” OSHA, Indoor Air Quality, 66 Fed. Reg. 64946 (2001). [↑](#footnote-ref-108)
108. Kirsch & Myers, *supra* note 16, § 17A.03[7]; Laurence S. Kirsch, *Behind Closed Doors: Indoor Air Pollution and Government Policy*, 6 Harv. Env’t L. Rev. 339, 380-82 (1982); EPA, EPA Actions to Protect the Public from Asbestos, <https://www.epa.gov/asbestos/epa-actions-protect-public-exposure-asbestos> [<https://perma.cc/M84H-LWP2>]. The CPSC also has the authority to ban a hazardous product if cautionary labeling is inadequate to protect the public. 15 U.S.C. § 1261(q)(1). The CPSC has banned a few products under this authority. CPSC, Federal Hazardous Substances Act (FHSA) Requirements, https://www.cpsc.gov/Business--Manufacturing/Business-Education/Business-Guidance/FHSA-Requirements [<https://perma.cc/RD2D-8KCA>] (listing banned products). [↑](#footnote-ref-109)
109. Gulf South Insulation v. CPSC, 701 F.2d 1137 (5th Cir. 1983) (holding that the ban was not supported with substantial evidence). [↑](#footnote-ref-110)
110. CPSC, CPSC Approves Request for Information on Gas Stove Hazards and Potential Solutions, Mar. 1, 2023, <https://www.cpsc.gov/About-CPSC/Commissioner/Richard-Trumka/Statement/CPSC-Approves-Request-for-Information-on-Gas-Stove-Hazards-and-Potential-Solutions> [<https://perma.cc/RD2D-8KCA>]; Ariel Wittenberg, *CPSC Chair: “I Am Not Looking to Ban Gas Stoves,”* Greenwire, Jan. 11, 2023, *available at* <https://www.eenews.net/articles/cpsc-chair-i-am-not-looking-to-ban-gas-stoves/> [<https://perma.cc/22TT-PB3D>]. [↑](#footnote-ref-111)
111. Kirsch, *supra* note 107, at 377. [↑](#footnote-ref-112)
112. *Id.* at 380. [↑](#footnote-ref-113)
113. 15 U.S.C. § 2056(b)(1). [↑](#footnote-ref-114)
114. 15 U.S.C. § 2056(a). [↑](#footnote-ref-115)
115. 15 U.S.C. § 2058(f)(3)(F). [↑](#footnote-ref-116)
116. *See generally* Eileen Flaherty, *Safety First: The Consumer Product Safety Improvement Act of 2008*, 21 Loy. Consumer L. Rev. 372, 376–77 (2009) (discussing how requirements regarding voluntary standards can delay or debilitate the agency’s mandatory rulemaking efforts). [↑](#footnote-ref-117)
117. 42 U.S.C. § 264(a). [↑](#footnote-ref-118)
118. 42 C.F.R. § 70.2. [↑](#footnote-ref-119)
119. Elena Pomponio, *Alleviating Restrictions on CDC Rulemaking: Lessons from the COVID-19 Pandemic*, 8.2 Admin. L. Rev. Accord 121, 130 (2023). [↑](#footnote-ref-120)
120. Ala. Ass’n of Realtors v. HHS, 594 U.S. 758, 760, 766 (2021). [↑](#footnote-ref-121)
121. Brenda Goodman, *CDC Sets First Target for Indoor Air Ventilation to Prevent Spread of Covid-19*, CNN (May 12, 2023), <https://www.cnn.com/2023/05/12/health/cdc-new-ventilation-target> [https://perma.cc/M9WH-37AH] (reporting comments of Joseph Allen that guidance will also help to address wildfire smoke and allergens); *Improving Ventilation in Buildings*, CDC (May 11, 2023), <https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/improving-ventilation-in-buildings.html> [https://perma.cc/XH4T-BP25] (recommending five air changes per hour and upgrading air filters to a minimum efficiency reporting value of 13). [↑](#footnote-ref-122)
122. *Departments and Agencies Commit to Cleaner Indoor Air Across the Nation*, White House (Dec. 8, 2022), <https://www.whitehouse.gov/ostp/news-updates/2022/12/08/fact-sheet-departments-and-agencies-commit-to-cleaner-indoor-air-across-the-nation/> [https://perma.cc/RBE2-TEUV]. [↑](#footnote-ref-123)
123. Airborne Act, H.R. 7671, 117th Cong. § 2(a) (2022). [↑](#footnote-ref-124)
124. Model Clean Indoor Air Act 8 (Johns Hopkins Ctr. for Health Sec. 2023). The Environmental Law Institute maintains a database of state laws relating to IAQ. *See generally* Database of State Indoor Air Quality Laws, Envtl. Law Inst., Mar. 2024, <https://www.eli.org/sites/default/files/files-pdf/2024%20IAQ%20Database_1.pdf> [<https://perma.cc/8CUH-7WAV>]. For examples of state laws focused on IAQ in schools, see, e.g., Ariz. Rev. Stat.§§ 41-5831 to -5832 (2024); Cal. Educ. Code § 17661(d) (2022); Conn. Gen. Stat. §§ 10-220, -291 (2023); Del. Code Ann. tit. 14, §§ 4301–08 (2024); L.D. 705, 130th Leg., 1st Reg. Sess. (Me. 2021). [↑](#footnote-ref-125)
125. *See* *STATE System Smokefree Indoor Air Fact Sheet*, CDC, https://www.cdc.gov/statesystem/factsheets/sfia/SmokeFreeIndoorAir.html [https://perma.cc/4BYL-9BG9] (last visited Jul. 27, 2024) (noting that as of March 31, 2023, 28 states have 100% smoke-free indoor air laws for bars, restaurants, and worksites). [↑](#footnote-ref-126)
126. Kirsch & Myers, *supra* note 16, § 17A.05. [↑](#footnote-ref-127)
127. *See* N.J. Admin. Code § 12:100-13 (2007). [↑](#footnote-ref-128)
128. N.J. Admin Code. § 12:100-13.3 to 13.4 (2007). [↑](#footnote-ref-129)
129. Cal. Code Regs. tit. 8, § 5139 (1976). [↑](#footnote-ref-130)
130. Cal. Code Regs. tit. 8, § 5142 (1987). [↑](#footnote-ref-131)
131. *Id.* § 5142. [↑](#footnote-ref-132)
132. Cal. Code Regs. tit. 8 § 5141.1 (2021). In addition to these workplace standards, California has also issued general IAQ guidelines based primarily on outdoor air quality standards. Dorothy Shimer, Thomas J. Phillips & Peggy L. Jenkins, Indoor Air Pollution in California 136–37 (Cal. Air Res. Bd. 2005). [↑](#footnote-ref-133)
133. Cal. Code Regs. tit. 17, §§ 93120–93120.12 (2008). [↑](#footnote-ref-134)
134. Cal. Code Regs. tit. 17, §§ 94800–94810 (2020). [↑](#footnote-ref-135)
135. Cal. Code Regs. tit. 8, § 3205(h)(1) (2023) (valid through February 2025). [↑](#footnote-ref-136)
136. Cty. Council for Montgomery Cty. 42-01 § 3-10 (Md. 2002). [↑](#footnote-ref-137)
137. Cty. Council for Montgomery Cty. 42-01§§ 3-10, 3-11, 3-13. [↑](#footnote-ref-138)
138. *Indoor Air Quality in Rental Dwellings*,Envtl. Law Inst (Dec. 2023), <https://www.eli.org/buildings/indoor-air-quality-rental-dwellings> [https://perma.cc/RC5V-9U4L]. [↑](#footnote-ref-139)
139. Erin Ailworth, *NYC to Consider Indoor Air Quality Regulations Following Covid-19 and Summer’s Smoky Haze*, Wall St. J., July 13, 2023. [↑](#footnote-ref-140)
140. *Id.* [↑](#footnote-ref-141)
141. Model Clean Indoor Air Act, *supra* note 123, at 8. [↑](#footnote-ref-142)
142. *Id.* at 17. The statute includes public spaces but not private spaces used solely for residential purposes or industrial spaces. *Id.* at 18. [↑](#footnote-ref-143)
143. *Id.* at 26. [↑](#footnote-ref-144)
144. *Id.* at 26–28. [↑](#footnote-ref-145)
145. *Id.* at 29–32. [↑](#footnote-ref-146)
146. Xiaoyu Liu, *ASTM and ASHRAE Standards for the Assessment of Indoor Air Quality*, *in* Handbook of Air Quality 1511, 1536 (Yinping Zhang et al. eds., 2022) (noting that ASHRAE ventilation standards are “the most prominent standards to specify minimum ventilation rates for acceptable IAQ” in the U.S.); Geoffrey M. White, Joshua Nichols & Jeff York, *Green Building Rating Systems and Green Leases*, 41 Env’t L. Rep. 10049, 10050 (2011) (LEED). [↑](#footnote-ref-147)
147. WHO, Guidelines for Indoor Air Quality: Selected Pollutants (2010). [↑](#footnote-ref-148)
148. *See* NASEM, *supra* note 10, at 101-02; *see also* Peter Alspach, *ASHRAE 62.1: A Review of Key Requirements and Concepts*, Consulting-Specifying Engineer (July 15, 2013), <https://www.csemag.com/articles/ashrae-62-1-a-review-of-key-requirements-and-concepts/> [https://perma.cc/S8QE-DPDQ] (describing ASHRAE Standard 62.1 as “the most commonly referenced standard to quantify acceptable conditions and appropriate HVAC system design” in the U.S.). [↑](#footnote-ref-149)
149. ASHRAE, Position Document on Indoor Air Quality 4 (2023), <https://www.ashrae.org/File%20Library/About/Position%20Documents/pd_indoor-air-quality-2023-06-28.pdf> [<https://perma.cc/J7BT-VR7V>]. [↑](#footnote-ref-150)
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151. *Id.* at 24; *see also id.* at 6 (explaining that energy conservation measures can conflict with IAQ by reducing dilution by outdoor air and filtration of indoor air). [↑](#footnote-ref-152)
152. Persily & Emmerich, *supra* note 49, at 17; Alspach, *supra* note 147; ASHRAE, Standard 62.1-2022 2 (2022), *available at* <https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards> [<https://perma.cc/Y3FC-H8H7>]. [↑](#footnote-ref-153)
153. ASHRAE 62.1-2022, *supra* note 151, at 3; *see also* NASEM, *supra* note 10, at 101. [↑](#footnote-ref-154)
154. *See infra* Part II.C.1 & 2. [↑](#footnote-ref-155)
155. *See infra* Part II.C.3; NASEM, *supra* note 10, at 104. [↑](#footnote-ref-156)
156. NASEM, *supra* note 10, at 104. [↑](#footnote-ref-157)
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159. ASHRAE, Standard 62.2-2022 2 (2022). ASHRAE has also published standards for health care facilities and green buildings, as well as best practice guides for building design, construction, and operation. ASHRAE Position, *supra* note 148, at 4. [↑](#footnote-ref-160)
160. ASHRAE Position, *supra* note 148, at 4; Cal. Code Regs. tit. 24, § 150.0(o) (2022) (https://www.energy.ca.gov/publications/2022/2022-building-energy-efficiency-standards-residential-and-nonresidential). A study of new homes built under California’s mechanical ventilation standards found acceptable indoor air quality as long as ventilation systems were operating. W.R. Chan, Y-S Kim, B.D. Less, B.C. Singer & Iain Walker, Lawrence Berkeley National Laboratory, Ventilation and Indoor Air Quality in New California Homes with Gas Appliances and Mechanical Ventilation v (2024), <http://dx.doi.org/10.20357/B7QC7X> [https://perma.cc/U8G2-55N6]. [↑](#footnote-ref-161)
161. *See* ASHRAE 62.2-2022, *supra* note 158, at 2. ASHRAE relies on other entities such as EPA and the WHO rather than establishing its own contaminant concentration standards. Nina Prescott, Mike Henchen, Emma Hines & Brady Seals, Rocky Mountain Inst., The Need for US Indoor Air Quality Guidelines (2023), <https://rmi.org/the-need-for-us-indoor-air-quality-guidelines/> [<https://perma.cc/R3XG-J9JP>]. [↑](#footnote-ref-162)
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163. Andrew Persily, *Challenges in Developing Ventilation and Indoor Air Quality Standards: The Story of ASHRAE Standard 62*, 91 Building & Env’t 61, 62 (2015). [↑](#footnote-ref-164)
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166. ASHRAE 241-2023, *supra* note 164, at 3; ASHRAE Press Release, *supra* note 164. [↑](#footnote-ref-167)
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168. *See* Persily, *supra* note 162, at 67–68. [↑](#footnote-ref-169)
169. *Id.* at 68. [↑](#footnote-ref-170)
170. *Id.* at 67. [↑](#footnote-ref-171)
171. *See* ASHRAE, Standard 62.1-2019 26–27 (2019), <https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards> (describing the IAQ procedure); *see* Persily, *supra* note 162, at 68; Brendon J. Burley, *An Update on ANSI/ASHRAE Standard 62.1*, 64 ASHRAE J. 28, 29–30 (2022) (explaining that 2022 revisions to IAQ Procedure require a post-construction test to determine whether contaminants are controlled to design limits). [↑](#footnote-ref-172)
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173. *LEED Rating System*, U.S. Green Bldg. Council, <https://www.usgbc.org/leed> [<https://perma.cc/JQ4F-Y435>]. [↑](#footnote-ref-174)
174. *Id.*; White et al., *supra* note 145, at 10051. [↑](#footnote-ref-175)
175. *See, e.g.*, U.S. Green Bldg Council, LEED v4.1 Building Design and Construction 217, 227 (2024). [↑](#footnote-ref-176)
176. *Id.* at 217. A building project with residential units must also meet other requirements, such as prohibiting unvented combustion appliances. *Id.* at 219–20. [↑](#footnote-ref-177)
177. *Id.* at 229–45. [↑](#footnote-ref-178)
178. *See* Hannah Phillips et al., *Taking the “LEED” in Indoor Air Quality: Does Certification Result in Healthier Buildings?*, 15 J. Green Building 55, 55 (2020) (finding lower levels of particulate matter in college campus buildings with LEED certification, compared to those without). [↑](#footnote-ref-179)
179. IOM, *supra* note 16, at 222. During the COVID pandemic, the “Safety First” program offered LEED pilot credits to incentivize increased outdoor air circulation, air filtration using MERV 13 filters, and other best practices. U.S. Green Bldg. Council, COVID-19 Response Credit Guide 13–14 (2021). The WELL Building Standard, managed by the International WELL Building Institute, is a rating and certification system that focuses on buildings’ impacts on human health and well-being. *Overview*, WELL v2 (2024), <https://v2.wellcertified.com/en/wellv2/overview/> [<https://perma.cc/TF4F-DJRZ>]. [↑](#footnote-ref-180)
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181. WHO Guidelines, *supra* note 179, at 4–7. [↑](#footnote-ref-182)
182. *Id.* at 11. [↑](#footnote-ref-183)
183. *See* Lidia Morawska & Wei Huang, *WHO Health Guidelines for Indoor Air Quality and National Recommendations/Standards*, *in* Handbook of Indoor Air Quality 1494 (Y. Zhang et al., eds. 2022). [↑](#footnote-ref-184)
184. WHO Guidelines, *supra* note 179, at 11. [↑](#footnote-ref-185)
185. *Id.* at 11; Morawska & Huang, *supra* note 182, at 1494; Dimitroulopoulou et al., *supra* note 179, at 8. The relatively few countries that have adopted IAQ standards have largely adopted threshold values higher than the WHO guideline levels. Morawska & Huang, *supra* note 182, at 1503. [↑](#footnote-ref-186)
186. *See* E. Donald Elliott & Daniel C. Esty, *Environmental Law for the 21st Century*, 40 Pace Env’t L. Rev. 454, 456 (2023). [↑](#footnote-ref-187)
187. *See* Daniel A. Farber, *Unpacking* EME Homer: *Cost, Proportionality, and Emissions Reductions*, 4 Mich. J. Env’t & Admin. L. 213, 214–15 (2015). [↑](#footnote-ref-188)
188. *See* Kirsch, *supra* note 107, at 383. [↑](#footnote-ref-189)
189. *Id.* at 383–85. [↑](#footnote-ref-190)
190. Burroughs & Hansen, *supra* note 17, at 156, 158–59 (characterizing ventilation as a “poor second choice” to source control of indoor air contaminants and noting limited ability of increased ventilation to control radon and VOCs). [↑](#footnote-ref-191)
191. Allen & Macomber, *supra* note 12, at 42–43 (“the majority of your exposure to *outdoor* air pollution can occur *indoors*”). *See generally* *Low-Cost Air Pollution Monitors and Indoor Air Quality*, EPA, https://www.epa.gov/indoor-air-quality-iaq/low-cost-air-pollution-monitors-and-indoor-air-quality [<https://perma.cc/DK43-EW8J> (last updated Jan. 3, 2024) (providing examples of remedial actions a building’s occupants can take after detecting elevated levels of indoor air pollutants). [↑](#footnote-ref-192)
192. *See* Kirsch, *supra* note 107, at 385. [↑](#footnote-ref-193)
193. NASEM PM, *supra* note 18, at 107. [↑](#footnote-ref-194)
194. Holly Doremus, Albert C. Lin & Ronald H. Rosenberg, Environmental Policy Law 631–32 (6th ed. 2012) (discussing instances of outdoor air pollution that drew attention to severity of problem). [↑](#footnote-ref-195)
195. *See* NASEM PM, *supra* note 18,at 107. [↑](#footnote-ref-196)
196. OSHA, *supra* note 10, at 4; Burroughs & Hansen, *supra* note 17, at 29–36. Poor IAQ itself may cause allergies and asthma. OSHA, *supra* note 10, at 4. [↑](#footnote-ref-197)
197. Burroughs & Hansen, *supra* note 17, at 23. [↑](#footnote-ref-198)
198. *See* *id.* at 57. [↑](#footnote-ref-199)
199. *See, e.g.,* Rory Van Loo, *Regulatory Monitors: Policing Firms in the Compliance Era*, 119 Colum. L. Rev. 369, 369 (2019) (discussing gradual growth of monitoring authority in federal safety, health, and environmental agencies). [↑](#footnote-ref-200)
200. *See* Transcript from Breath of Fresh Air: Unveiling the Model Clean Indoor Air Act to Safeguard Public Health, Johns Hopkins Cent. for Health Sec. (Aug. 17, 2023), ¶ 22, https://centerforhealthsecurity.org/sites/default/files/2023-08/230817-cleanairtranscript.pdf [<https://perma.cc/E85A-QHPD>] (explaining that model state IAQ law excludes private residences and other private spaces on account of privacy concerns). [↑](#footnote-ref-201)
201. U.S. Const. amend. IV; Marshall v. Barlow’s, Inc., 436 U.S. 307, 312 (1978). [↑](#footnote-ref-202)
202. Camara v. Mun. Court, 387 U.S. 523, 530–31 (1967). [↑](#footnote-ref-203)
203. Eve Brensike Primus, *Disentangling Administrative Searches*, 111 Colum. L. Rev. 254, 256 (2011). [↑](#footnote-ref-204)
204. Milagros Ródenas Garcia et al., *Review of Low-Cost Sensors for Indoor Air Quality*, 57 Applied Spectroscopy Rev. 747, 769 (2022); Alexandre Correia, Luís Miguel Ferreria, Paulo Coimbra, Pedro Moura & Aníbal T. de Almeida, *Smart Thermostats for a Campus Microgrid: Demand Control and Improving Air Quality*, 15 Energies, Feb. 15, 2022, at 5–6. [↑](#footnote-ref-205)
205. EPA *Low-Cost*, *supra* note 190; Tim Heffernan, *The Best Home Air Quality Monitor*, N.Y. Times Wirecutter (Sept. 18, 2023), <https://www.nytimes.com/wirecutter/reviews/best-home-air-quality-monitor> [<https://perma.cc/8PUL-APYJ>; Daniel Wroclawski, *Best Indoor Air Quality Monitors of 2023*, Consumer Reports (Nov. 30, 2023), <https://www.consumerreports.org/home-garden/indoor-air-quality-monitors/best-indoor-air-quality-monitors-of-the-year-a7500139084/> [<https://perma.cc/8M6C-GMTD>]. [↑](#footnote-ref-206)
206. Ingrid Demanega et al., *Performance Assessment of Low-Cost Environmental Monitors and Single Sensors Under Variable Indoor Air Quality and Thermal Conditions*, 187 Building & Env’t, 2021, at 1, 8–9, 13. [↑](#footnote-ref-207)
207. *See* EPA Low-Cost, *supra* note 190. [↑](#footnote-ref-208)
208. *Id*.; *see also* *Air Sensor Performance Targets and Testing Protocols,* EPA, <https://www.epa.gov/air-sensor-toolbox/air-sensor-performance-targets-and-testing-protocols> [<https://perma.cc/T567-HX44>] (last updated Mar. 4, 2024) (discussing reports aimed at “provid[ing] a consistent set of testing protocols, metrics, and target values to evaluate the performance of air sensors” for non-regulatory applications). [↑](#footnote-ref-209)
209. Garcia et al., *supra* note 203, at 750, 769. [↑](#footnote-ref-210)
210. *See* Ge Song, Zhengtao Ai, Zhengxuan Liu & Guoqiang Zhang, *A Systematic Literature Review on Smart and Personalized Ventilation Using CO2 Concentration Monitoring and Control*, 8 Energy Reports 7523 (2022). [↑](#footnote-ref-211)
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212. *See* NASEM, *supra* note 10, at 126. [↑](#footnote-ref-213)
213. NASEM, *supra* note 10, at 2–4. [↑](#footnote-ref-214)
214. Lewis et al., *supra* note 13, at 223 (“Strategies that rely on householders investing in, for example installing heat pumps, air filters and ventilation systems will skew benefits towards those who can afford to pay.”). [↑](#footnote-ref-215)
215. Allen & Macomber, *supra* note 12, at 63–70, 219–26. [↑](#footnote-ref-216)
216. Lidia Morawska et al., *Mandating Indoor Air Quality for Public Buildings*, 383 Sci. 1418, 1420 (2024). [↑](#footnote-ref-217)
217. Frank P. Grad, Treatise on Environmental Law § 2.04[2] (2024) (“State air pollution control laws have generally been upheld as a proper exercise of the state’s police power”). [↑](#footnote-ref-218)
218. *Legislation for Clean Air: An Indoor Front*, 82 Yale L.J. 1040, 1051 (1973). [↑](#footnote-ref-219)
219. *See* U.S. v. Lopez, 514 U.S. 549, 558 (1995) (recognizing Congress’ authority to regulate “things in interstate commerce” under Commerce Clause). [↑](#footnote-ref-220)
220. *See* Kleppe v. New Mexico, 426 U.S. 529, 540 (1976) (“[t]he general government doubtless has a power over its own property analogous to the police power of the several states”); *Legislation for Clean Air*, *supra* note 217, at 1051–52 n.92 (suggesting power to regulate federally financed buildings under Necessary and Proper Clause). [↑](#footnote-ref-221)
221. *Id.* at 1047–48. [↑](#footnote-ref-222)
222. *See* David M. Driesen, *The Economic/Noneconomic Activity Distinction Under the Commerce Clause*, 67 Case W. Res. L. Rev. 337, 372 (2016) (discussing judicial determinations that commercial transactions constitute economic activity under *Lopez*). [↑](#footnote-ref-223)
223. *See id.* at 359 (discussing Court’s acceptance of production and consumption as economic activities under *Lopez*). [↑](#footnote-ref-224)
224. UNEP, Regulating Air Quality: The First Global Assessment of Air Pollution Legislation 56–57 (2021); *see* Gaetano Settimo, Maurizio Manigrasso, & Pasquale Avino, *Indoor Air Quality: A Focus on the European Legislation and State-of-the-Art Research in Italy*, 11 Atmosphere 370, at 4–8 (2020) (discussing IAQ initiatives in various EU member states). [↑](#footnote-ref-225)
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226. *Id.*; Morawska & Huang, *supra* note 182, at 13. [↑](#footnote-ref-227)
227. Jocelyn Moore, Francis Lavoie & Katherine Guindon-Kezis, *Health Canada’s Indoor Air Program: Risk Assessment and Research to Support Standards Development*, IAQ 2020: Indoor Environmental Quality Performance Approaches, at 1, 2 (explaining role of the Indoor Air Contaminants Assessment Section of the Air Health Program at Health Canada in issuing the guidelines). The Canada Environmental Protection Act authorizes the Minister of Health to “issue objectives, guidelines and codes of practice with respect to the elements of the environment that may affect the life and health of the people of Canada.” Canada Environmental Protection Act (S.C. 1999, c. 33) Sec. 55(1). [↑](#footnote-ref-228)
228. Moore, Lavoie, & Guindon-Kezis, *supra* note 226, at 2. [↑](#footnote-ref-229)
229. Government of Canada, Indoor Air Quality Resources for Professionals, <https://www.canada.ca/en/health-canada/services/air-quality/residential-indoor-air-quality-guidelines.html> [https://perma.cc/FJE3-S7B8]; Moore, Lavoie & Guindon-Kezis, *supra* note 226, at 2. [↑](#footnote-ref-230)
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     <https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidance-fine-particulate-matter-pm2-5-residential-indoor-air.html> [https://perma.cc/N9X4-F8TT]. [↑](#footnote-ref-231)
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232. *Id.* [↑](#footnote-ref-233)
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234. Health Canada, Indoor Air Quality Exposure Limits at Health Canada (2023), https://ww2.arb.ca.gov/sites/default/files/2023-06/Moore\_IACAS\_guidelines.pdf [https://perma.cc/U847-52H3]. [↑](#footnote-ref-235)
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238. *Id.* [↑](#footnote-ref-239)
239. Motoya Hayashi, Kenichi Kobayashi, Hoon Kim & Noriko Kaihara, *The State of the Indoor Air Environment in Buildings and Related Tasks in Japan*, 69 J. Natl. Inst. Pub. Health 63, 63–64 tbl.1 (2020). [↑](#footnote-ref-240)
240. *Id.*; Dyani Lewis, *Diseases in the Room*, 615 Nature 206, 208 (2023). The requirements apply to schools with a total floor area of at least 8000 square meters and other buildings of at least 3000 square meters. Hayashi, Kobayashi, Kim & Kaihara, *supra* note 238, at 63–64. [↑](#footnote-ref-241)
241. Hayashi, Kobayashi, Kim & Kaihara, *supra* note 238, at 64. [↑](#footnote-ref-242)
242. Lewis, *supra* note 239, at 208. [↑](#footnote-ref-243)
243. Hayashi, Kobayashi, Kim & Kaihara, *supra* note 238, at 67 fig.7. [↑](#footnote-ref-244)
244. Indoor Air Quality Control Act, 2016 (Act No. 14486) (Kr.), <https://elaw.klri.re.kr/eng_service/lawView.do?hseq=41231&lang=ENG> [https://perma.cc/LKN8-QAW5]. [↑](#footnote-ref-245)
245. IAQCA art. 3(1). [↑](#footnote-ref-246)
246. IAQCA art. 3(2), 3(3). [↑](#footnote-ref-247)
247. IAQCA arts. 2, 5; Maia Foster, Note, *Legal Strategies to Minimize Subway Air Pollution in the United States*, 72 Duke L.J. 1345, 1364 (2023); Ministry of Environment (South Korea), Indoor Air Quality Management, <https://www.airkorea.or.kr/jfile/readDownloadFile.do?fileId=165883c0cdb84&fileSeq=1&useSecurity=&uploadMode=db>. PM10 includes ultrafine particles, which have a diameter less than or equal to 0.1 micrometer; fine particles, which have a diameter less than or equal to 2.5 micrometers; and thoracic particles, which have a diameter less than or equal to 10 micrometers. Agency for Toxic Substances and Disease Registry, Guidance for Inhalation

     Exposures to Particulate Matter, at 3 (2024), <https://www.atsdr.cdc.gov/pha-guidance/resources/ATSDR-Particulate-Matter-Guidance-508.pdf> [https://perma.cc/7VDW-62NL]. [↑](#footnote-ref-248)
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249. IAQCA, arts. 11, 12. One study found lower indoor pollutant concentrations in regulated facilities. Jinho Yang, Ji-Hoon Seo, Na-Na Jeong & Jong-Ryeul Sohn, *Effects of Legal Regulation on Indoor Air Quality in Facilities for Sensitive Populations—A Field Study in Seoul Korea*, 64 Env’t Mgmt. 344, 349-51 (2019). [↑](#footnote-ref-250)
250. Dong Hwa Kang, *Addressing Indoor Air Pollution Challenges Through Concrete Public Policies in South Korea*, Field Actions Science Reports (Special Issue 21), 82, 83–84 (2020). [↑](#footnote-ref-251)
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252. Indoor Air Quality, *supra* note 250*.* [↑](#footnote-ref-253)
253. IAQMA, *supra* note 250, arts. 7–10. [↑](#footnote-ref-254)
254. Hu & Cheng, *supra* note 250, at 3–4. [↑](#footnote-ref-255)
255. IAQMA, *supra* note 250, arts. 13–15. [↑](#footnote-ref-256)
256. Hu & Cheng, *supra* note 250, at 4–5. [↑](#footnote-ref-257)
257. # Lewis, *supra* note 239, at 206; Maïthé Chini, *Bars, Cinemas, Gyms: Belgium Agrees on 'Ventilation Plan' for Public Places*, Brussels Times (Apr. 4, 2022), <https://www.brusselstimes.com/214866/bars-cinemas-gyms-belgium-agrees-on-ventilation-plan-for-public-places> [https://perma.cc/8ZCY-J4LX]; Legal Framework Regarding Indoor Air Quality, <https://www.health.belgium.be/en/closer-legal-framework-indoor-air-quality> [https://perma.cc/D8NG-RJUE].

     [↑](#footnote-ref-258)
258. World Health Network, Belgium Clean Air Law: A Law to Improve Indoor Air Quality in Enclosed Spaces Open to the Public, <https://whn.global/belgium-clean-air-law-a-law-to-improve-indoor-air-quality-in-enclosed-spaces-open-to-the-public/> [https://perma.cc/FG8A-WX5H]; Mary Hui, *How to Tackle the Global Indoor Air Crisis*, Quartz, <https://qz.com/how-to-tackle-the-global-indoor-air-crisis-1850444266> [https://perma.cc/YKZ5-F9S9]. [↑](#footnote-ref-259)
259. Chini, *supra* note 256; Legal Framework Regarding Indoor Air Quality, *supra* note 256 (noting that the “law establishes two reference levels that enable the indoor air quality to be assessed”). [↑](#footnote-ref-260)
260. Legal Framework Regarding Indoor Air Quality, *supra* note 256. [↑](#footnote-ref-261)
261. The proposal is subject to ongoing negotiations between the European Parliament and the Council of the EU. DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings (recast), Eur. Parl. Doc. (A9-0033/2023) (2023), <https://www.europarl.europa.eu/doceo/document/TA-9-2023-0068_EN.html#title2> [https://perma.cc/533M-QT4A]. The EPBD is the primary legislation regulating buildings across the EU. [↑](#footnote-ref-262)
262. *Id.* art. 11a, ¶ 1. [↑](#footnote-ref-263)
263. *Id.* art. 2, ¶ 57(g). [↑](#footnote-ref-264)
264. *Id.* art. 11, ¶ 2. [↑](#footnote-ref-265)
265. *Id.* art. 11, ¶ 4. [↑](#footnote-ref-266)
266. European Parliament Press Release, Energy Performance of Buildings Directive (Mar. 1, 2023), <https://www.europarl.europa.eu/RegData/etudes/ATAG/2023/739377/EPRS_ATA(2023)739377_EN.pdf> [https://perma.cc/KYN5-GLX6]. [↑](#footnote-ref-267)
267. *See id.* [↑](#footnote-ref-268)
268. Prescott, Henchen, Hines & Seals, *supra* note 160. [↑](#footnote-ref-269)
269. *See infra* text accompanying note 269. [↑](#footnote-ref-270)
270. 42 U.S.C. § 7403. [↑](#footnote-ref-271)
271. Prescott, Henchen, Hines & Seals, *supra* note 160. [↑](#footnote-ref-272)
272. ATSDR, What Are the Standards and Regulations for Environmental Radon Levels?, Case Studies in Environmental Medicine: Radon Toxicity 37–39 (2010), <https://www.atsdr.cdc.gov/csem/radon/standards.html> [https://perma.cc/5CLU-XUKM]; Prescott, Henchen, Hines & Seals, *supra* note 160. [↑](#footnote-ref-273)
273. 15 U.S.C. § 2663. [↑](#footnote-ref-274)
274. Prescott, Henchen, Hines & Seals, *supra* note 159; *see* Environmental Law Institute, Radon in Homes: Strengthening State Policy to Reduce Risk and Save Lives (2012). [↑](#footnote-ref-275)
275. *See* H.R. 2919, 103d Cong. § 3 (1994); S. 656, 103d Cong. (1994). [↑](#footnote-ref-276)
276. James E. Satterfield, Comment, *High Hopes and Failed Expectations: The Environmental Record of the 103d Congress*, 25 Env’t L. Rep. 10089, 10100-01 (1995); *see also* Michael T. Pyle, Comment, *Environmental Law in an Office Building: The Sick Building Syndrome*, 9 J. Env’t L. & Litig. 173, 209-12 (1994) (discussing indoor air legislative proposals from 103d Congress). Subsequent IAQ bills also relied on voluntary guidelines. *See* Foster, *supra* note 246, at 1380-83 Table 1 (2023) (noting that none of listed bills became law). [↑](#footnote-ref-277)
277. H.R. 2919 § 3; S. 656 § 3. Lawmakers indicated that the bill was not intended to confer new regulatory authority on EPA. Guiffrida, *supra* note 72, at 358. [↑](#footnote-ref-278)
278. S. 656 § 5. [↑](#footnote-ref-279)
279. Prescott, Henchen, Hines & Seals, *supra* note 160; Kirsch, *supra* note 107, at 390–91. [↑](#footnote-ref-280)
280. *See* Kirsch, *supra* note 107, at 387–88. [↑](#footnote-ref-281)
281. *See* Cary Coglianese, *Environmental Soft Law as a Governance Strategy*, 61 Jurimetrics (Special Issue) 19, 20–21 (2020). [↑](#footnote-ref-282)
282. Johns Hopkins Center for Health Security, *supra* note 123, at 7 (suggesting that comprehensive federal action on IAQ appears unlikely at this time, given the absence of federal legislation explicitly authorizing such action and the rise of judicial doctrines limiting federal agency authority); Kimberly Chen, Note, *A Cooperative Federalism Model for Building Energy Codes*, 121 Colum. L. Rev. 2119, 2146 n.171 (2021). [↑](#footnote-ref-283)
283. Kirsch, *supra* note 107, at 393; *see also* Chen, *supra* note 281, at 2130, 2146-48 (discussing race-to-bottom concerns and offering arguments for greater involvement in building energy code regulation). [↑](#footnote-ref-284)
284. Kirsch, *supra* note 107, at 388. (“[V]oluntary standards will be followed by industry only when market forces dictate that they be followed.”). [↑](#footnote-ref-285)
285. Prescott, Henchen, Hines & Seals, *supra* note 160. [↑](#footnote-ref-286)
286. Allen & Macomber, *supra* note 12, at 55–65. [↑](#footnote-ref-287)
287. *See* Johns Hopkins Center for Health Security, *supra* note 123, at 26–28; *see also supra* text accompanying notes 140–144. OSHA’s 1994 proposed IAQ regulations also contained procedural requirements for employers to develop and implement IAQ compliance plans. OSHA, 59 Fed. Reg. 16036 (proposed Apr. 5, 1994). [↑](#footnote-ref-288)
288. *Cf.* Johns Hopkins Center for Health Security, *supra* note 123, at 26–27 (model provisions regarding indoor air contaminant testing and public posting of results). [↑](#footnote-ref-289)
289. *Cf. id.* at 26-28 (model provisions regarding IAQ assessments). [↑](#footnote-ref-290)
290. *See supra* text accompanying notes 230-234 (discussing Canada’s use of reference levels). [↑](#footnote-ref-291)
291. Boston Public Schools, Indoor Air Quality (IAQ) Sensor Dashboard, <https://www.bostonpublicschools.org/Page/8810> [https://perma.cc/F35W-QD8U]. [↑](#footnote-ref-292)
292. *Id.*; Boston Public Schools, BPS Indoor Air Quality Monitoring and Response Action Plan, (2022), <https://drive.google.com/file/d/1L2V1VKdvgWnzAsu7R76E9rjwgKzLeliY/view> [https://perma.cc/7T3G-N8PD]. [↑](#footnote-ref-293)
293. Boston Public Schools, *supra* note 290. [↑](#footnote-ref-294)
294. *See* Katrina Fischer Kuh, *Informational Regulation, the Environment, and the Public*, 105 Marquette L. Rev. 603, 610–11 (2022) (explaining that information disclosure can inform individual choices and preferences, influence behavior of upstream actors, and prompt behavioral change). [↑](#footnote-ref-295)
295. *See generally id.* (discussing the National Environmental Policy Act, Toxics Release Inventory, California’s Proposition 65, and other examples of informational regulation). [↑](#footnote-ref-296)
296. *Id.* at 660. [↑](#footnote-ref-297)
297. Ken Sexton, *Indoor Air Quality: An Overview of Policy and Regulatory Issues*, 11 Sci. Tech. & Human Values 53, 59 (1986). [↑](#footnote-ref-298)
298. John Saffell & Sascha Nehr, *Improving Indoor Air Quality through Standardization*, 3 Standards 240, 257 (2023) (“[I]t is necessary to consider the specific requirements for air quality management approaches in different indoor environments.”). [↑](#footnote-ref-299)
299. *See supra* Part II.A. [↑](#footnote-ref-300)
300. Persily, *supra* note 97, at 65; ASHRAE, ANSI/ASHRAE 62.1-2013, at 28 (2013). [↑](#footnote-ref-301)
301. *See* The Johns Hopkins Center for Health Security, *supra* note 123. [↑](#footnote-ref-302)
302. *See supra* Part III.B; Foster, *supra* note 246, at 1376. [↑](#footnote-ref-303)
303. *See* EPA, Indoor Air Quality (2024), https://www.epa.gov/report-environment/indoor-air-quality [https://perma.cc/AZ72-5Q4R] (mentioning “the very young, older adults, people with cardiovascular or respiratory disease” as especially susceptible to pollution). [↑](#footnote-ref-304)
304. *Cf.* Morawska et al., *supra* note 215, at 1420 (noting potential for IAQ regulation of owners of indoor premises that already are subject to other regulation). [↑](#footnote-ref-305)
305. *Cf.* *id.* at 1418 (“Although enforcement of IAQ performance standards in homes is not possible, homes must be designed and equipped so that they could meet the standards.”). [↑](#footnote-ref-306)
306. *See* Lewis, Jenkins & Whitty, *supra* note 13, at 221. [↑](#footnote-ref-307)
307. Saffell & Nehr, *supra* note 297, at 257; Eurovent, Proposed Modifications and Guidelines for Implementation of Article 11A “Indoor Environmental Quality” in EPBD Draft 5 (2023) (“[D]irect measurement of all indoor air pollutants is impossible in practice and generally requires sampling and subsequent chemical analysis.”); Dickson, *supra* note 72, at 20, 56 (concluding that pollutant-by-pollutant approach to indoor air regulation does not make sense, given multiplicity of pollutants, lack of knowledge, and difficulty of justifying individual pollutant regulation). [↑](#footnote-ref-308)
308. Jennifer Schultz, *Carbon Monoxide Detector Installation Statutes*, National Conference of State Legislatures (Aug. 29, 2023), <https://www.ncsl.org/environment-and-natural-resources/carbon-monoxide-detector-installation-statutes> [https://perma.cc/AV8T-KMHK]. [↑](#footnote-ref-309)
309. *See supra* Part III.B. [↑](#footnote-ref-310)
310. Eurovent, *supra* note 306, at 3, 5; Saffell & Nehr, *supra* note 297, at 250 (noting that CO2 monitors are readily available at low cost). [↑](#footnote-ref-311)
311. Morawska et al., *supra* note 215, at 1419. [↑](#footnote-ref-312)
312. Persily, *supra* note 162, at 18; Morawska et al., *supra* note 215, at 1418–19 (recommending use of proxy parameters to address current infeasibility of monitoring indoor pathogens); Lewis, Jenkins & Whitty, *supra* note 13, at 221 (noting also that CO2 levels offer little or no information about levels of VOCs and other pollutants). While high CO2 concentrations have been associated with sick building syndrome, such concentrations are suspected to be an indicator of inadequate ventilation—and high levels of other pollutants—rather than the cause of reported symptoms. ASHRAE, ASHRAE Position document on Indoor Carbon Dioxide 5 (2022); Dimitroulopoulou et. al, *supra* note 179, at 3–5. Indeed, ASHRAE cautions that CO2 concentrations alone “are not a good overall metric of IAQ” because levels of many indoor air pollutants are independent of the density of people in a space. ASHRAE, *supra* note 148, at 5. [↑](#footnote-ref-313)
313. ASHRAE, *supra* note 311, at 5–7 ; CDC, Ventilation in Buildings 16 (2023), <https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html#Ventilation-FAQs> [https://perma.cc/HYZ4-9D3Z]; Morawska et al., *supra* note 215, at 1419 ( “CO2 sensors are readily available, inexpensive, and robust and can be used in all interiors”); Chini, *supra* note 256. Indoor limits or guidelines for CO2 often range from 1000 ppm to 1500 ppm. ASHRAE, *supra* note 308, at 5. [↑](#footnote-ref-314)
314. *See supra* text accompanying note 18. [↑](#footnote-ref-315)
315. *Cf.* Saffell & Nehr, *supra* note 297, at 257 (suggesting prioritization of “ubiquitous air pollutants,” and then “highly hazardous substances” in addressing indoor air pollution). [↑](#footnote-ref-316)
316. California established standards limiting formaldehyde emissions from composite wood products in 2010, and, pursuant to federal legislation enacted in 2008, EPA followed suit in 2016. Formaldehyde Emission Standards for Composite Wood Products, 81 Fed. Reg. 89674, 89678 (Dec. 12, 2016). [↑](#footnote-ref-317)
317. For example, thousands of chemicals used in plastics production are unregulated even though they are hazardous to human health or the environment. *See* Sandee LaMotte, *Toxic Plastic Chemicals Number in the Thousands, Most Are Unregulated, Report Finds*, CNN, Mar. 14, 2024, https://www.cnn.com/2024/03/14/health/toxic-unregulated-chemicals-report-wellness/index.html [https://perma.cc/32MP-EZXY] (reporting on PlastChem report, available at https://plastchem-project.org/). [↑](#footnote-ref-318)
318. *See* Kirsch, *supra* note 107, at 388–89. [↑](#footnote-ref-319)
319. Holly Doremus, Albert Lin & Ronald Rosenberg, Environmental Policy Law 32–34 (6th ed. 2012). [↑](#footnote-ref-320)
320. *See id.*, at 632–33, 661. [↑](#footnote-ref-321)
321. *See supra* Parts II.C.3, III.B.1; ASHRAE, ANSI/ASHRAE Addendum aa to ANSI/ASHRAE Standard 62.1-2019, at 3 Table 6-5 (2021), <https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/62_1_2019_aa_20220121.pdf> [https://perma.cc/A7EN-KN2M]. [↑](#footnote-ref-322)
322. NASEM, *supra* note 10, at 36, 156–57; IOM, *supra* note 16, at 25; Foster, *supra* note 246, at 1374; Kirsch, *supra* note 107, at 389–90; Persily & Emmerich, *supra* note 49, at 3. Over three decades ago, EPA bemoaned the difficulty of setting standards for “hundreds of indoor air pollutants” for which “little information is available,” EPA, *supra* note 97, at 10-2, a characterization that largely rings true today. [↑](#footnote-ref-323)
323. Doremus et al., *supra* note 318, at 632-35 (offering overview of Clean Air Act). [↑](#footnote-ref-324)
324. *See* Utility Air Regulatory Group v. Environmental Protection Agency, 573 U.S. 302, 322 (2014) (explaining that Prevention of Significant Deterioration and Title V permitting requirements of Clean Air Act focus on “a relative handful of large sources capable of shouldering heavy substantive and procedural burdens,” and not millions of small pollution sources nationwide); *see also* Jody Freeman, *The Obama Administration’s National Auto Policy: Lessons from the “Car Deal*,” 35 Harv. Env’t L. Rev. 343, 346-63 (2011) (discussing regulation of vehicle emissions through regulation of auto manufacturers). [↑](#footnote-ref-325)
325. Sexton, *supra* note 296, at60 (reasoning that setting indoor ambient air quality standards “would be impractical because of the prohibitive monitoring costs and the difficulty of enforcement” in tens of millions of residences). [↑](#footnote-ref-326)
326. NASEM, *supra* note 10, at 156. [↑](#footnote-ref-327)
327. Robert M. Friedman, Donna Downing & Elizabeth M. Gunn, *Environmental Policy Instrument Choice: The Challenge of Competing Goals*, 10 Duke Env’t L. & Pol’y F. 327, 338–39 (2000); *see* Kirsch, *supra* note 107, at 389 (explaining that building codes “are administrable” and “do not involve restrictions on personal behavior”). [↑](#footnote-ref-328)
328. *See* Morawska et al., *supra* note 215, at 1419 (explaining importance of ventilation as an indoor air pollution control strategy); *see* EPA, *supra* note 97, at 10-3, 10-4. [↑](#footnote-ref-329)
329. Tufecki, *supra* note 41. [↑](#footnote-ref-330)
330. *See supra* Parts II.B, IV.C.2. [↑](#footnote-ref-331)
331. Kirsch, *supra* note 107, at 388 (noting that “many indoor air pollution problems are at most only partially attributable to products”). [↑](#footnote-ref-332)
332. NASEM, *supra* note 10, at 36. [↑](#footnote-ref-333)
333. *See* Tufecki, *supra* note 41. [↑](#footnote-ref-334)
334. *See* Erica Werner, *How to Make Your Home More Energy Efficient—and Get a Tax Break Too*, Wash. Post, Jan. 26, 2023. [↑](#footnote-ref-335)