Notes

LEGAL STRATEGIES TO MINIMIZE SUBWAY AIR POLLUTION IN THE UNITED STATES

MAIA FOSTER†

ABSTRACT

Air pollution in U.S. subway systems poses a major threat to public health. People in subway stations breathe in dangerously high levels of dusts, called particulate matter. Current legislation does not effectively address this problem; in fact, the United States does not have a comprehensive indoor air quality law at all. Left unregulated, people regularly exposed to subway air pollution could suffer respiratory and cardiovascular issues and even premature death.

To mitigate these health effects, some countries have imposed PM standards in subway systems and underground spaces. Others have standards covering all indoor spaces. In the United States, many subway systems have begun exploring technologies to filter subway air in the wake of the coronavirus pandemic. To support their efforts and innovation, the United States should enact legislation establishing a grant and loan program for subway systems' air-purifying initiatives. Modeled after the successful Diesel Emissions Reduction Act, this law would adopt a carrot-based approach to effectively reduce subway air pollution, allowing each system to tailor initiatives to their unique characteristics. While the United States should explore a mandatory standards-based approach long term, it should prioritize this legislation to protect the public more quickly from this ongoing threat.

† Duke University School of Law, J.D. expected 2023; University of Virginia, B.A. 2017. *Duke Law Journal* editors spent many hours editing this Note, and I thank them, particularly Mia Kim, Leila Ouchchy, Grey Howard, Sydney Engle, and Jameris Ocasio-Palacios. Thanks also to Professor Rebecca Rich for igniting my interest in legal writing and Professor Jonas Monast for his guidance and insights on this topic. Finally, thank you to my family for their loving and unwavering support.

INTRODUCTION

In February 2021, headlines announced a new public health threat, proclaiming "People should be alarmed,"[1] "Scientists shocked,"[2] and "Study finds subway air is heavily contaminated."[3] Despite dropping mid-pandemic, these headlines had nothing to do with COVID-19. Instead, they highlighted a new airborne danger: high levels of pollution in U.S. subway systems. One headline lamented, "[S]ubway riders should've been wearing masks all along."[4]

These stories broadcast a New York University ("NYU") study finding high levels of fine dusts, known as particulate matter ("PM"),[5] in the air of U.S. subway systems. Surveying over seventy stations across the Northeast, researchers found levels of fine particulate matter ("$PM_{2.5}$")[6] as high as fifty times the U.S. Environmental Protection Agency's ("EPA") recommended exposure level for outdoor air.[7] Lead author David Luglio highlighted the serious health

1. Oliver Milman, *'People Should Be Alarmed': Air Pollution in US Subway Systems Stuns Researchers*, GUARDIAN (Feb. 10, 2021, 3:00 AM), https://www.theguardian.com/environment/2021/feb/10/subway-air-pollution-new-york-washington-dc [https://perma.cc/U74P-DXY9].

2. Alexandra Kelley, *Scientists Shocked by Unsafe Levels of Air Pollution in US Subway Systems*, HILL: CHANGING AM. (Feb. 11, 2021), https://thehill.com/changing-america/well-being/medical-advances/538432-scientists-shocked-by-unsafe-levels-of-air [https://perma.cc/L8UG-JD6H].

3. Justin George, *Study Finds Subway Air Is Heavily Contaminated with Hazardous Pollutants*, WASH. POST (Feb. 12, 2021, 5:11 PM), https://www.washingtonpost.com/local/trafficandcommuting/subway-air-contamination/2021/02/12/68ab3c72-6d3d-11eb-9ead-673168d5b874_story.html [https://perma.cc/74QE-8JLX].

4. Sean Szymkowski, *Apparently, Subway Riders Should've Been Wearing Masks All Along*, CNET (Feb. 17, 2021, 2:41 PM), https://www.cnet.com/roadshow/news/subway-riders-masks-air-pollution [https://perma.cc/C9A5-Z5YA].

5. The U.S. Environmental Protection Agency ("EPA") describes particulate matter as "a mixture of solid particles and liquid droplets found in the air" that range from microscopic to visible to the naked eye. *Particulate Matter (PM) Basics*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/pm-pollution/particulate-matter-pm-basics [https://perma.cc/G6ES-SKT3], (last updated July 18, 2022).

6. The EPA distinguishes PM types based on particle size. *Id.* While PM_{10} is made up of inhalable particles measuring 10 micrometers in diameter and below, fine particulate matter, or $PM_{2.5}$, consists of those particles 2.5 micrometers in diameter and smaller. *Id.* As $PM_{2.5}$ is small enough to penetrate the lungs and enter the bloodstream, it "pose[s] the greatest risk to health." *Id.*; *see infra* Part I.B.

7. *See* David G. Luglio, Maria Katsigeorgis, Jade Hess, Rebecca Kim, John Adragna, Amna Raja, Colin Gordon, Jonathan Fine, George Thurston, Terry Gordon & M.J. Ruzmyn Vilcassim, *$PM_{2.5}$ Concentration and Composition in Subway Systems in the Northeastern United States*, ENV'T HEALTH PERSPS., Feb. 2021, at 027001-1, 027001-8 (dividing the one-hour maximum $PM_{2.5}$

risks of exposure to the millions of people commuting and working in subway systems in the United States.[8] The researchers concluded with an urgent call for further research and mitigation efforts.[9]

Air pollution in subways is not a new phenomenon. The first underground railway system in the world, London's Tube, originally ran coal-fired trains that released sulfurous fumes throughout the system.[10] Despite using "blowholes" to expel fumes, soot and smoke contaminated the air inside the Tube shafts.[11] Although the Tube switched to electric trains when building its deeper lines at the end of the nineteenth century, mistaken understandings of airflow and lack of ventilation kept the system polluted.[12] Today, the deeper lines generate the highest concentrations of PM in the entire system.[13] And, decades later, researchers have found similar pollution patterns across the Atlantic.[14]

In the United States, underground PM exposure poses a major environmental justice issue, disproportionately affecting Black and Latino Americans as well as the poor. A majority of rail riders are people of color,[15] and Black Americans are overrepresented in rail ridership (19 percent)[16] compared to the general population (12.7

concentration of 1,780 μg/m^3 at Christopher Street Station, a subway station in New York City, by the EPA's twenty-four-hour ambient standard of 35 μg/m^3).

8. George, *supra* note 3.

9. *See* Luglio et al., *supra* note 7 (noting the need for further investigation on the topic and mitigation initiatives "to protect the tens of thousands of subway workers and millions of daily commuters from potentially unwarranted health risks").

10. Camilla Hodgson, Leslie Hook & Steven Bernard, *London Underground: The Dirtiest Place in the City*, FIN. TIMES (Nov. 5, 2019), https://www.ft.com/content/6f381ad4-fef7-11e9-be59-e49b2a136b8d [https://perma.cc/VW3Y-LJEY]; Debabani Majumdar, *'Sulphurous' Fumes and Class Division on Victorian Tube*, BBC (Jan. 10, 2013), https://www.bbc.com/news/uk-england-london-20901856 [https://perma.cc/MRD7-WV2R].

11. *Id.*

12. *Id.*

13. *Id.*

14. *See* Kate Baggaley, *Air Pollution in US Subway Stations Is Disturbingly High*, POPULAR SCI. (Feb. 11, 2021, 11:00 AM), https://www.popsci.com/story/health/subway-public-transit-cities-pollution-health [https://perma.cc/NE6D-2HJQ] ("[Subway] platforms deep within the bowels of large stations had higher amounts of airborne particles than platforms nearer to the surface.").

15. HUGH M. CLARK, AM. PUB. TRANSP. ASS'N, WHO RIDES PUBLIC TRANSPORTATION 22 (2017), https://www.apta.com/wp-content/uploads/Resources/resources/reportsandpublications/Documents/APTA-Who-Rides-Public-Transportation-2017.pdf [https://perma.cc/47ZR-ME5D].

16. *Id.*

percent).[17] In New York City, 63 percent of riders who use both the city subway and bus identify as races other than white; in addition, 53 percent of riders who exclusively use the subway identify as nonwhite.[18] Furthermore, in urban areas, minorities are more likely to *regularly* use public transportation, as "34% of blacks and 27% of Hispanics report taking public transit daily or weekly, compared with only 14% of whites."[19] Moreover, of all public transit commuters, Black Americans have the longest average commute time, and Asian, Latino, Native American, and mixed-race individuals all have longer average commute times than white Americans.[20]

Additionally, transit employees, who are regularly exposed to underground PM pollution during the workday, are also likely to be minorities. In fact, 26.4 percent of "[s]ubway, streetcar, & other rail transportation workers" are Black,[21] almost double the representation of Black Americans in the total U.S. population.[22] In certain subway systems, this percentage can be much higher. For example, 80 percent of the New York City Transit workforce—who oversee all city bus and subway services—are minorities, and 46 percent are Black.[23] Additionally, the Washington Metropolitan Area Transit Authority ("WMATA") serving D.C. has said that 75 percent of its employees and contractors and a stark 96 percent of its bus and rail operators are

17. *DPO5: ACS Demographic and Housing Estimates: 2017: ACS 1-Year Estimates Data Profiles*, U.S. CENSUS BUREAU (2017), https://data.census.gov/table?q=percentage+of+black+people+in+the+U.S.+in+2017&tid=ACSDP1Y2017.DP05 [https://perma.cc/L2U4-4RQK].

18. *See* RSG, INC., NEW YORK CITY TRAVEL SURVEY 88 (2020), https://new.mta.info/document/28971 [https://perma.cc/ZWF5-FWEN] (subtracting the percentage of white subway and bus users and subway-alone users from 100 percent to determine the percentages for nonwhite passengers).

19. Monica Anderson, *Who Relies on Public Transit in the U.S.*, PEW RSCH. CTR. (Apr. 7, 2016), https://www.pewresearch.org/fact-tank/2016/04/07/who-relies-on-public-transit-in-the-u-s [https://perma.cc/4Q7D-PCMY].

20. *Commute Time: All Workers Should Have Reasonable Commutes.*, NAT'L EQUITY ATLAS (2019), https://nationalequityatlas.org/indicators/Commute_time#/?tranmode01=2 [https://perma.cc/4ASD-KAA9].

21. *Subway, Streetcar, & Other Rail Transportation Workers*, DATA USA, https://datausa.io/profile/soc/subway-streetcar-other-rail-transportation-workers#employment [https://perma.cc/3DH7-ZZ2M].

22. *See QuickFacts: United States*, U.S. CENSUS BUREAU, https://www.census.gov/quickfacts/fact/table/US [https://perma.cc/95QS-6EHS], (last updated July 1, 2021) (finding that the current percentage of Black Americans in the U.S. population is 13.6 percent).

23. METRO. TRANSP. AUTH., DIVERSITY COMMITTEE MEETING: SEPTEMBER 2021, at 35 (2021), https://new.mta.info/document/52706 [https://perma.cc/SL7A-ZP43].

Black.[24] In April 2020, John Samuelsen, international president of the Transport Workers Union, observed:

> Anecdotally, almost every transit worker develops lung conditions, lung problems, and anecdotally, so many transit workers I began on the job with died of lung related problems . . . . They breathe in steel dust, they breathe in manganese from the welding, they breathe in creosote, they breathe in all of the the [sic] disgusting stuff in the subway.[25]

Over time, subway workers are particularly vulnerable to the long-term consequences of PM exposure.[26]

Lastly, subway platforms and stations often provide a regular place of refuge for people without housing in urban areas, who are also predominantly poor and Black. The 2020 New York City Mayor's Management Report found that

> [p]eople of color, particularly African-Americans, are over-represented among those who are experiencing homelessness, both in New York City and throughout the country. Poverty is a strong predictor of homelessness; and Black families and individuals are more likely to experience poverty, especially deep poverty, than their White counterparts. Higher incarceration rates, especially for Black men, are also linked to increased risk of homelessness.[27]

Additionally, many people without housing shelter in subway stations overnight. This became clear in New York City in February 2021, when a new policy of disinfecting stations from 1:00 to 5:00 a.m. every day led to the eviction, sometimes forcible, of the many people who had regularly stayed in those stations.[28] In the Washington, D.C., area, the

---

24. Faiz Siddiqui, *Three Pools of Black Workers and Job Applicants Granted Class Status in Discrimination Suit Against Metro*, WASH. POST (Apr. 26, 2017, 6:00 AM), https://www.washingtonpost.com/news/dr-gridlock/wp/2017/04/26/three-pools-of-black-workers-and-job-applicants-granted-class-status-in-discrimination-suit-against-metro [https://perma.cc/V2A6-9T2M].

25. Dana Rubinstein, *Subway and Bus Workers Are Bearing a Disproportionate Coronavirus Death Toll*, POLITICO (Apr. 7, 2020, 6:34 PM), https://www.politico.com/states/new-york/albany/story/2020/04/07/subway-and-bus-workers-are-bearing-a-disproportionate-coronavirus-death-toll-1273457 [https://perma.cc/TD6H-Z49P].

26. George, *supra* note 3.

27. BILL DE BLASIO, DEAN FULEIHAN & JEFF THAMKITTIKASEM, CITY OF N.Y., MAYOR'S MANAGEMENT REPORT 197 (2020), https://www1.nyc.gov/assets/operations/downloads/pdf/mmr2020/2020_mmr.pdf [https://perma.cc/7D59-CPR5].

28. Christina Goldbaum, *The Subway Was Their Refuge on Cold Nights. Now It's Off-Limits.*, N.Y. TIMES (Feb. 8, 2021), https://www.nytimes.com/2021/02/08/nyregion/nyc-subway-homeless.html [https://perma.cc/SEJ5-ZV6U].

2022 Annual Point-in-Time Count of Persons Experiencing Homelessness designated metro stations as "hot spot" locations for people without housing.[29] People who shelter in stations overnight spend much more time there than the typical commuter and likely more than the daily worker.

Despite these impacts, the United States and most other countries do not have laws that effectively regulate subway air pollution. In fact, only 7 percent of countries have indoor air quality ("IAQ") standards at all.[30] While uncertainties exist as to the chemical composition and sources of PM in subways, the precautionary principle[31] calls for regulation.[32] Additionally, as the United States is currently experiencing heightened awareness of IAQ issues due to the COVID-19 pandemic, there may be no better time to act than now.

Motivated by the public health and environmental justice implications of subway air pollution, this Note outlines the state of subway and indoor air quality policies in the United States and around the world, emphasizing a broad need for stricter regulation. The Note proceeds in four parts. Part I provides a brief scientific primer on PM pollution in subways. Part II surveys how the United States regulates indoor air at the federal and state level. Part III gives an overview of international statutory and voluntary IAQ policies. Part IV addresses broad and narrow policy options for mitigating subway air pollution—namely, regulating indoor air pollution under existing federal laws, enacting standalone legislation modeled off international approaches, and creating a funding program. It concludes by recommending as a short-term solution that Congress create voluntary IAQ guidelines and

29. METRO. WASH. COUNCIL OF GOV'TS, HOMELESSNESS IN METROPOLITAN WASHINGTON: RESULTS AND ANALYSIS FROM THE ANNUAL POINT-IN-TIME (PIT) COUNT OF PERSONS EXPERIENCING HOMELESSNESS app. B at 67 (2022).

30. UNITED NATIONS ENV'T PROGRAMME, REGULATING AIR QUALITY: THE FIRST GLOBAL ASSESSMENT OF AIR POLLUTION LEGISLATION 56 fig.21 (2021).

31. The precautionary principle is the proposition that "in cases of serious or irreversible threats to the health of humans or ecosystems, acknowledged scientific uncertainty should not be used as a reason to postpone preventive measures." WORLD HEALTH ORG. EUR., THE PRECAUTIONARY PRINCIPLE: PROTECTING PUBLIC HEALTH, THE ENVIRONMENT AND THE FUTURE OF OUR CHILDREN 7 (Marco Martuzzi & Joel A. Tickner eds., 2004), https://www.euro.who.int/__data/assets/pdf_file/0003/91173/E83079.pdf [https://perma.cc/FA5U-VN3E].

32. Luglio et al., *supra* note 7; *see* David Kriebel, Joel Tickner, Paul Epstein, John Lemons, Richard Levins, Edward L. Loechler, Margaret Quinn, Ruthann Rudel, Ted Schettler & Michael Stoto, *The Precautionary Principle in Environmental Science*, 109 ENV'T HEALTH PERSPS. 871, 871 (2001) (including as one of the precautionary principle's four central components "taking preventive action in the face of uncertainty").

subsidize municipalities to reduce pollution in their local subway systems.

I. SCIENTIFIC BACKGROUND

As nearly enclosed, industrial spaces, underground subway stations tend to trap and circulate dust and other small particles. This Part will first examine the mechanisms by which subways become polluted and discuss current PM levels in subways. Next, it will consider the health effects of PM at those levels, particularly among vulnerable populations like children, the elderly, and people with underlying medical conditions. This risk can and should be mitigated.

A. Air Pollution Levels in American Subways

Several factors contribute to the PM level in subways, including the use of fossil fuels,[33] brake and wheel type,[34] and the particular characteristics of each station, including age, the presence or absence of platform screen doors, and depth,[35] with deeper platforms posing a greater hazard.[36] System-wide implementation of ventilation technologies and the frequency of trains can similarly impact PM levels.[37] This issue requires more research to ascertain the impacts of each factor contributing to PM levels in subways, including sources outside of stations.[38] However, the variety of factors demonstrates the possibility for policy intervention at many points, based on the specific characteristics of each subway system and station.

---

33. Li Cohen, *Millions of U.S. Subway Riders and Workers at Risk for Severe Side Effects from Air Pollution, Study Warns*, CBS NEWS (Feb. 10, 2021, 11:50 PM), https://www.cbsnews.com/news/millions-of-subway-commuters-and-workers-in-northeast-u-s-are-facing-potentially-fatal-side-effects-from-air-pollution [https://perma.cc/LZ5F-4TBP].

34. *See* Teresa Moreno & Fulvio Amato, *Commuting by Subway? What You Need To Know About Air Quality*, VEOLIA INST. REV.: FACTS REPS. (SPECIAL ISSUE) 24, 26 (2020) ("Key factors influencing subway air pollution include types of brakes . . . and wheels . . . .").

35. *See id.* ("[S]tation depth, date of construction, . . . and . . . the presence or absence of platform screen-door systems" are also "[k]ey factors influencing subway air pollution.").

36. *See* Hodgson et al., *supra* note 10 (concluding that "[d]eep tunnels on the Tube expose commuters to the most pollution").

37. *See* Moreno & Amato, *supra* note 34 ("Key factors influencing subway air pollution include . . . type of ventilation . . . [and] train frequency . . . .").

38. *See* Luglio et al., *supra* note 7 ("[T]hese findings of poor air quality in subway systems should prompt further investigation as to the levels, sources, composition, and human health effects of the $PM_{2.5}$ pollution in subway systems.").

In early 2021, NYU researchers made headlines after surveying subway air pollution in the northeastern United States.[39] Over a few months, the scientists monitored PM levels in seventy-one subway stations in Boston, New York City, Philadelphia, and Washington, D.C.[40] They found that rush hour $PM_{2.5}$ concentrations were "2 to 7 times the U.S. EPA's 24-h[our] ambient air standard."[41] In fact, one station far exceeded the standard; Christopher Street Station, part of New York City's PATH train system, had the highest real-time concentration of $PM_{2.5}$ at a staggering 1,780 $\mu g/m^3$, fifty times the EPA's daily ambient standard.[42] High PM levels in a virtually enclosed space indicate a need for action.[43]

B. Health Effects of PM Pollution

PM, and especially $PM_{2.5}$, poses serious health risks to exposed persons.[44] Coarser PM_{10} can cause eye, nose, and throat irritation.[45] Smaller $PM_{2.5}$ particles harm the body by passing through the lung barrier and entering the bloodstream,[46] which can ultimately lead to

39. *See, e.g.*, Milman, *supra* note 1 ("'New Yorkers in particular should be concerned about the toxins they are inhaling,' said the study co-author Terry Gordon . . . with the research finding that concentrations of hazardous metals and organic particles were anywhere from two to seven times higher than outdoor air samples in the city."); Kelley, *supra* note 2 ("Gordon . . . told CBS that his team was 'surprised' at the high levels of pollution in subway systems across Northeastern cities."); George, *supra* note 3 ("A study found that subway air is heavily polluted . . . ."); Szymkowski, *supra* note 4 ("The air pollution in subway stations is terrible, according to a new study from New York University[] . . . .").

40. Luglio et al., *supra* note 7, at 027001-1, 027001-3.

41. *Id.* at 027001-8. The EPA's standard, established via the National Ambient Air Quality Standards provision of the Clean Air Act, is set at a level "requisite to protect the public health" with "an adequate margin of safety." Clean Air Act § 109(b)(1), 42 U.S.C. § 7409(b)(1). The current ambient air standard for $PM_{2.5}$ is 35 $\mu g/m^3$. Luglio et al., *supra* note 7.

42. Luglio et al., *supra* note 7, at 027001-3, 027001-8 (dividing Christopher Street Station's gravimetric maximum $PM_{2.5}$ concentration by the EPA's twenty-four-hour ambient standard of 35 $\mu g/m^3$).

43. *See id.* at 027001-8 (advocating near-term mitigation efforts to minimize subway air pollution).

44. For the distinction between $PM_{2.5}$ and larger PM_{10} particles, see *supra* note 6 and accompanying text.

45. *How Does PM Affect Human Health?*, U.S. ENV'T PROT. AGENCY, https://www3.epa.gov/region1/airquality/pm-human-health.html [https://perma.cc/A5GD-WNT4], (last updated Mar. 28, 2022).

46. *Ambient (Outdoor) Air Pollution*, WORLD HEALTH ORG. (Sept. 22, 2021), https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health [https://perma.cc/M6R9-2LBG].

myriad cardiovascular and respiratory problems[47] and even premature death.[48] Repeated exposure to PM increases the risk of developing lung cancer.[49] Effects are particularly damaging for children, the elderly, and people with preexisting heart and lung conditions.[50] And in relation to subway air pollution, at the levels measured in the NYU study, researchers found that daily commuters could face an estimated 11 percent increase in their risk of death by cardiovascular disease.[51]

Although the EPA has not set IAQ standards for PM,[52] it has set standards for ambient $PM_{2.5}$ at daily average levels above 35 $\mu g/m^3$ to

47. *How Does PM Affect Human Health?*, *supra* note 45 ("Health effects may include cardiovascular effects such as cardiac arrhythmias and heart attacks, and respiratory effects such as asthma attacks and bronchitis."); *see Health and Environmental Effects of Particulate Matter (PM)*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm [https://perma.cc/LMT3-KDHM], (last updated Aug. 30, 2022) (linking PM exposure to "nonfatal heart attacks[,] irregular heartbeat[,] aggravated asthma[,] decreased lung function[, and] increased respiratory symptoms").

48. *How Does PM Affect Human Health?*, *supra* note 45. Many studies have linked PM exposure to premature death. The National Academy of Sciences estimated that "anthropogenic $PM_{2.5}$ was responsible for 107,000 premature deaths in 2011, at a cost to society of $886 billion." Andrew L. Goodkind, Christopher W. Tessum, Jay S. Coggins & Julian D. Marshall, *Fine-Scale Damage Estimates of Particulate Matter Air Pollution Reveal Opportunities for Location-Specific Mitigation of Emissions*, 116 PNAS 8775, 8775 (2019). The National Bureau of Economic Research and Carnegie Mellon University found that a 5 percent increase in $PM_{2.5}$ levels between 2016 and 2018 led to almost ten thousand more premature deaths in adults over the age of thirty. Karen Clay & Nicholas Z. Muller, *Recent Increases in Air Pollution: Evidence and Implications for Mortality* 8, 24 tbl.5 (Nat'l Bureau of Econ. Rsch., Working Paper No. 26381, 2019), https://www.nber.org/papers/w26381 [https://perma.cc/KV2M-DMQJ]. Other studies have found "strong evidence of the causal link between long-term $PM_{2.5}$ exposure and mortality." X. Wu, D. Braun, J. Schwartz, M.A. Kioumourtzoglou & F. Dominici, *Evaluating the Impact of Long-Term Exposure to Fine Particulate Matter on Mortality Among the Elderly*, SCI. ADVANCES, July 17, 2020, at 1, 1. Researchers have estimated that the United States could save over 140,000 lives in a decade if it lowered its annual ambient $PM_{2.5}$ standard from 12 $\mu g/m^3$ to 10 $\mu g/m^3$. *Id.* at 1, 2. In 2021, the National Institute of Health found that "253 premature deaths per million population are associated with exposure to ambient $PM_{2.5}$." Nilakshi T. Waidyatillake, Patricia T. Campbell, Don Vicendese, Shyamali C. Dharmage, Ariadna Curto & Mark Stevenson, *Particulate Matter and Premature Mortality: A Bayesian Meta-Analysis*, 18 INT'L J. ENV'T RSCH. & PUB. HEALTH, July 19, 2021, at 1, 15.

49. *See Ambient (Outdoor) Air Pollution*, *supra* note 46 ("Chronic exposure to particles contributes to the risk of . . . lung cancer.").

50. *Health and Environmental Effects of Particulate Matter (PM)*, *supra* note 47.

51. Luglio et al., *supra* note 7 (assuming commuters are exposed to the level of pollution in Christopher Street Station for fifteen minutes on the platform and forty minutes in a subway car each day and using "an association of a 6% increase in relative risk for each 10$\mu g/m^3$ increase in long-term (e.g., annual average) $PM_{2.5}$").

52. *See Regulatory and Guidance Information by Topic: Air*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/regulatory-information-topic/regulatory-and-guidance-information-topic-

avoid serious health risks.[53] The World Health Organization's ("WHO") Air Quality Guidelines are even more stringent, recommending exposure levels of no more than 15 μg/m^3 using a twenty-four-hour average.[54] Importantly, the WHO has found health impacts from $PM_{2.5}$ even at very low concentrations; in fact, "*no threshold* has been identified below which no damage to health is observed."[55]

Additionally, subway PM differs in composition from ambient PM, which could have implications for the nature and severity of its health effects. Ambient PM generally consists of "sulfate, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water."[56] Subway PM, on the other hand, is thought to be much heavier in metals,[57] which researchers posit may make it more harmful to human health.[58] Despite this uncertainty, researchers still "call for mitigation efforts, such as improved ventilation to protect the tens of thousands of subway workers and millions of daily commuters from potentially unwarranted health risks."[59]

---

air [https://perma.cc/H4KF-N8A6], (last updated June 21, 2022) ("EPA does not regulate indoor air.").

53. *See* 40 C.F.R. § 50.18(a) (2022) ("The national primary ambient air quality standard[] for $PM_{2.5}$ [is] . . . 35 μg/m^3 24-hour average concentration . . . ."); Review of the National Ambient Air Quality Standards for Particulate Matter, 85 Fed. Reg. 82684, 82685 (Dec. 18, 2020) (indicating that primary National Ambient Air Quality Standards are health-based).

54. WORLD HEALTH ORG., WHO GLOBAL AIR QUALITY GUIDELINES: PARTICULATE MATTER ($PM_{2.5}$ AND PM_{10}), OZONE, NITROGEN DIOXIDE, SULFUR DIOXIDE AND CARBON MONOXIDE 88 (2021) [hereinafter WHO GLOBAL AIR QUALITY GUIDELINES]; *see* WORLD HEALTH ORG. EUR., WHO GUIDELINES FOR INDOOR AIR QUALITY: SELECTED POLLUTANTS 2 (2010) [hereinafter WHO INDOOR AIR QUALITY GUIDELINES] (noting that the WHO "has stressed since the publication of the first edition of the [air quality] guidelines . . . that they should be applicable to both indoor and outdoor air").

55. *Ambient (Outdoor) Air Pollution*, *supra* note 46 (emphasis added).

56. *Id.*

57. David S. Grass, James M. Ross, Farnosh Family, Jonathan Barbour, H. James Simpson, Drissa Coulibaly, Jennifer Hernandez, Yingdi Chen, Vesna Slavkovich, Yongliang Li, Joseph Graziano, Regina M. Santella, Paul Brandt-Rauf & Steven N. Chillrud, *Airborne Particulate Metals in the New York City Subway: A Pilot Study To Assess the Potential for Health Impacts*, 110 ENV'T RSCH. 1, 1 (2010).

58. *See, e.g.*, Haseeb Tufail Moryani, Shuqiong Kong, Jiangkun Du & Jianguo Bao, *Health Risk Assessment of Heavy Metals Accumulated on $PM_{2.5}$ Fractioned Road Dust from Two Cities of Pakistan*, INT'L J. ENV'T RSCH. & PUB. HEALTH, Oct. 2020, at 1, 2 ("Recent research has demonstrated that heavy metals in $PM_{2.5}$, including (Pb, Cu, Ni, and Fe) collected from heavy traffic areas are capable of causing of [sic] several respiratory and cardiovascular diseases. Hence, even containing a slight portion of metals in $PM_{2.5}$ can be injurious for human health.").

59. Luglio et al., *supra* note 7.

II. U.S. LEGAL BACKGROUND

The United States does not have a comprehensive federal IAQ law.[60] The country's landmark air pollution law, the Clean Air Act,[61] does not apply to indoor air.[62] Additionally, "[n]o federal agency has broad statutory authority concerning pollution indoors," although a number have some limited authority.[63] Despite the introduction of a number of IAQ bills in the 1980s and 1990s, Congress has not been able to pass a broad IAQ law.[64] At the state level, IAQ laws typically focus on radon, mold, or ensuring clean indoor air in schools.[65] Only two

60. *See* LINDA-JO SCHIEROW & DAVID M. BEARDEN, CONG. RSCH. SERV., R42620, FEDERAL PROGRAMS RELATED TO INDOOR POLLUTION BY CHEMICALS 35 (2012) ("Since 1998, no legislation has been introduced that would comprehensively address federal control of indoor air quality, or indoor environmental quality more generally.").

61. *Summary of the Clean Air Act*, U.S. ENV'T PROT. AGENCY [hereinafter *CAA Summary*], https://www.epa.gov/laws-regulations/summary-clean-air-act [https://perma.cc/SQ3L-AH2B], (last updated Sept. 12, 2022). "The Clean Air Act (CAA) is the comprehensive federal law that regulates air emissions from stationary and mobile sources." *Id.* It authorizes the EPA to establish National Ambient Air Quality Standards ("NAAQS") for criteria air pollutants. Clean Air Act § 109(a), 42 U.S.C. § 7409(a); *see* 40 C.F.R. § 50.6(a) (2022) (establishing NAAQS for PM_{10}); 40 C.F.R. § 50.18(a) (2022) (establishing updated NAAQS for $PM_{2.5}$). Criteria air pollutants are the six "common" pollutants that the EPA "regulates . . . by developing limits that are based on human health and/or environmental criteria." *Managing Air Quality – Air Pollutant Types*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/air-quality-management-process/managing-air-quality-air-pollutant-types [https://perma.cc/6QGF-USH4], (last updated July 18, 2022); *see Criteria Air Pollutants*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/criteria-air-pollutants [https://perma.cc/WMM8-UT2Y], (last updated Aug. 9, 2022) (listing the six currently designated criteria air pollutants: ozone, PM, carbon monoxide, lead, sulfur dioxide, and nitrogen dioxide).

62. Clean Air Act § 302(g) (defining "air pollutant" as "any air pollution agent or combination of such agents, including any physical, chemical, biological, radioactive . . . substance or matter which is emitted into or otherwise enters the *ambient air*" (emphasis added)). Additionally, EPA regulations define "ambient air" as "that portion of the atmosphere, *external to buildings*, to which the general public has access." 40 C.F.R. § 50.1(e) (2022) (emphasis added). These statutory and regulatory definitions seem to preclude CAA regulation of indoor PM as the statute currently stands.

63. SCHIEROW & BEARDEN, *supra* note 60, at 4–27 (describing the EPA's authority to "characterize indoor air problems; identify, assess, and implement strategies to mitigate hazards; and disseminate information about indoor environmental quality control" as well as the limited authority over IAQ regulation of the Agency for Toxic Substances and Disease Registry, the Consumer Product Safety Commission, the Department of Defense, the Department of Energy, the Department of Health and Human Services, the General Services Administration, the Department of Housing and Urban Development, the Occupational Safety and Health Administration, and the Office of the Federal Environmental Executive, among others).

64. *See infra* app. tbl.1.

65. *See ELI's Database of State Indoor Air Quality Laws: Main Page*, ENV'T L. INST., https://www.eli.org/buildings/database-state-indoor-air-quality-laws [https://perma.cc/8ZAX-9KM4] (providing database excerpts for three IAQ law topics: schools, mold, and radon).

states have laws directing state agencies to broadly regulate indoor PM.[66] Ultimately, no current federal statute or regulation effectively limits PM indoors, and no current statute, federal or state, specifically addresses subway air quality.

A. Federal IAQ Law

The "EPA does not regulate indoor air . . . ."[67] However, the Occupational Safety and Health Administration ("OSHA") directly regulates indoor air pollutants in the workplace,[68] and Congress has established the Interagency Committee on Indoor Air Quality ("CIAQ") to coordinate IAQ research and initiatives.[69] Additionally, introduced bills may provide some insight as to what a future federal IAQ statute could look like.[70] Furthermore, the federal government has had success in reducing air pollution on school buses—a kind of quasi-indoor space—through the Diesel Emissions Reduction Act ("DERA").[71]

1. *The Occupational Safety and Health Act ("OSHAct").* The OSHAct authorizes OSHA to regulate indoor air pollutants in the workplace.[72] Shortly after the Act's enactment in 1970, OSHA issued

66. *See* ENV'T L. INST., ENVIRONMENTAL LAW INSTITUTE DATABASE OF STATE INDOOR AIR QUALITY LAWS: COMPLETE DATABASE 23, 61 (2021) [hereinafter ENV'T L. INST., COMPLETE DATABASE], https://www.eli.org/sites/default/files/docs/greenbuilding/2021_complete_database.pdf [https://perma.cc/M76H-KVF5] (listing one Illinois law and one Oregon law that regulate indoor PM).

67. *Regulatory and Guidance Information by Topic: Air*, *supra* note 52. *But see* Arnold W. Reitze, Jr. & Sheryl-Lynn Carof, *The Legal Control of Indoor Air Pollution*, 25 B.C. ENV'T AFFS. L. REV. 247, 254–56 (1998) (explaining that the CAA may reduce indoor air pollution through reductions in outdoor air pollution; that the Toxic Substances Control Act gives the EPA the authority to regulate chemicals that can release pollutants indoors; and that the Federal Insecticide, Fungicide, and Rodenticide Act, the Comprehensive Environmental Response, Compensation, and Liability Act, and the Safe Drinking Water Act may also have provisions regulating indoor air).

68. Reitze & Carof, *supra* note 67, at 258.

69. *Federal Interagency Committee on Indoor Air Quality*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/indoor-air-quality-iaq/federal-interagency-committee-indoor-air-quality [https://perma.cc/M74Q-4GDX], (last updated July 19, 2022).

70. *See infra* Part II.A.3.

71. *See* RICHARD K. LATTANZIO, CONG. RSCH. SERV., IF11331, THE DIESEL EMISSIONS REDUCTION ACT (DERA) PROGRAM 1 (2021) (describing reductions in pollution due to DERA).

72. *See* Occupational Safety and Health Act of 1970 § 6(a), 29 U.S.C. § 655(a) (authorizing OSHA to adopt existing federal or national consensus standards as legally enforceable OSHA

legally enforceable permissible exposure limits ("PELs") for indoor air pollutants.[73] Since then, OSHA has established PELs for nearly six hundred air pollutants.[74] While OSHA regulates many component pollutants of PM separately,[75] the agency also includes a PEL for "[p]articulates not otherwise regulated."[76] This PEL is 5 mg/m^3 (5,000 $\mu g/m^3$), based on an eight-hour average, for the respirable fraction of general dust (PM_{10}).[77]

OSHA itself acknowledges that "many of its permissible exposure limits . . . are outdated and inadequate for ensuring protection of worker health."[78] In fact, most have not been updated since the adoption of the OSHAct.[79] Recognizing this, OSHA has recommended three alternative sources of exposure guidelines to employers as "limits that may serve to better protect workers."[80] However, no workplace

standards); *Permissible Exposure Limits – Annotated Tables*, U.S. DEP'T OF LAB.: OCCUPATIONAL SAFETY & HEALTH ADMIN. [hereinafter *PELs Tables*], https://www.osha.gov/annotated-pels [https://perma.cc/P6ZT-ZXWR] (citing the Walsh-Healy Public Contracts Act and consensus standards from the American Standards Association as the sources of OSHA's general industry PELs for indoor air pollutants). The OSHAct requires that each employer "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 his employees." 29 U.S.C. § 654(a)(1). While the OSHAct applies to most federal government and private sector employers and workers, it only protects state and local government workers in states with an OSHA-approved state plan. OCCUPATIONAL SAFETY & HEALTH ADMIN., U.S. DEP'T OF LAB., OSHA 3302-01R 2020, ALL ABOUT OSHA 6–8 (2020), https://www.osha.gov/sites/default/files/publications/all_about_OSHA.pdf [https://perma.cc/7P5M-UE8C].

73. *PELs Tables*, *supra* note 72.

74. U.S. GOV'T ACCOUNTABILITY OFF., GAO/RCED-92-8, INDOOR AIR POLLUTION: FEDERAL EFFORTS ARE NOT EFFECTIVELY ADDRESSING A GROWING PROBLEM 19 (1991) [hereinafter GAO REPORT]. The limits are based on an eight-hour time-weighted average, mirroring the typical eight-hour workday. *See Permissible Exposure Limits – Annotated Tables: OSHA Annotated Table Z-1*, U.S. DEP'T OF LAB.: OCCUPATIONAL SAFETY & HEALTH ADMIN. [hereinafter *Table Z-1*], https://www.osha.gov/annotated-pels/table-z-1 [https://perma.cc/DK38-B7FQ] (explaining that all OSHA PELs use an eight-hour time-weighted average unless otherwise indicated).

75. *See Table Z-1*, *supra* note 74 (listing PELs for sulfates, nitrates, ammonia, and black carbon).

76. 29 C.F.R. § 1910.1000 (2022).

77. *Id.*; *see Inhalable Particulate Matter and Health (PM2.5 and PM10)*, CAL. AIR RES. BD., https://ww2.arb.ca.gov/resources/inhalable-particulate-matter-and-health [https://perma.cc/XS2Q-YKM6] ("[Particles] with a diameter of 10 microns or less (PM10) are inhalable into the lungs . . . .").

78. *See PELs Tables*, *supra* note 72.

79. *Id.*

80. These three alternative sources are the California Division of Occupational Safety and Health ("Cal/OSHA"), the American Conference of Governmental Industrial Hygienists

exposure limit—mandatory or recommended—approaches the EPA's ambient standard. Furthermore, no PEL or recommended standard exists for $PM_{2.5}$.

2. *The Interagency Committee on Indoor Air Quality*. Established in 1983, the CIAQ is responsible for coordinating IAQ research among the different levels of government, researchers, the private sector, and the general public.[81] Twenty-four federal agencies are members of the CIAQ.[82] Pursuant to the 1986 Superfund Amendments and Reauthorization Act, the CIAQ also supports indoor air quality research at the EPA.[83] However, subsequent GAO reports have found that the CIAQ has had limited effectiveness,[84] and the CIAQ has not pushed for a comprehensive IAQ law.

3. *Introduced Bills*. In the 1980s and 1990s, members of Congress introduced several bills to enact a comprehensive IAQ law.[85] These bills primarily focused on research and designating clear lines of authority over IAQ issues within the government.[86] Senator George

("ACGIH"), and the National Institute for Occupational Safety and Health ("NIOSH"). *Id.* Notably, Cal/OSHA provides the only alternative standard for PM, similarly set at 5 mg/m^3 (5,000 $\mu g/m^3$) for PM_{10}. *Table Z-1*, *supra* note 74. Additionally, while the ACGIH does not have an analogous exposure limit for PM_{10}, its guidelines recommend that "airborne concentrations of respirable dust [should] be kept below 3 mg/m^3," or 3,000 $\mu g/m^3$. *The National Institute for Occupational Safety and Health (NIOSH): Occupational Exposure Limits*, CTRS. FOR DISEASE CONTROL & PREVENTION, https://www.cdc.gov/niosh/topics/flavorings/limits.html [https://perma.cc/E7CP-MA9H], (last updated June 28, 2018).

81. *Federal Interagency Committee on Indoor Air Quality*, *supra* note 69.

82. *See id.* (listing the agency members of the CIAQ). Five federal agencies serve as co-chairs: the EPA, the Consumer Product Safety Commission, the Department of Energy, NIOSH, and OSHA. *Id.*

83. *Id.*

84. *See* GAO REPORT, *supra* note 74, at 6–7 (finding that the CIAQ's lack of a specific national agenda and clearly defined agency roles has stifled its effectiveness); U.S. GOV'T ACCOUNTABILITY OFF., GAO-08-980, INDOOR MOLD: BETTER COORDINATION OF RESEARCH ON HEALTH EFFECTS AND MORE CONSISTENT GUIDANCE WOULD IMPROVE FEDERAL EFFORTS 30–31 (2008) (finding that the CIAQ "had more substantive discussions in the past on research projects, funding, and which research priorities needed to be addressed than it does now").

85. *See, e.g.*, Indoor Air Pollution Research Act of 1982, H.R. 6298, 97th Cong. (1982); Indoor Air Quality Act of 1988, S. 1629, 100th Cong. (1987); Indoor Air Act of 1994, S. 656, 103d Cong. (1993); Indoor Air Act of 1997, H.R. 2952, 105th Cong. (1997).

86. *See, e.g.*, Indoor Air Pollution Research Act of 1982, H.R. 6298, 97th Cong. (1982); Indoor Air Quality Act of 1988, S. 1629, 100th Cong. (1987); Indoor Air Act of 1994, S. 656, 103d Cong. (1993); Indoor Air Act of 1997, H.R. 2952, 105th Cong. (1997).

Mitchell and Representative Joseph P. Kennedy II led these efforts, introducing bills regularly from the 99th through the 105th Congress.[87] Although each bill varied slightly, many shared common provisions.[88]

Starting in 1994, bills began including provisions directing the EPA to set voluntary guidelines to reduce common significant indoor-air health risks.[89] Additionally, the Indoor Air Pollution Research Act of 1982 would have required the EPA to work with state, local, and private sector stakeholders to develop industrywide voluntary IAQ standards for residential buildings.[90] Other IAQ bills have focused on narrower issues tailored to particular problems.[91] However, no introduced bill thus far has proposed a broad mandatory IAQ standards program or legislation focused specifically on mitigating subway air pollution.

4. *The Diesel Emissions Reduction Act*. Originally enacted as part of the Energy Policy Act of 2005,[92] DERA created a grant and loan program at both the federal and state level to upgrade legacy diesel engines, reducing their emissions.[93] Part of DERA's federal grant allocation specifically funds a school-bus-upgrade rebate program to protect schoolchildren from diesel exhaust.[94] Much like the subway,

87. *See, e.g.*, Indoor Air Quality Research Act of 1985, S. 1198, 99th Cong. (1985); Indoor Air Quality Act of 1987, H.R. 3809, 100th Cong. (1987); Indoor Air Act of 1994, S. 656, 103d Cong. (1993); Indoor Air Act of 1997, H.R. 2952, 105th Cong. (1997).

88. *See infra* app. tbl.1.

89. *See, e.g.*, Indoor Air Act of 1994, H.R. 2919, 103d Cong. (1993); Indoor Air Act of 1995, H.R. 933, 104th Cong. (1995).

90. *See* Indoor Air Pollution Research Act of 1982, H.R. 6289, 97th Cong. (1982).

91. *See, e.g.*, Filtering and Retrofitting the Environment for Safe and Healthy Activities Indoors and Revenue (FRESH AIR) for Businesses Act, H.R. 1398, 117th Cong. (2021) (offering a payroll tax credit equal to 50 percent of the cost of ventilation, zoning, air filtration, and purification expenses for businesses, with a cap of $15,000 per year); Keeping Schools Safe Act, S. 4782, 116th Cong. (2020) (proposing grants to improve IAQ in elementary and secondary schools through monitoring and ventilation).

92. Energy Policy Act of 2005, Pub. L. No. 109-58, §§ 791–97, 119 Stat. 594, 838–44 (codified as amended at 42 U.S.C. §§ 16131–16137).

93. LATTANZIO, *supra* note 71, at 1. To receive federal funding, potential recipients must submit an application to the EPA's Office of Transportation and Air Quality. *2021 DERA National Grants – Closed Announcement FY 2021*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/grants/2021-dera-national-grants-closed-announcement-fy-2021 [https://perma.cc/PHF5-87GY], (last updated July 6, 2021).

94. *See School Bus Rebates: Diesel Emissions Reduction Act (DERA)*, U.S. ENV'T PROT. AGENCY [hereinafter *School Bus Rebates*], https://www.epa.gov/dera/rebates [https://perma.cc/9Z36-H6P2], (last updated May 20, 2022) ("The 2021 DERA School Bus Rebates will offer

school buses are a form of public transit with high levels of pollution; in fact, vehicle exhaust pollution levels can be four times higher inside school buses than in passenger cars.[95]

DERA has successfully reduced diesel emissions. For example, the EPA estimates that DERA reduced "emissions of NO_x by 474,700 tons, PM by 15,490 tons, and hydrocarbons by 17,700 tons over the lifetime of the affected engines."[96] The agency also estimates that DERA resulted in 2,300 fewer premature deaths, with total monetized health benefits equal to $19 billion.[97] Another indicator of the program's success and necessity is that "DERA funding requests have exceeded availability by as much as 35:1 for the [school bus] rebate program and 7:1 for the national grant competition."[98] DERA's grant program relies on congressional appropriations,[99] and Congress renewed and reauthorized DERA in 2010[100] and 2021.[101]

B. State and Local Law

Hundreds of state laws govern indoor air quality, but few address indoor PM.[102] The majority of statutes fall into three main categories:

approximately $10 million to public and private fleet owners for the replacement of old diesel school buses with new buses certified to EPA's cleanest emission standards.").

95. GINA M. SOLOMON, TODD R. CAMPBELL, GAIL RUDERMAN FEUER, JULIE MASTERS, ARTINEH SAMKIAN & KAVITA ANN PAUL, NAT. RES. DEF. COUNCIL, NO BREATHING IN THE AISLES: DIESEL EXHAUST INSIDE SCHOOL BUSES 3 (2001), https://www.nrdc.org/sites/default/files/schoolbus.pdf [https://perma.cc/VHS6-FP3K].

96. LATTANZIO, *supra* note 71, at 1.

97. *Id.*

98. *Id.*

99. *Id.* at 1–2.

100. Diesel Emissions Reduction Act of 2010, Pub. L. No. 111-364, 124 Stat. 4056 (codified as amended at 42 U.S.C. §§ 15801, 16131–16134, 16137).

101. Consolidated Appropriations Act, 2021, Pub. L. No. 116-260, div. S, sec. 101, 134 Stat. 1182, 2243 (2020) (codified as amended at 42 U.S.C. § 16137).

102. *See generally* ENV'T L. INST., COMPLETE DATABASE, *supra* note 66 (listing all state IAQ laws, with only four referring to "particulates," "particulate matter," or "IPM").

school-focused,[103] mold,[104] and radon laws.[105] Only two state statutes authorize state agencies to broadly implement indoor air pollution standards for PM. In Illinois, the Indoor Air Quality Act requires the Indoor Air Pollution Advisory Council to "develop statewide indoor air quality guidelines."[106] Guidelines established under the law include a recommendation that $PM_{2.5}$ "be maintained at less than the [former] NAAQS of 65 $\mu g/m^3$ during a 24-hour time period."[107] It is not clear if these standards have been updated in accordance with the current $PM_{2.5}$ NAAQS of 35 $\mu g/m^3$, adopted in 2012.[108] Additionally, Oregon law authorizes the Oregon Health Authority ("OHA") to establish IAQ standards for significant air pollutants, which include PM.[109] It is not clear if the OHA has promulgated these standards. Furthermore, no state specifically regulates IAQ in mass transit vehicles or stations.

Notably, in light of recent reports on subway air pollution and an increased need to monitor subway air due to COVID-19, some local transit systems are voluntarily implementing methods of pollution reduction.[110] Additionally, mask mandates on underground railway

103. *See generally* ENV'T L. INST., DATABASE OF STATE INDOOR AIR QUALITY LAWS: DATABASE EXCERPT: IAQ IN SCHOOLS (2021), https://www.eli.org/sites/default/files/docs/greenbuilding/2021_schools.pdf [https://perma.cc/MUC9-TQ7R] (listing school-specific IAQ statutes in one of three more-specific databases created by the Environmental Law Institute).

104. *See generally* ENV'T L. INST., DATABASE OF STATE INDOOR AIR QUALITY LAWS: DATABASE EXCERPT: MOLD LAWS (2021), https://www.eli.org/sites/default/files/docs/greenbuilding/2021_mold.pdf [https://perma.cc/4G6A-ZWH8] (listing mold IAQ statutes in one of three more-specific databases created by the Environmental Law Institute).

105. *See generally* ENV'T L. INST., DATABASE OF STATE INDOOR AIR QUALITY LAWS: DATABASE EXCERPT: RADON LAWS (2021), https://www.eli.org/sites/default/files/docs/greenbuilding/2021_radon.pdf [https://perma.cc/RHC7-WMFZ] (listing radon IAQ statutes in one of three more-specific databases created by the Environmental Law Institute).

106. 410 ILL. COMP. STAT. ANN. 87/15 (West 2022).

107. *IDPH Guidelines for Indoor Air Quality*, ILL. DEP'T OF PUB. HEALTH, https://dph.illinois.gov/topics-services/environmental-health-protection/toxicology/indoor-air-quality-healthy-homes/idph-guidelines-indoor-air-quality.html [https://perma.cc/SBY3-BH9M].

108. *Timeline of Particulate Matter (PM) National Ambient Air Quality Standards (NAAQS)*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/pm-pollution/timeline-particulate-matter-pm-national-ambient-air-quality-standards-naaqs [https://perma.cc/C6Y5-UAGX], (last updated Nov. 24, 2021).

109. OR. REV. STAT. ANN. § 433.521 (West 2022).

110. For example, the Bay Area Rapid Transit system in San Francisco is experimenting with dense filter panels intended to trap small particles within the subway system. George, *supra* note 3. New York City's Metropolitan Transportation Authority is "expanding new filtration systems on trains that can trap viruses and cycle air in and out of subway cars every three minutes." *Id.* In Washington, D.C., the Washington Metropolitan Area Transit Authority received a $600,000 grant from the Federal Transit Administration for "enhanced air filtration and purification

systems, while intended to inhibit the spread of COVID-19, can also help prevent the inhalation of PM to varying degrees based on mask type.[111]

III. INTERNATIONAL APPROACHES TO IAQ

While the United States lacks a comprehensive indoor air quality statute, other countries have enacted broad IAQ standards. Two countries—South Korea and Taiwan—have statutes specifically governing IAQ in subway systems.[112] Others have general IAQ laws or laws restricting indoor air pollution in the workplace, much like the OSHAct.[113] Other countries and the WHO have promulgated voluntary guidelines.[114] Hong Kong combines a certification scheme with standards-based guidelines.[115] Lastly, the European Commission offers an example of an IAQ research program meant to induce future legislation.[116] A comparison chart of all regimes mentioned can be found in Table 2 in the Appendix.[117]

A. Standards-Based IAQ Statutes That Explicitly Govern Subway Systems

South Korea[118] and Taiwan[119] have enacted statutes authorizing government ministries to promulgate mandatory IAQ standards. Both

technologies." Press Release, U.S. Congressman Steny Hoyer, Maryland Delegation Members Applaud More Than $1 Million for WMATA and Montgomery County Transit To Improve COVID-19 Safety (Jan. 26, 2021), https://hoyer.house.gov/content/maryland-delegation-members-applaud-more-1-million-wmata-and-montgomery-county-transit [https://perma.cc/G928-9B4L].

111. *See* Kabindra M. Shakya, Alyssa Noyes, Randa Kallin & Richard E. Peltier, *Evaluating the Efficacy of Cloth Facemasks in Reducing Particulate Matter Exposure*, 27 J. EXPOSURE SCI. & ENV'T EPIDEMIOLOGY 352, 356 (2017) (comparing the relative effectiveness of cloth, N95, and disposable surgical masks in reducing exposure to PM).

112. *See infra* notes 118–119 and accompanying text.

113. *See infra* Part III.B.2.

114. *See infra* Part III.C.

115. *See infra* notes 179–182 and accompanying text.

116. *See infra* notes 186–187 and accompanying text.

117. *See infra* app. tbl.2.

118. Sillaegonggijil Gwallibeop [Indoor Air Quality Control Act] (S. Kor.), *translated in* Korea Legislation Research Institute's online database, https://elaw.klri.re.kr/eng_service/lawView.do?hseq=48555&lang=ENG [https://perma.cc/G5G5-C66K].

119. Shinei Kongqi Pinzhi Guanli Fa (室內空氣品質管理法) [Indoor Air Quality Act] (promulgated by the Env't Prot. Admin., Nov. 23, 2011, effective Nov. 23, 2012) (Taiwan), *translated in* FAWUBU FAGUI ZILIAOKU, https://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?pcode=O0130001 [https://perma.cc/M9W2-J684].

countries have enacted standards for indoor PM_{10} and $PM_{2.5}$ pursuant to those laws.[120] Additionally, both laws cover underground subway platforms, stations, and carriages.[121] These two countries directly confront the issue of subway air pollution, in contrast to the United States' current hands-off approach.

1. *South Korea*. South Korea was the first country to enact comprehensive legislation regarding indoor air quality,[122] possibly due to its ubiquitous underground spaces, including numerous shopping centers[123] and subway systems.[124] As some locations "are susceptible to severe indoor air pollution," the South Korean Ministry of Environment ("MOE") enacted the Underground Air Quality Management Act ("Underground Act") in 1996.[125] The Underground Act originally authorized the MOE to establish IAQ standards for underground shopping districts and subway systems.[126] However, awareness of air pollution in aboveground buildings led to the passage

120. *See* Sangjun Choi, Ju-Hyun Park, Seo-Yeon Bae, So-Yeon Kim, Hyaejeong Byun, Hyunseok Kwak, Sungho Hwang, Jihoon Park, Hyunhee Park, Kyong-Hui Lee, Won Kim & Dong-Uk Park, *Characteristics of PM_{10} Levels Monitored for More Than a Decade in Subway Stations in South Korea*, 19 AEROSOL & AIR QUALITY RSCH. 2746, 2746, 2752 (2019) (describing South Korean PM standards); Shinei Kongqi Pinzhi Biaozhun (室內空氣品質標準) [Indoor Air Quality Standards] (promulgated by the Env't Prot. Admin., Nov. 23, 2011, effective Nov. 23, 2012), art. 2 (Taiwan), FAWUBU FAGUI ZILIAOKU, https://law.moj.gov.tw/LawClass/LawAll.aspx?pcode=O0130005 [https://perma.cc/TC22-RAG2] (establishing Taiwan's PM standards).

121. *See* Indoor Air Quality Control Act, art. 1 (S. Kor.) (covering "mass transit vehicles"); Indoor Air Quality Act, art. 3 (Taiwan) (defining covered indoor spaces as including "closed or semi-closed space in buildings intended for public use, and passenger carrying space by means of mass transportation").

122. Wen-Tien Tsai, *A Comparative Study on the Statutory and Technical Regulations for Controlling Indoor Volatile Organic Compounds in Taiwan and Japan*, ATMOSPHERE, May 2018, at 1, 3.

123. *See Underground Shopping Malls*, IMAGINE YOUR KOREA, https://english.visitkorea.or.kr/enu/SHP/SH_ENG_2_7.jsp [https://perma.cc/N6TU-ZAV9], (last updated Oct. 7, 2021) (providing examples of underground shopping centers).

124. *See Subways*, IMAGINE YOUR KOREA, https://english.visitkorea.or.kr/enu/TRP/TP_ENG_6.jsp [https://perma.cc/877V-DUQF], (last updated Sept. 27, 2021) (mentioning subway systems in five major South Korean cities, including Seoul's "expansive" underground transportation system).

125. Soo Ran Won, Young Sung Ghim, Jeonghoon Kim, Jungmin Ryu, In-Keun Shim & Jongchun Lee, *Volatile Organic Compounds in Underground Shopping Districts in Korea*, 18 INT'L J. ENV'T RSCH. & PUB. HEALTH, May 21, 2021, at 1, 1.

126. Jihasaenghwalgonggangonggijilgwallibeop [Air Quality Control in Underground Locations Act] art. 3, *amended by* Act. No. 6911, May 29, 2003 (S. Kor.), *translated in* Korea Legislation Research Institute's online database, https://elaw.klri.re.kr/eng_service/lawView.do?lang=ENG&hseq=8283 [https://perma.cc/7828-YJ24].

of the comprehensive Indoor Air Quality Control Act ("IAQCA") in 2003.[127] The IAQCA expands covered buildings to include all "public-use facilities."[128] As amended, its purpose is "to protect [public] health . . . and to prevent environmental risks[] by adequately maintaining and controlling indoor air quality within public-use facilities, newly-built multi-family housing, and mass transit vehicles."[129]

The MOE sets exposure limits pursuant to the IAQCA.[130] The current exposure limit for PM_{10} is 150 μg/m^3 based on a twenty-four-hour average.[131] In 2018, amendments to the IAQCA set a $PM_{2.5}$ daily average exposure limit of 50 μg/m^3.[132] Local governments may impose more stringent standards than the IAQCA.[133] In the absence of a mandatory standard for a pollutant, the IAQCA also allows for the implementation of voluntary standards.[134] If a public-use facility is in violation of any mandatory standards, certain governmental officials may order its owners to improve or replace ventilation or air-purifying equipment or take other measures as necessary.[135] Additional enforcement mechanisms include up to one year of prison time and fines between five and twenty million won (equivalent to about $4,000 to $15,800).[136]

---

127. MINISTRY OF ENV'T, REPUBLIC OF KOREA, GREEN KOREA 2004: BUILDING AN ECO-COMMUNITY FOR THE 21ST CENTURY 50 (2004).

128. Sillaegonggijil Gwallibeop [Indoor Air Quality Control Act], art. 1 (S. Kor.), *translated in* Korea Legislation Research Institute's online database, https://elaw.klri.re.kr/eng_service/lawView.do?hseq=48555&lang=ENG [https://perma.cc/G5G5-C66K].

129. *Id.* (emphasis added).

130. *Id.* at art. 5(2).

131. Choi et al., *supra* note 120, at 2746. The EPA's twenty-four-hour NAAQS for PM_{10} is similarly 150 μg/m^3. 40 C.F.R. § 50.6(a) (2022).

132. *Id.* at 2752. The EPA's twenty-four-hour NAAQS for $PM_{2.5}$ is 35 μg/m^3. 40 C.F.R. § 50.18(a) (2022).

133. *See, e.g.*, *Indoor Air Quality Control at Public Use Facilities: Clean Air for All*, SEOUL SOLUTION, https://seoulsolution.kr/en/content/indoor-air-quality-control-public-use-facilities-clean-air-all [https://perma.cc/TKW6-V9TU], (last updated Dec. 23, 2016) (discussing Seoul's IAQ standards, which are more stringent than the IAQCA requirements).

134. Sillaegonggijil Gwallibeop [Indoor Air Quality Control Act], art. 6 (S. Kor.), *translated in* Korea Legislation Research Institute's online database, https://elaw.klri.re.kr/eng_service/lawView.do?hseq=48555&lang=ENG [https://perma.cc/G5G5-C66K].

135. *Id.* at art. 10.

136. *Id.* at art. 14–16; *see 1 KRW to USD: Convert South Korean Won to United States Dollar*, FORBES ADVISOR (Feb. 11, 2023, 1:58 PM), https://www.forbes.com/advisor/money-transfer/currency-converter/krw-usd [https://perma.cc/9GM8-C62E] (listing the conversion rate of Korean won to U.S. dollars, as of February 11, 2022, as 1 won per 0.000789 dollars).

Other IAQCA provisions restrict the use of particular construction materials in new facilities and housing,[137] require measurement and monitoring of IAQ,[138] provide technical, administrative, and financial support to facilities used by vulnerable populations,[139] and allow for the establishment of an "Indoor Air Quality Monitoring Network to control indoor air quality comprehensively and systematically."[140] Additionally, Article 9-2 allows the MOE to establish specific management guidelines for the manufacture and operation of mass transit vehicles.[141]

2. *Taiwan*. Indoor air quality has long been a salient issue in Taiwan; in fact, "sick-building or sick-house syndrome has attracted social attention since the early 1990s."[142] Taiwan's Environmental Protection Administration issued suggested IAQ guidelines in 2005.[143] By 2011, Taiwan had enacted the Indoor Air Quality Act ("IAQA") "to improve indoor air quality and to protect public health."[144] The IAQA sets mandatory standards for indoor air pollutants, including PM_{10} and $PM_{2.5}$.[145] It specifically defines "indoor" to mean "closed or semi-closed space in buildings intended for public use, and passenger carrying space by means of mass transportation."[146] Buildings covered under the law include universities, government agencies, transportation stations, medical care centers, movie theaters, malls, gyms, other public buildings, and some private sector buildings.[147] The

137. Indoor Air Quality Control Act, art. 11(1) (S. Kor.).

138. *Id.* at art. 12(1).

139. *Id.* at art. 12-2(1).

140. *Id.* at art. 12-4(1).

141. *Id.* at art. 9-2(1).

142. Tsai, *supra* note 122. *See generally* Lin Hsin-Ching, *Are Sick Buildings Making You Sick?*, TAIWAN PANORAMA (Feb. 2012), https://www.taiwan-panorama.com/Articles/Details?Guid=ff881533-c4d1-4f58-b320-ee8609571bf9&langId=3&CatId=7 [https://perma.cc/X2YL-CT2P] (describing the history of sick building syndrome and IAQ legislation in Taiwan).

143. Tsai, *supra* note 122.

144. Shinei Kongqi Pinzhi Guanli Fa (室內空氣品質管理法) [Indoor Air Quality Act] (promulgated by the Env't Prot. Admin., Nov. 23, 2011, effective Nov. 23, 2012), art. 1 (Taiwan), *translated in* Fawubu Fagui Ziliaoku, https://law.moj.gov.tw/ENG/LawClass/LawAll. aspx?pcode=O0130001 [https://perma.cc/M9W2-J684].

145. *Id.* at art. 3–4.

146. *Id.* at art. 3 (emphasis added).

147. Tsai, *supra* note 122, at 4.

standard for PM_{10} is 75 μg/m^3, and that for $PM_{2.5}$ is 35 μg/m^3.[148] Both are based on a twenty-four-hour average.[149]

Like South Korea's IAQCA, Taiwan's IAQA includes several complementary provisions that aid in reducing indoor air pollution. Article 5 of the IAQA authorizes "[c]ompetent authorities . . . [to] commission professional organizations to conduct matters relating to surveys, tests, education, public awareness, guidance, training, and research related to indoor air quality."[150] Additionally, each building owner or manager must create and maintain an indoor air quality management plan.[151] They must also participate in regular testing of air quality in their buildings, conducted only by laboratories that have received permits to do so from the Taiwanese government.[152]

Fines for failing to comply with the IAQA range from NT$5,000 to NT$250,000 (equivalent to about $160 to $8,300) and accumulate per violation.[153] The agency determines the exact amount of a fine based on the severity of the violation.[154]

B. Other Standards-Based IAQ Statutes

Like the United States, some countries have laws setting general building or workplace IAQ standards without explicit provisions regulating subway air quality. Below are examples of each model.

1. *General IAQ Statutes*. Japan broadly regulates IAQ. Article 4 of Japan's Act on Maintenance of Sanitation in Buildings ("AMSB") authorizes the promulgation of standards to maintain the indoor

148. Shinei Kongqi Pinzhi Biaozhun (室內空氣品質標準) [Indoor Air Quality Standards] (promulgated by the Env't Prot. Admin., Nov. 23, 2011, effective Nov. 23, 2012), art. 2 (Taiwan), Fawubu Fagui Ziliaoku, https://law.moj.gov.tw/LawClass/LawAll.aspx?pcode=O0130005 [https://perma.cc/TC22-RAG2].

149. *Id.* Note that the EPA twenty-four-hour standard for PM_{10} is twice as high, at 150 μg/m^3, but the EPA standard for $PM_{2.5}$ is the same. 40 C.F.R. §§ 50.6(a), 50.18(a) (2022).

150. Indoor Air Quality Act, art. 5 (Taiwan).

151. *Id.* at art. 8.

152. *Id.* at art. 10–11.

153. *Id.* at art. 13–18; *see 1 TWD to USD: Convert New Taiwan Dollar to United States Dollar*, FORBES ADVISOR (Feb. 11, 2023, 1:41 PM), https://www.forbes.com/advisor/money-transfer/currency-converter/twd-usd [https://perma.cc/N4VV-MHTA] (listing the conversion rate of New Taiwan dollars to U.S. dollars, as of February 11, 2023, as 1 new Taiwan dollar to 0.033114 dollars).

154. Indoor Air Quality Act, art. 19 (Taiwan).

environmental quality of covered buildings.[155] The Act governs IAQ in buildings with floor space greater than 3,000 m^2 "that are used as entertainment venues, department stores, meeting halls, libraries, museums, art galleries, amusement halls, stores, offices, inns, etc."[156] The law does not cover smaller buildings or individual residences.[157] Notably, a separate law governs workplace safety and health; the IAQ of some buildings, like factories and hospitals, is fully regulated under that law rather than the AMSB.[158]

Standards for pollutants, including PM_{10}, are set via the Management Standard for Environmental Sanitation for Buildings by the Ministry of Health, Labor and Welfare.[159] The current standard for suspended particulate matter is 0.150 mg/m^3 (150 $\mu g/m^3$).[160] Notably, violating the standard alone does not trigger government disciplinary action.[161] Instead, enforcement is typical only when "severely inadequate environmental sanitary conditions are present, such as those which may impair people's health in specified buildings, *in*

155. Kenchiku-mono ni okeru eisei-teki kanky no kakuho ni kansuru h ritsu [Act on Maintenance of Sanitation in Buildings], Law No. 20 of 1970, § 2, art. 4 (Japan), (e-Gov H rei kensaku [H rei DB]), https://elaws.e-gov.go.jp/document?lawid=345AC1000000020_20190401_429A C0000000041&keyword= %E8%A1%9B%E7%94%9F [https://perma.cc/YAX3-PSXT].

156. Motoya Hayashi, Kenichi Kobayashi, Hoon Kim & Noriko Kaihara, *The State of the Indoor Air Environment in Buildings and Related Tasks in Japan*, 69 J. NAT'L INST. PUB. HEALTH 63, 63–64 (2020).

157. Koichi Harada, Asako Hasegawa, Chan-Nian Wei, Keiko Minamoto, Yukari Noguchi, Kunio Hara, Osamu Matsushita, Kosuke Noda & Atsushi Uedac, *A Review of Indoor Air Pollution and Health Problems from the Viewpoint of Environmental Hygiene: Focusing on the Studies of Indoor Air Environment in Japan Compared to Those of Foreign Countries*, 56 J. HEALTH SCI. 488, 489 (2010).

158. Jun Kagawa, *Indoor Air Quality Standards and Regulations in Japan*, 2 INDOOR ENV'T 223, 226 (1993).

159. Kenchiku-mono ni okeru eisei-teki kanky no kakuho ni kansuru h ritsu [Act on Maintenance of Sanitation in Buildings], Law No. 20 of 1970 (Japan), (e-Gov H rei kensaku [H rei DB]), https://elaws.e-gov.go.jp/document?lawid=345AC1000000020_20190401_429AC00 00000041&keyword=%E8%A1%9B%E7%94%9F [https://perma.cc/ECS9-7LZY].

160. Keiichi Furuya, Yoshiyuki Kudo, Kiyo Okinaga, Maho Yamuki, Sentaro Takahashi, Yoichi Araki & Yoshiharu Hisamatsu, *Seasonal Variation and Their Characterization of Suspended Particulate Matter in the Air of Subway Stations*, 19 J. TRACE & MICROPROBE TECHS. 469, 476 (2001). Suspended particulate matter differs from PM_{10}, so the EPA's standards are not directly comparable. *See* Kunio Hara, Junichi Homma, Kenji Tamura, Mariko Inoue, Kanae Karita & Eiji Yano, *Decreasing Trends of Suspended Particulate Matter and $PM_{2.5}$ Concentrations in Tokyo, 1990–2010*, 63 J. AIR & WASTE MGMT. ASS'N 737, 737–38 (2013) ("[Suspended particulate matter] is defined as airborne particulate matter with an aerodynamic diameter of less than approximately 7 μm . . . and is slightly different from PM_{10} (i.e., fine particulate matter with an aerodynamic diameter of less than 10 μm . . .).").

161. Kagawa, *supra* note 158, at 227.

addition to violation of the management standards."[162] In this way, the standards are made less stringent.

2. *Workplace IAQ Statutes*. Australia regulates IAQ under the Work Health and Safety Act, which requires any "person conducting a business or undertaking [to reasonably] ensure . . . the health and safety" of workers.[163] Pursuant to the Act, the Australian National Occupational Health and Safety Commission released its Workplace Exposure Standards for Airborne Contaminants, most recently updated in 2019.[164] The standards do not list a general level for $PM_{2.5}$ or PM_{10}.[165] However, guidelines suggest that for PM not otherwise classified, the exposure level should be less than 10 mg/m^3 (equivalent to 10,000 $\mu g/m^3$) based on an eight-hour average.[166] This level is twice as high as the OSHAct's eight-hour PEL for "[p]articulates not otherwise regulated."[167] Regulations require that no worker be exposed to an airborne pollutant that exceeds its exposure standard.[168] Businesses must monitor air quality to ensure compliance.[169]

Similar legislation in the United Kingdom regulates IAQ through workplace exposure limits ("WELs") for several substances that are in dust or particulate form.[170] However, the United Kingdom's law does not include a catchall provision for particulate matter not associated with a particular chemical, a key difference from the OSHAct.[171]

---

162. *Id.* (emphasis added).

163. *Work Health and Safety Act 2011* (Cth) s 19 (Austl.).

164. *See* SAFE WORK AUSTL., WORKPLACE EXPOSURE STANDARDS FOR AIRBORNE CONTAMINANTS 13–41 (2019) [hereinafter WORKPLACE EXPOSURE STANDARDS], https://www.safeworkaustralia.gov.au/system/files/documents/1912/workplace-exposure-standards-airborne-contaminants.pdf [https://perma.cc/UN86-ANTX] (listing the 2019 workplace exposure standards).

165. *See id.* (making no mention of a standard for PM).

166. SAFE WORK AUSTL., GUIDANCE ON THE INTERPRETATION OF WORKPLACE EXPOSURE STANDARDS FOR AIRBORNE CONTAMINANTS 26 (2013), https://www.safeworkaustralia.gov.au/system/files/documents/1705/guidance-interpretation-workplace-exposure-standards-airborne-contaminants-v2.pdf [https://perma.cc/H5MB-HEAH].

167. *Table Z-1*, *supra* note 74.

168. WORKPLACE EXPOSURE STANDARDS, *supra* note 164, at 4.

169. *Id.*

170. HEALTH & SAFETY EXEC., EH40/2005 WORKPLACE EXPOSURE LIMITS 9–21 (4th ed. 2020), https://www.hse.gov.uk/pubns/priced/eh40.pdf [https://perma.cc/3N6T-R28C].

171. *See id.* (failing to list a WEL for particulates otherwise unregulated); *Table Z-1*, *supra* note 74 (listing a PEL for "[p]articulates not otherwise regulated").

C. Voluntary Schemes

While most countries lack a binding IAQ statute, many have adopted voluntary standards to encourage reductions in indoor air pollution.[172] Additionally, the WHO has released recommended IAQ guidelines to assist countries in setting their own standards.[173]

China and Singapore both have voluntary standards.[174] In 2002, China's State Environmental Protection Administration enacted a regulation "specif[ying] the indoor air quality parameters and inspection methods" for residential and office buildings.[175] The standard for PM_{10} is 0.15 mg/m^3 (150 $\mu g/m^3$) based on a twenty-four-hour average, the same as the EPA's daily NAAQS for PM_{10}.[176] Additionally, the Singapore Standard for Indoor Air Quality for Air-Conditioned Buildings provides recommended maximum concentrations of indoor pollutants for all premises "where air-conditioning is used intermittently or continuously."[177] The standard for PM_{10} is 50 $\mu g/m^3$ based on an eight-hour average.[178]

In a slightly different policy, Hong Kong has adopted a voluntary standard but added a certification scheme. Hong Kong launched its Indoor Air Quality Certification Scheme in 2003.[179] The voluntary scheme rewards owners of offices and public buildings who meet

---

172. *See generally Copy of All IAQ Guidelines Reports*, IEQ GUIDELINES, https://ieqguidelines.org/table.html [https://perma.cc/KRV6-UPPL] (listing many government and international indoor air pollution guidelines).

173. *See infra* notes 183–184 and accompanying text.

174. *See Copy of All IAQ Guidelines Reports*, *supra* note 172 (describing China's and Singapore's particulate matter standards as "Government Guidelines" instead of binding regulations).

175. Shinei Kongqizhiliang Biaozhun (室内空气质量标准) [Indoor Air Quality Standard] (promulgated by State Env't Prot. Admin., Nov. 19, 2002, effective Oct. 1, 2003) MINISTRY OF HEALTH (China), *translated in* CHINESESTANDARD.NET's online database, https://www.chinesestandard.net/PDF.aspx/GBT18883-2002 [https://perma.cc/4MD3-64XQ].

176. *Id.*; *see* 40 C.F.R. § 50.6(a) (2022) (setting the daily NAAQS for PM_{10} at 150 $\mu g/m^3$).

177. *SS 554:2016+A1:2021: Code of Practice for Indoor Air Quality for Air-Conditioned Buildings*, SING. STANDARDS COUNCIL, https://www.singaporestandardseshop.sg/Product/SSPdtDetail/8ee48ab1-38f5-4dae-a469-b8612a05876f [https://perma.cc/YR97-83PG].

178. KWOK WAI MUI, LING TIM WONG & TXZ WUN TSANG, H.K. POLYTECHNIC UNIV., FEASIBILITY STUDY OF IMPLEMENTING AN INDOOR AIR QUALITY INDEX IN HONG KONG 66 (2017). Because the standard is based on an eight-hour average, it is not directly comparable to the EPA's twenty-four-hour standard.

179. *IAQ Certification Scheme: Background*, ENV'T PROT. DEP'T INDOOR AIR QUALITY INFO. CTR., https://www.iaq.gov.hk/en/iaq-certification-scheme-background [https://perma.cc/Q4HF-GSZG].

particular "IAQ Objectives" for a number of indoor air pollutants.[180] Hong Kong updated its 2003 IAQ Objectives in 2019.[181] For PM_{10}, current building owners may receive a "Good Class" certificate by maintaining indoor levels below 100 $\mu g/m^3$ and an "Excellent Class" certificate by maintaining levels below 20 $\mu g/m^3$, both based on an eight-hour average.[182]

At the international level, the WHO has adopted voluntary IAQ standards. While the WHO's indoor standards do not include $PM_{2.5}$ and PM_{10}, the organization has referred to its ambient air standards as recommended limits for indoor $PM_{2.5}$ and PM_{10} levels.[183] The current ambient and indoor twenty-four-hour standards are 15 $\mu g/m^3$ for $PM_{2.5}$ and 45 $\mu g/m^3$ for PM_{10}.[184] The WHO's standards are more stringent than the EPA's daily ambient standards of 35 $\mu g/m^3$ for $PM_{2.5}$ and 150 $\mu g/m^3$ for PM_{10}.[185]

D. Research Programs

Another category of IAQ law is research-focused legislation. Research programs can inform countries' eventual adoption of IAQ standards and regulations. For example, the European Commission funded an extensive air quality monitoring study in Barcelona's subway system between 2014 and 2018.[186] The project's goals included "[d]eveloping proposals for helping local/national authorities to implement effective air mitigation measures in subway systems."[187] As mentioned, most IAQ bills that have been introduced in the U.S. Congress similarly focused on research efforts.[188]

---

180. *Id.*

181. *Update of the IAQ Objectives*, ENV'T PROT. DEP'T INDOOR AIR QUALITY INFO. CTR. 1, https://www.iaq.gov.hk/wp-content/uploads/2021/04/annex-summary-of-old-and-new-iaqos_eng_v2.pdf [https://perma.cc/6VHF-HGFC].

182. *Id.* Because the IAQ Objectives are based on an eight-hour average, they are not directly comparable to the EPA's twenty-four-hour standard.

183. *See* WHO INDOOR AIR QUALITY GUIDELINES, *supra* note 54, at 4 (finding that because of the lack of evidence showing a significant difference between indoor and outdoor PM, "the [ambient] air quality guidelines for particulate matter recommended by the [WHO] 2005 global update . . . are also applicable to indoor spaces").

184. WHO GLOBAL AIR QUALITY GUIDELINES, *supra* note 54, at 88, 97.

185. *See* 40 C.F.R. § 50.18(a) (2022) (setting the daily NAAQS for $PM_{2.5}$ at 35 $\mu g/m^3$); 40 C.F.R. § 50.6(a) (2022) (setting the daily NAAQS for PM_{10} at 150 $\mu g/m^3$).

186. *Implementing Methodologies and Practices To Reduce Air Pollution of the Subway Environment*, EUR. COMM'N: TRIMIS, https://trimis.ec.europa.eu/project/implementing-methodologies-and-practices-reduce-air-pollution-subway-environment [https://perma.cc/39A3-GYXH].

187. *Id.*

188. *See supra* Part II.A.3.

IV. ADVOCATING A NEW APPROACH IN THE UNITED STATES

The United States has a clear gap in indoor air pollution regulation. Given the high level of PM pollution in subway systems and its disproportionately high burden on Black, Latino, and poor Americans, the United States should close this gap. This Part will address possible legislative solutions to the subway pollution problem. First, it will discuss the possibility of enacting effective indoor air pollution legislation within the framework of the OSHAct or the CAA, both of which present difficulties that would make this option less effective or nearly impossible. Second, it will address the option of enacting new legislation modeled either on a standards-based law, like South Korea's, or a funding incentive program, like DERA. While a binding standard would be preferable in the long term, political and legal obstacles to using federal legislation to require local government-run subway systems to reduce pollution make DERA a more promising model for IAQ legislation in the short term.

A. Difficulties Under Current Federal Law: The OSHAct and the CAA

Regulating IAQ under existing law would remove many procedural obstacles, not least of which is the time and effort to draft, garner support for, and pass completely new legislation. However, the two major federal laws under which IAQ would most reasonably fall—the OSHAct and the CAA—have procedural and substantive issues that ultimately make them impractical. First, the OSHAct has weak PM standards that are difficult (if not impossible) to amend; additionally, it may not cover all subways, as some are state-run public entities in states without an OSHA-approved plan.[189] Second, the CAA

189. States and territories that have a publicly run subway system but currently do not have an OSHA-approved state plan—and therefore are not bound by the requirements of the OSHAct—include the District of Columbia, Georgia, Pennsylvania, and Texas. *See State Plans*, U.S. DEP'T OF LAB.: OCCUPATIONAL SAFETY & HEALTH ADMIN., https://www.osha.gov/stateplans [https://perma.cc/NKZ3-PN44] (listing states with and without OSHAct coverage for state and local government employees); *see also* NAT'L CAP. PLAN. COMM'N, REVIEW OF PROJECTS FROM THE WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY 1 (2019), https://www.ncpc.gov/docs/publications/WMATA_Resource_Guide_2019.pdf [https://perma.cc/SYR6-VBP2] (commenting on WMATA in Washington, D.C.); John D. Toon, *Metropolitan Atlanta Rapid Transit Authority*, NEW GA. ENCYCLOPEDIA, https://www.georgiaencyclopedia.org/articles/business-economy/metropolitan-atlanta-rapid-transit-authority-marta [https://perma.cc/2KXC-TZK8], (last updated Apr. 14, 2021) (describing the Metropolitan Atlanta Rapid Transit Authority in Atlanta, Georgia); John Hepp, *SEPTA*, ENCYCLOPEDIA OF GREATER

currently only encompasses ambient air pollution, and all previous bills introducing IAQ laws in the United States would have enacted legislation separate from the CAA. Therefore, the difficulties of regulating IAQ under these two statutes may simply not be worth the trouble.

1. *OSHAct.* Underground railway stations and trains are places of work for transit employees and may therefore fall under the OSHAct, which requires employers to comply with health and safety regulations and standards promulgated pursuant to the Act.[190] These standards include PELs for various indoor air pollutants, including PM_{10}.[191] However, the OSHAct's weak, difficult-to-amend PELs make it a less feasible home for effective IAQ—and therefore subway air pollution—standards.

PM standards under OSHA are not stringent enough. The OSHA eight-hour PEL for PM_{10} is 5,000 $\mu g/m^3$,[192] over thirty-three times South Korea's eight-hour PM_{10} limit of 150 $\mu g/m^3$.[193] Additionally, no PEL specifically addresses $PM_{2.5}$. Both deficiencies render the current OSHA PM PELs grossly inadequate.

Two factors make it unlikely that OSHA would tighten its PELs. First, OSHA has never successfully fully updated its PELs.[194] Despite many PELs being "dangerously out of date" and not adequately protecting workers, OSHA has only issued updated PELs for about thirty chemicals since 1971.[195] Additionally, these updates have not

---

PHILA. (2014), https://philadelphiaencyclopedia.org/essays/septa [https://perma.cc/56S3-8VJU] (discussing the Southeastern Pennsylvania Transportation Authority in Philadelphia, Pennsylvania); *Facts About Dallas Area Rapid Transit (DART)*, DART, https://www.dart.org/about/dartfacts.asp [https://perma.cc/6PSG-NR95] (providing an overview of the Dallas Area Rapid Transit agency in Dallas, Texas).

190. *See* Occupational Safety and Health Act of 1970 § 5(a)(2), 29 U.S.C. § 654(a)(2) ("Each employer . . . shall comply with occupational safety and health standards promulgated under this chapter.").

191. *See PELs Tables*, *supra* note 72 (referring to PELs as mandatory standards adopted shortly after the enactment of the OSHAct).

192. 29 C.F.R. § 1910.1000 (2022); *see supra* notes 26–27 and accompanying text.

193. Choi et al., *supra* note 120, at 2746.

194. *See* Dave Johnson, *OSHA's Exposure Limits Are Dangerously Out of Date*, INDUS. SAFETY & HYGIENE NEWS (Jan. 4, 2016), https://www.ishn.com/articles/103083-oshas-exposure-limits-are-dangerously-out-of-date [https://perma.cc/6SZN-PE9R] ("Many of the PELs have not been updated since 1971 . . . .").

195. *Id.*

always been as ambitious as competing standards.[196] In the late 1980s, OSHA attempted to update its PELs en masse.[197] However, the U.S. Court of Appeals for the Eleventh Circuit vacated the rule on the basis that the agency did not explain why existing limits created a significant risk or whether or not the new standards "were economically or technologically feasible."[198] OSHA now only updates its PELs individually.[199] Given the disparity between the current PEL for PM_{10} and EPA and international standards, lowering the PM_{10} PEL to a suitably protective level and adding a $PM_{2.5}$ PEL may not be realistic. While Congress could pass new legislation directing OSHA to set PM PELs at stricter standards, it has never done so for a PEL. Ultimately, the obstacles to updating current PELs make the OSHAct less desirable as a main framework for subway air quality law.

2. *CAA*. Unlike the OSHAct, the CAA does not have an existing standard for indoor air pollutants. In fact, the CAA currently exclusively regulates emissions into ambient air.[200] In its fifty-year history, the CAA has never included IAQ provisions, and bills proposing federal IAQ legislation have attempted to enact separate legislation or amend statutes other than the CAA.[201] However, as the United States' comprehensive air quality statute, the CAA could be the natural home for broader IAQ legislation. Its mission to "protect and enhance the quality of the Nation's air resources"[202] may not have to apply exclusively to outdoor air. In fact, reducing indoor air pollution similarly "promote[s] the public health and welfare and the

196. *See* Kyle W. Morrison, *Reaching the Limit on PELs*, SAFETY+HEALTH (May 1, 2010), https://www.safetyandhealthmagazine.com/articles/reaching-the-limit-on-pels-2 [https://perma.cc/D7Q3-JWNG] ("[F]ollowing petitions, lawsuits and a court order, OSHA updated the [hexavalent chromium] PEL, but the 2006 update was at a level 5 times weaker than the limit NIOSH recommended in the late 1970s.").

197. *Id.*

198. *Id.*

199. *Id.*

200. *See CAA Summary*, *supra* note 61 ("The Clean Air Act . . . regulates air emissions from stationary and mobile sources . . . . [T]his law authorizes EPA to establish National Ambient Air Quality Standards (NAAQS) . . . .").

201. *See, e.g.*, Indoor Air Quality Act of 1990, S. 657, 101st Cong. (1990) (as reported by S. Comm. on Env't & Pub. Works, May 24, 1990) (enacting a new statute); Indoor Air Quality Act of 1989, H.R. 1530, 101st Cong. (1989) (enacting a new statute); Indoor Air Act of 1997, H.R. 2952, 105th Cong. (1997) (amending the Public Health Service Act).

202. Clean Air Act § 101(b)(1), 42 U.S.C. § 7401(b)(1).

productive capacity of [the U.S.] population"[203] by providing safe indoor spaces for people to visit, work, and engage in economic activity.

An IAQ law mirroring the CAA would likely consist of broad IAQ standards. One disadvantage of this strategy is the unsuitability of mandatory standards for IAQ law. In fact, "the indoor environment does not lend itself to the regulatory approach typically used to limit ambient air pollutants" due to indoor pollutants' variety of sources, including "biological sources, . . . combustion of substances, . . . and emissions from building materials," among others.[204] Researchers have therefore suggested that guideline values are more helpful in regulating IAQ.[205]

Furthermore, it is unclear how IAQ standards would fit into the structure of the CAA, as indoor air pollution reduction has different target structures. Current CAA provisions focus primarily on the regulation of emissions from large stationary entities[206] and vehicles[207] to meet the National Ambient Air Quality Standards for a number of pollutants.[208] The Act therefore combats ambient air pollution by requiring reductions in emissions *at particular sources*.[209] In contrast, indoor air pollution's variety of diverse, scattered sources does not lend itself to this framework.[210]

But even if IAQ standards would fit into the structure of the CAA, regulating IAQ under the CAA would have serious disadvantages. First, as in other sections of the CAA, Congress would need to engage in time-consuming line drawing to establish clear categories of

---

203. *Id.*

204. Kenichi Azuma, Hideto Jinno, Toshiko Tanaka-Kagawa & Shinobu Sakai, *Risk Assessment Concepts and Approaches for Indoor Air Chemicals in Japan*, 225 INT'L J. HYGIENE & ENV'T HEALTH, no. 113470, 2020, at 2.

205. *Id.*

206. *See, e.g.*, Clean Air Act § 111, 42 U.S.C. § 7411 (outlining the New Source Performance Standard program, in which the EPA creates a list of stationary source categories and establishes performance standards for new or modified sources within these categories).

207. *See* Clean Air Act § 202, 42 U.S.C. § 7521 (authorizing the EPA to establish emission standards for motor vehicles).

208. *See* Clean Air Act § 109(a), 42 U.S.C. § 7409(a) (authorizing the EPA to establish NAAQS for criteria air pollutants); *see, e.g.*, 40 C.F.R. § 50.6(a) (2022) (establishing NAAQS for PM_{10}); 40 C.F.R. § 50.18(a) (2022) (establishing updated NAAQS for $PM_{2.5}$).

209. *See Regulatory and Guidance Information by Topic: Air*, *supra* note 52 ("The Clean Air Act . . . gives EPA the authority to limit emissions of air pollutants coming from sources like chemical plants, utilities, and steel mills.").

210. *See supra* note 204 and accompanying text.

buildings to which the provision would apply.[211] For example, it may not be equitable to place the same burden on small store owners to maintain IAQ standards as owners and operators of large, heavily trafficked buildings. Determining the line—whether based on square footage, expected visitors, the demographic makeup of the people affected, etc.—would require extra research and time. Furthermore, the CAA tends to focus on particular pollutants.[212] However, a larger number of pollutants are likely hazardous in enclosed, indoor spaces than outdoors, as indicated by OSHA's hundreds of PELs.[213] This could further slow progress. One way to remedy this would be to set standards for only a select few pollutants, including PM. However, this option would still run into the same issues of equity and lack of control over certain sources of indoor air pollution; in fact, outdoor air, which building owners may not be able to mitigate, "is a major $PM_{2.5}$ source in rooms with natural ventilation."[214] Although this list of issues is not exclusive, it demonstrates that an IAQ law, whether broad or narrow, should likely fall outside the CAA.

B. Enacting New Federal Legislation: Building off International Standards-Based Models and DERA

Although U.S. environmental law frameworks may not include a feasible home for IAQ legislation, potential options exist outside of current federal law. This Part will consider the merits of (1) international standards-based laws and (2) DERA as models for new U.S. regulation. It will conclude by arguing that, while both have strengths, DERA presents a stronger model for future regulation,

211. *See* Clean Air Act § 111(b)(1)(A), 42 U.S.C. § 7411(b)(1)(A) (authorizing categorization of sources that contribute significantly to air pollution); Clean Air Act § 112(a)(1)–(2), 42 U.S.C. § 7412(a)(1)–(2) (distinguishing between major sources and area sources).

212. *See* Clean Air Act § 112(a)(6), (b), 42 U.S.C. § 7412(a)(6), (b) (defining hazardous air pollutants); Clean Air Act § 108(a), 42 U.S.C. § 7408(a) (establishing the method of designation for criteria air pollutants).

213. *See* GAO REPORT, *supra* note 74 (stating that OSHA has set six hundred PELs for indoor air pollutants); *Criteria Air Pollutants*, *supra* note 60 (listing the six currently designated criteria air pollutants); *Toxic Air Pollutants*, AM. LUNG ASS'N, https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/toxic-air-pollutants [https://perma.cc/YH2R-SHJU], (last updated July 13, 2020) ("The U.S. Environmental Protection Agency has classified 187 pollutants as hazardous.").

214. Sotiris Vardoulakis, Evanthia Giagloglou, Susanne Steinle, Alice Davis, Anne Sleeuwenhoek, Karen S. Galea, Ken Dixon & Joanne O. Crawford, *Indoor Exposure to Selected Air Pollutants in the Home Environment: A Systematic Review*, 17 INT'L J. ENV'T RSCH. & PUB. HEALTH, Dec. 2, 2020, at 1.

particularly because the diverse sources of indoor air pollution and procedural obstacles to enacting mandatory standards may make voluntary guidelines with a funding program better suited to IAQ issues, including in subway systems.

1. *International-Model-Based Approach: IAQ Guidelines Promulgated Through a New Law*. New federal legislation modeled after international air quality statutes could be a viable way to introduce statutory or regulatory limits on PM pollution in subways, whether through a broad IAQ statute or one exclusively focused on subway systems. Both South Korea and Taiwan provide models for an independent, standards-based IAQ law.[215] One major benefit of such a broad approach to subway air pollution is that it can simultaneously impact air quality levels in subways and in other buildings and structures with IAQ issues.[216] Additionally, these laws provide one comprehensive statute for all IAQ law and policy, creating a natural place for future IAQ laws and designating clear agency authority over indoor air pollution policy.[217] Lastly, passage of a concrete IAQ law, especially such a sweeping law, could generate popular support and faith in the government to handle other environmental issues.[218]

However, these approaches still suffer from the same drawbacks as a standards-based approach under the CAA; indoor air pollutants can come from a variety of interacting sources,[219] and debates over and creation of standards for a large number of pollutants could delay progress. While both South Korea and Taiwan partially mitigate these issues by applying IAQ standards only to larger, mainly public facilities,[220] administration of such an extensive program in a country as large as the United States would be difficult. An approach similar to the CAA's state implementation plans[221] could delegate administration

215. *See supra* notes 118–119 and accompanying text.

216. *See, e.g.*, *supra* notes 146–147 and accompanying text.

217. *See supra* notes 128, 144 and accompanying text.

218. With respect to the CAA, polls have shown that as recently as 2018, voters were "broadly favorable toward the Clean Air Act (65%) and EPA (59%), as well as EPA's efforts to enforce stricter limits on air pollution (74% support, including 48% strongly support)." *New Poll: Voters Overwhelmingly Support Stricter Limits on Smog*, AM. LUNG ASS'N (Apr. 24, 2018), https://www.lung.org/media/press-releases/new-poll-smog [https://perma.cc/8YZS-TPML].

219. *See supra* note 204 and accompanying text.

220. *See supra* notes 129, 146–147 and accompanying text.

221. *See Basic Information About Air Quality SIPs*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/air-quality-implementation-plans/basic-information-about-air-quality-sips [https://

and detailed planning to the states. However, the sheer number of affected buildings could still require a huge amount of time and effort by either the state or federal government.[222] Lastly, subway air pollution is a current environmental justice problem requiring expedient solutions,[223] and passage of a broad IAQ law may take much longer than passage of one narrowly tailored to the subway IAQ problem.

South Korea's Underground Air Quality Management Act[224] provides a loose model for a subway-specific policy. While the Underground Act included subterranean spaces like underground shopping districts in addition to subway stations,[225] a narrower approach only encompassing subway stations could be considered in the United States. One benefit of such an approach is that bill sponsors could lean into the saliency of the subway pollution issue, increasing the chance of a bill passing quickly. Additionally, Congress could tailor standards to the conditions of subway systems; for example, the law (or its subsequent regulations) could initially focus on PM pollution before expanding, avoiding debate about other pollutants. As new research comes out about other underground pollutants, the standards could be amended. Lastly, a law tailored to the subway issue could include other subway-specific provisions, possibly incorporating technology standards or funding provisions.

However, a subway-specific law runs into some of the same issues as a broader law. First, a mandatory-standards-based approach that sets aggressive limits on subway PM may place too heavy a burden on subway systems, which often run tight budgets.[226] Second, given

---

perma.cc/8V5B-TXH7], (last updated Jan. 25, 2022) (describing state implementation plans as "collection[s] of regulations and documents used by a state, territory, or local air district to implement, maintain, and enforce the National Ambient Air Quality Standards, or NAAQS, and to fulfill other requirements of the Clean Air Act").

222. As for federal government buildings alone, the U.S. General Services Administration "owns and leases over 376.9 million square feet of space in 9,600 buildings in more than 2,200 communities nationwide." *GSA Properties*, U.S. GEN. SERVS. ADMIN., https://www.gsa.gov/real-estate/gsa-properties [https://perma.cc/RBS2-5ANZ], (last updated Aug. 31, 2022).

223. *See supra* notes 15, 20 and accompanying text.

224. Jihasaenghwalgonggangonggijilgwallibeop [Air Quality Control in Underground Locations Act], *amended by* Act. No. 6911, May 29, 2003 (S. Kor.), *translated in* National Law Information Center's online database, https://elaw.klri.re.kr/eng_service/lawView.do?lang=ENG&hseq=8283 [https://perma.cc/7828-YJ24].

225. *Id.*

226. *See, e.g.*, Tom Dempsey, *A 'Doomsday Scenario' | Public Hearing Brings up Concerns in Maryland over WMATA Budget Cuts*, WUSA9 (Mar. 10, 2021, 12:05 AM), https://www.wusa9.

uncertainty over the sources of subway air pollution, mandatory standards may not be attainable, and burdens may vary widely over different subway systems and stations. Additionally, as most subway providers are states and municipalities, a mandatory standard could force state and local administration of a federal law, running into anticommandeering issues.[227] If enforcement mechanisms include withholding state funding or imposing high fines, the "stick" approach of this law could also lead to political resistance from subway systems. Instead, a "carrot" approach offering funding and modeled off a law like DERA, in conjunction with voluntary guidelines, may be more successful.

2. *DERA-Based Approach: A Funding Program That Incentivizes Action at the State and Local Level.* A DERA-based funding program may provide the format necessary to mitigate subway air pollution quickly and with the support of subway operators. A program like DERA's would have three main benefits: (1) a specific focus on subways; (2) a carrot-based approach; and (3) flexibility for subway systems to experiment with various methods of pollution mitigation. First, as with a subway-focused, standard-based program, a funding program targeting subway air pollution could capitalize on the current saliency of the issue to pass more quickly. Furthermore, as the DERA framework provides a reward for action, rather than a punishment for inaction,[228] subway systems would likely also support its passage and participate.[229] Additional targeted funding to budget-constrained subways could allow systems that could not otherwise afford it to invest in mitigation efforts. Additionally, without the pressure of punishment

com/article/news/local/maryland/wmata-budget-2022-cuts-maryland-metro-rail-bus/65-b93294b9-caca-413d-902a-294bffaeab08 [https://perma.cc/66KE-F6MD] (explaining that WMATA faced a funding gap of $210 million in 2021); Michelle Kaske, *MTA Faces $2.5 Billion Deficit Once Aid Runs Out, Group Says*, BLOOMBERG (July 20, 2021, 12:15 PM), https://www.bloomberg.com/news/articles/2021-07-20/mta-faces-2-5-billion-deficit-once-aid-runs-out-group-says [https://perma.cc/F8LF-GQBQ] ("New York's Metropolitan Transportation Authority will face ongoing budget shortfalls of nearly $2.5 billion a year.").

227. *See* New York v. United States, 505 U.S. 144, 188 (1992) ("The Federal Government may not compel the States to enact or administer a federal regulatory program.").

228. *See supra* Part II.A.4.

229. *See* Jason Scott Johnston, *Regulatory Carrots and Sticks in Climate Policy: Some Political Economic Observations*, 6 TEX. A&M L. REV. 107, 109–10 (2018) ("Once in existence, legislative carrots generate economic rents that create present day capitalized gains, which drive up the stakes for beneficiaries, thus rationally motivating them . . . to make sure that they keep the carrots.").

if standards are not met, subway systems would have more flexibility to experiment with potential new technologies that would be too risky otherwise.

The primary downside of a DERA-based program is that it only targets one issue: subway air pollution. Broader IAQ laws could simultaneously regulate indoor air pollution in a variety of indoor spaces. Additionally, the law would be yet another federal program reliant on yearly funding.[230] If Congress were to decide not to reauthorize its IAQ legislation, it could become ineffective.[231] However, of the disadvantages of each type of approach, a DERA-based law's disadvantages seem the easiest to overcome. For example, a separate funding program does not preclude the establishment of broad IAQ standards; instead, it allows subways to begin working on reducing PM pollution while Congress decides how to set IAQ standards or voluntary guidelines. In addition, Congress could initially authorize funding for subways long into the future, and, if the law is effective, subways should no longer need funding, as the air will be clean.

CONCLUSION

For the sake of public health, the United States must enact stricter subway air quality legislation. The potential impacts of PM on human health are serious and often deadly, and current federal law does not provide an effective avenue for IAQ regulation. However, the Diesel Emissions Reduction Act provides a promising model for legislation. Using DERA's structure as a model, the United States could pass a funding-incentive law to aid subway systems in cutting down pollution. At the same time, the United States should look to international models to develop broad IAQ guidelines for buildings in general. PM pollution disproportionately affects historically oppressed groups, particularly Black Americans. Because the Biden administration has emphasized environmental justice[232] and because this issue will

230. *See* LATTANZIO, *supra* note 71, at 2 (describing DERA's reliance on congressional appropriations).

231. *Id.*

232. Agya K. Aning, *The Biden Administration's Embrace of Environmental Justice Has Made Wary Activists Willing To Believe*, INSIDE CLIMATE NEWS (Aug. 1, 2021), https://insideclimatenews.org/news/01082021/biden-environmental-justice [https://perma.cc/22K8-AD2Q].

continue to harm commuters, transit workers, and others daily, the United States should quickly act to reduce subway air pollution.

APPENDIX

Table 1: Indoor Air Quality Bills Introduced in the United States[233]

Year	Bill Number	Name	Congress	Primary Sponsor	General Provisions
2021	H.R.1398[234]	Filtering and Retrofitting the Environment for Safe and Healthy Activities Indoors and Revenues for Businesses Act	117th	Rep. Carolyn Bourdeaux (D-GA-7)	Payroll tax credit to incentivize employers to improve ventilation, zoning, air filtration, and purification Would have funded up to 50 percent of the cost with a cap of $15,000 per year
2020	S.4782[235]	Keeping Schools Safe Act	116th	Sen. Martin Heinrich (D-NM)	Grants to improve IAQ in schools
1997	H.R.2952[236]	Indoor Air Act of 1997	105th	Rep. Joseph P. Kennedy II (D-MA-8)	Numerous provisions on research, establishment of new offices, etc. Would have authorized promulgation of voluntary IAQ guidelines

233. None of the listed bills became law.

234. Filtering and Retrofitting the Environment for Safe and Healthy Activities Indoors and Revenue ("FRESH AIR") for Businesses Act, H.R. 1398, 117th Cong. (2021).

235. Keeping Schools Safe Act, S. 4782, 116th Cong. (2020).

236. Indoor Air Act of 1997, H.R. 2952, 105th Cong. (1997).

1995	H.R.933[237]	Indoor Air Act of 1995	104th	Rep. Joseph P. Kennedy II (D-MA-8)	Numerous provisions on research, establishment of new offices, etc. Would have authorized promulgation of voluntary IAQ guidelines
1994	S.656[238]	Indoor Air Act of 1994	103rd	Sen. George Mitchell (D-ME)	Numerous provisions on research, establishment of new offices, etc. Would have authorized promulgation of voluntary IAQ guidelines
1994	H.R.2919[239]	Indoor Air Act of 1994	103rd	Rep. Joseph P. Kennedy II (D-MA-8)	Numerous provisions on research, establishment of new offices, etc. Would have authorized promulgation of voluntary IAQ guidelines
1993	H.R.1930[240]	Indoor Air Quality Act of 1993	103rd	Rep. Joseph P. Kennedy II (D-MA-8)	Numerous provisions on research, establishment of new offices, etc.
1991	S.455[241]	Indoor Air Quality Act of 1991	102nd	Sen. George Mitchell (D-ME)	Numerous provisions on research, establishment of new offices, etc.

237. Indoor Air Act of 1995, H.R. 933, 104th Cong. (1995).
238. Indoor Air Act of 1994, S. 656, 103d Cong. (1993).
239. Indoor Air Act of 1994, H.R. 2919, 103d Cong. (1993)
240. Indoor Air Quality Act of 1993, H.R. 1930, 103d Cong. (1993).
241. Indoor Air Quality Act of 1991, S. 455, 102d Cong. (1991).

1991	H.R.1066[242]	Indoor Air Quality Act of 1991	102nd	Rep. Joseph P. Kennedy II (D-MA-8)	Numerous provisions on research, establishment of new offices, etc.
1990	H.R.5155[243]	Indoor Air Quality Act of 1990	101st	Rep. Robert Roe (D-NJ-8)	Numerous provisions on research, establishment of new offices, etc.
1990	S.657[244]	Indoor Air Quality Act of 1990	101st	Sen. George Mitchell (D-ME)	Numerous provisions on research, establishment of new offices, etc.
1989	H.R.1530[245]	Indoor Air Quality Act of 1989	101st	Rep. Joseph P. Kennedy II (D-MA-8)	Numerous provisions on research, establishment of new offices, etc.
1988	S.1629[246]	Indoor Air Quality Act of 1988	100th	Sen. George Mitchell (D-ME)	Provisions on research efforts, implementation plan First bill to propose the establishment of an Office of Indoor Air Quality at the EPA
1988	H.R.5373[247]	Indoor Air Quality Act of 1988	100th	Rep. Joseph P. Kennedy II (D-MA-8)	Provisions on research efforts, implementation plan
1987	H.R.3809[248]	Indoor Air Quality Act of 1987	100th	Rep. Joseph P. Kennedy II (D-MA-8)	Provisions on research efforts, implementation plan

242. Indoor Air Quality Act of 1991, H.R. 1066, 102d Cong. (1991).
243. Indoor Air Quality Act of 1990, H.R. 5155, 101st Cong. (1990).
244. Indoor Air Quality Act of 1990, S. 657, 101st Cong. (1989).
245. Indoor Air Quality Act of 1989, H.R. 1530, 101st Cong. (1989).
246. Indoor Air Quality Act of 1988, S. 1629, 100th Cong. (1987).
247. Indoor Air Quality Act of 1988, H.R. 5373, 100th Cong. (1988).
248. Indoor Air Quality Act of 1987, H.R. 3809, 100th Cong. (1987).

1985	H.R.2101[249]	Indoor Air Quality Act of 1985	99th	Rep. Claudine Schneider (R-RI-2)	Provisions on research efforts, implementation plan
1985	S.1198[250]	Indoor Air Quality Research Act of 1985	99th	Sen. George Mitchell (D-ME)	EPA IAQ research program Would have authorized creation of committees with reps from agencies, scientific community, industry, and NGOs Would have required the EPA to create IAQ research implementation plan within ninety days
1982	H.R.6289[251]	Indoor Air Pollution Research Act of 1982	97th	Rep. Claudine Schneider (R-RI-2)	EPA IAQ research program Would have established body similar to current CIAQ Would have required the EPA to work with state and local officials and private sector to develop industrywide voluntary IAQ standards for residential buildings

249. Indoor Air Quality Act of 1985, H.R. 2101, 99th Cong. (1985).
250. Indoor Air Quality Research Act of 1985, S. 1198, 99th Cong. (1985).
251. Indoor Air Pollution Research Act of 1982, H.R. 6289, 97th Cong. (1982).

Table 2: International Indoor Air Quality Laws

Governing Body	**Law or Regulation**	**Year**	**Mandatory or Voluntary**	**Covered Buildings (if applicable)**	**PM_{10} Standard**	**$PM_{2.5}$ Standard**
Australia[252]	Work Health and Safety Act	2011	Mandatory	Workplaces	n/a (but guidelines suggest 10 mg/m^3 (10,000 $\mu g/m^3$))	n/a
China[253]	Indoor Air Quality Standard	2002	Voluntary	Residential and office buildings	0.15 mg/m^3 (150 $\mu g/m^3$) (24-hr)	n/a
Hong Kong[254]	Indoor Air Quality Certification Scheme	2003	Voluntary	Offices and public buildings	Good Class: 100$\mu g/m^3$ (8-hr); Excellent Class: 20 $\mu g/m^3$ (8-hr)	n/a

252. *See supra* notes 163–166 and accompanying text.
253. *See supra* notes 174–176 and accompanying text.
254. *See supra* notes 179–182 and accompanying text.

Japan[255]	Act on Maintenance of Sanitation in Buildings	1970	Mandatory	Buildings with floor space greater than 3,000 m^2 used as entertainment venues, department stores, meeting halls, libraries, museums, art galleries, amusement halls, stores, offices, inns, etc.	150 $\mu g/m^3$ for suspended PM (unclear whether 8-hr or 24-hr)	n/a
Singapore[256]	Standard for Indoor Air Quality for Air-Conditioned Buildings	2016	Voluntary	All buildings with intermittent or continuous use of air conditioning	50 $\mu g/m^3$ (8-hr)	n/a
South Korea[257]	Indoor Air Quality Control Act	2003	Mandatory	Public-use facilities, newly built multifamily housing, and mass transit vehicles	150 $\mu g/m^3$ (24-hr)	50 $\mu g/m^3$ (24-hr)

255. *See supra* notes 155–160 and accompanying text.
256. *See supra* notes 174, 177–178 and accompanying text.
257. *See supra* notes 127–132 and accompanying text.

Taiwan[258]	Indoor Air Quality Act	2011	Mandatory	Universities, government agencies, transportation stations, medical care centers, movie theaters, malls, gyms, carriages in mass transportation, and more	75 μg/m^3 (24-hr)	35μg/m^3 (24-hr)
United Kingdom[259]	Control of Substances Hazardous to Health	2002	Mandatory	Workplaces	n/a	n/a
WHO[260]	Global Air Quality Guidelines [AMBIENT]	2021	Voluntary	Unspecified	45 μg/m^3 (24-hr, ambient air)	15 μg/m^3 (24-hr, ambient air)

258. *See supra* notes 144–149 and accompanying text.

259. *COSHH Basics*, HEALTH & SAFETY EXEC., https://www.hse.gov.uk/coshh/basics/index.htm [https://perma.cc/4M3F-834R].

260. WHO GLOBAL AIR QUALITY GUIDELINES, *supra* note 54, at 88, 97.