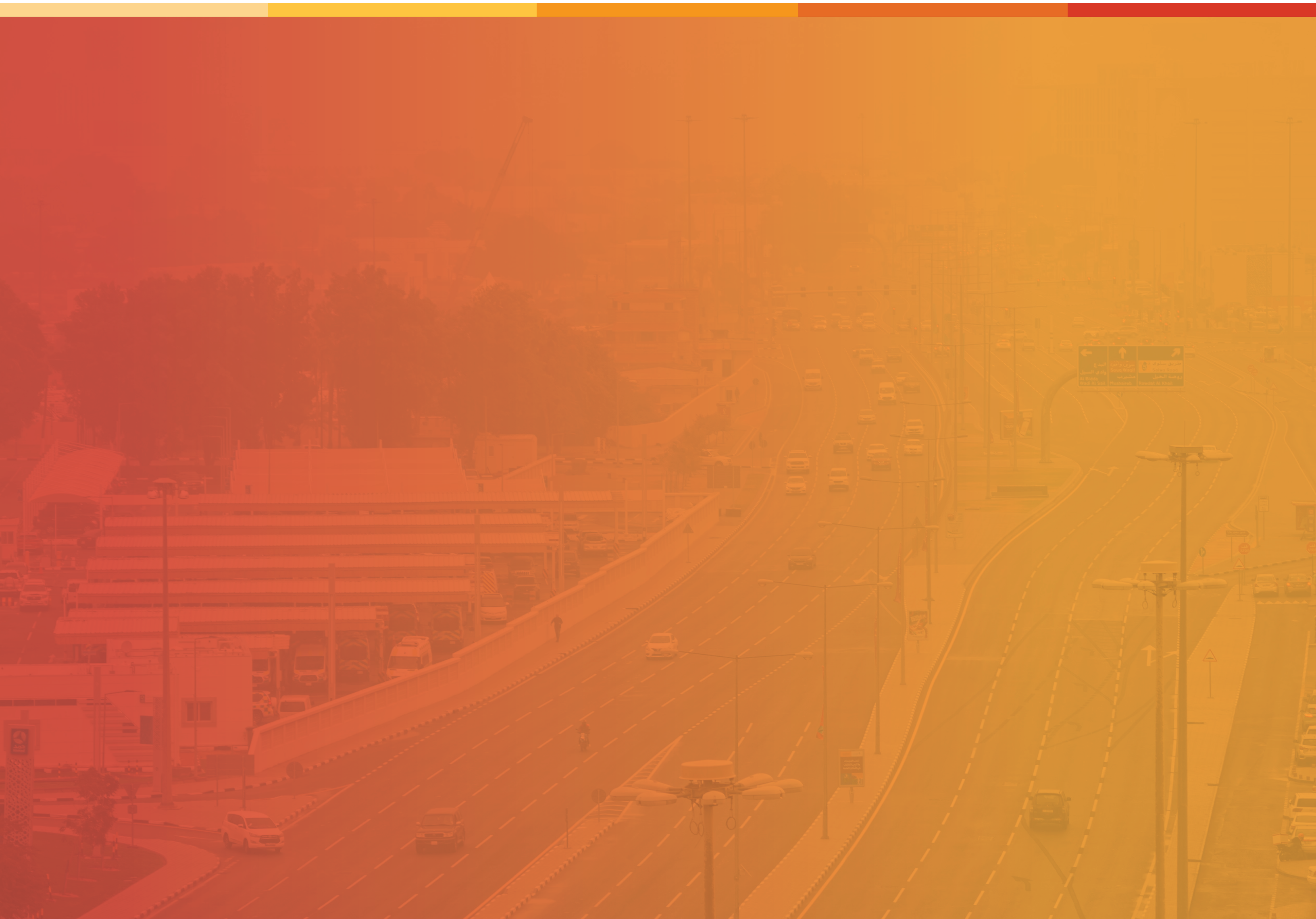
AQLI Air Quality Life Index®

AIR QUALITY LIFE INDEX® | 2024

Annual Update

By Michael Greenstone, Tanushree Ganguly, Christa Hasenkopf, Nishka Sharma and Hrishikesh Gautam



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ACKNOWLEDGEMENTS

We would also like to deeply thank Prof. Randall Martin, Dr. Aaron van Donkelaar and the Atmospheric Composition Analysis Group at the University of Washington at St. Louis for their continued partnership in providing us with global satellite-derived annual ground level $PM_{2.5}$ data. We would like to acknowledge Aarsh Batra for providing excellent data analysis and Avi Sharma for his support in generating maps for this manuscript.

Dear Friends and Colleagues,

We're pleased to bring you the latest data from the Air Quality Life Index (AQLI). This data shows that fine particulate air pollution remains the greatest external threat to public health. But pollution is also unequally distributed amongst the world, with those breathing the dirtiest air (top quintile) expected to see almost 3 years cut from their lives if high pollution persists compared to those breathing the cleanest air (bottom quintile).

In this year's report we build off a theme from last year: that pollution is unequal because the basic tools and infrastructure countries have to fight pollution is unequal. The missing tools we highlighted last year focused on funding availability, monitoring and open data access. To help confront this global challenge, this year we launched a new initiative—the EPIC Air Quality Fund—to support local groups and organizations in installing monitors and providing open data to communities that could benefit the most. Providing this data allows citizens to understand the depth of the pollution problem where they live and call for change.

Open access to data also provides a necessary guidepost for setting and evaluating air quality standards—the theme of this year's report. Our report shows that if countries adopt ambitious standards and implement policies to achieve them, global life expectancy would significantly improve. These standards—some strong and some weak—reflect the multiple policy goals countries have as they balance economic, environmental, and health goals. However, more than three-quarters of countries and territories around the world are not meeting their national pollution standards or have not even set a standard.

While the AQLI Annual Report highlights where standards have not been met, and policies are failing, it's important to also highlight the success stories that can aid other parts of the world. Throughout history countries like the United States, Europe, Japan, and, most recently, China have been able to significantly reduce air pollution thanks to strong policies (policies that came only after a persistent, public call for change). China, for example, now meets its national standard and residents are living two years longer because of the policy changes that have significantly reduced pollution since the country declared a war against it in 2014. Building on this success, China is now aiming for a further 10 percent reduction in particulate concentrations across its prefectures by 2025, compared to 2020 levels.

India's national standard is similar to China's, but only 60 percent of the population breathes air that meets this standard. Fortunately, India is responding by implementing innovative policies. In 2019, the state of Gujarat—in collaboration with Greenstone and colleagues—launched the world's first market for particulate pollution. The market has since reduced pollution by 20-30 percent in the city of Surat, and is rapidly expanding to other cities and states. These types of innovative policies demonstrate that it is possible to achieve improvements in air quality and people's health, without unduly impeding economic growth (in this case, it increased economic growth).

EPIC will continue to bring data about the pollution people breathe to communities who would benefit the most through our Air Quality Fund, effectively communicate how this pollution impacts their health through the AQLI, and work with governments on the ground to devise and test policies that reduce this pollution at the least cost. This multi-pronged strategy aims to not just expose the problem—that widespread pollution is causing the average person on the planet to lose 1.9 years off their life—but to also help solve it.

Sincerely,

Michael Greenstone
Milton Friedman
Distinguished Service Professor
Director, EPIC

Christa Hasenkopf
Director, Clean Air Program
EPIC

Tanushree Ganguly
Director, AQLI
EPIC

At a Glance

While global pollution declined slightly in 2022, it is still the greatest external threat to human life expectancy.

- The AQLI's 2022 data reveals that permanently reducing global $PM_{2.5}$ pollution to meet the World Health Organization (WHO) guideline of 5 µg/m³ would add 1.9 years onto average human life expectancy—or a combined 14.9 billion life years.
- The impact of $PM_{2.5}$ on global life expectancy is comparable to that of smoking, 1.3 times that of childhood and maternal malnutrition, 4.4 times that of high alcohol use, 5.8 times that of transport injuries like car crashes and unsafe water, and 6.7 times that of HIV/AIDS.[1]

Pollution is highly unequal around the world, and so are policy ambitions.

- People in the most polluted areas of the world breathe air that is six times more polluted than those in the least polluted areas. As a result, their life expectancy is reduced by an average of 2.7 years compared to those living in the cleanest places.
- National air quality standards—an important tool to set strong policies—vary significantly, with some countries enforcing strict limits as low as the WHO guideline, others setting looser limits up to 50 µg/m³, and some having no standards at all.

Many countries with national standards are not meeting them, impacting life expectancy.

- Ninety-four out of 252 countries and territories globally have national standards, making up 80 percent of the world's population.[2] However, 37 of those countries aren't meeting them, making up 30 percent of the world's population.
- If all countries and territories with standards met them, the average person living in these regions would add 1.2 years onto their lives.

When countries enforce and meet their national standards, life expectancy improves.

- Because of stringent policies, the United States and Europe have significantly reduced pollution—now accounting for only 3.9 percent of the health burden from particulate pollution globally. Both regions have introduced or enacted even more stringent standards over the last year, which if met would result in an average gain in life expectancy of 1.3 months and 4 months in the United States and Europe, respectively.
- China has also succeeded in meeting its national standards. Residents are now living 2 years longer because of the policy changes that have significantly reduced pollution since the country declared a war against it in 2014.
- While India's national standard is similar to China's, only 60 percent of the population breathes air that meets this standard. Fortunately, India is responding by implementing innovative policies. In 2019, the state of Gujarat launched the world's first market for particulate pollution. The market has since reduced pollution by 20-30 percent in the city of Surat and is rapidly expanding to other cities and states.

Many countries without national standards are highly polluted and lack critical tools.

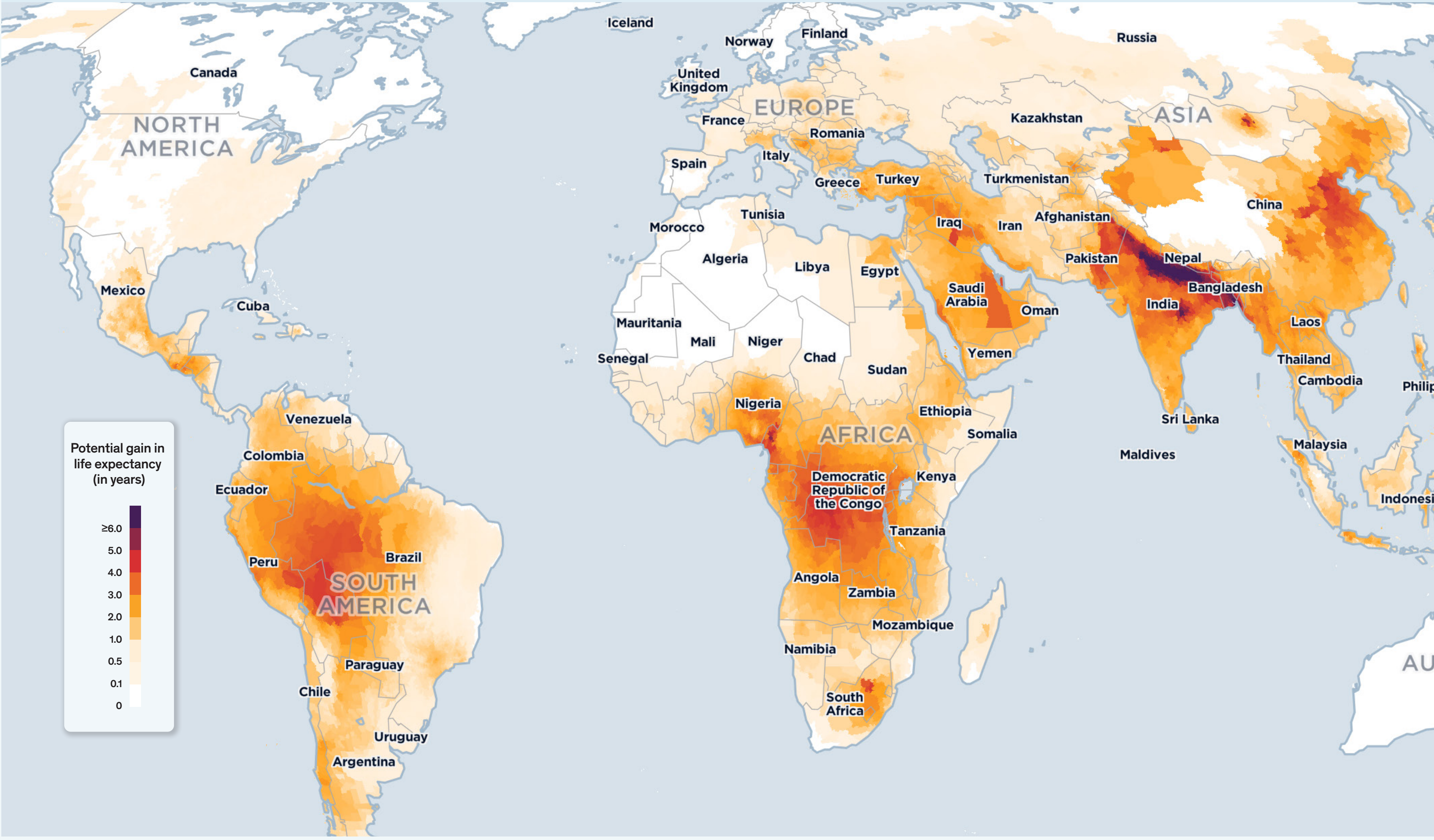
- More than half of all countries and territories around the world—158 out of 252—don't have a pollution standard at all. Those countries make up 12.4 percent of the health burden from particulate pollution globally. Only one-third of the countries that don't have standards show evidence of government monitoring, and less than 1 percent of these countries have fully open data. With little data, it is difficult to set pollution standards and enforce them.
- To help confront this challenge, this year EPIC launched the EPIC Air Quality Fund to support local groups and organizations in installing monitors and providing open data to communities that could benefit the most.

The decline in global pollution in 2022 was due almost entirely to a trend reversal in South and Southeast Asia, while pollution is on the rise in the Middle East and North Africa and Sub-Saharan Africa.

- Global pollution declined in 2022 almost entirely due to a trend reversal in South Asia—with an 18 percent decline in

1 Global Burden of Disease (https://vizhub.healthdata.org/gbd-results/) level-2 causes and risks data and WHO Life Tables (https://apps.who.int/gho/data/node. main.LIFECOUNTRY?lang=en) were combined with the Life table method to arrive at these results. "$PM_{2.5}$ relative to WHO Guideline" bar displays the reduction in life expectancy relative to the WHO guideline as calculated by latest AQLI (2022) data

2 AQLI's compilation of country-level national ambient $PM_{2.5}$ standards can be found here (Country_annual_average_pm2.5_standards_July2024 - Google Sheets). The information in this sheet is updated to the best of our knowledge. We encourage readers to reach out if information provided here is incorrect, missing, or has been updated.



pollution over one year (and to a lesser extent, Southeast Asia, with a 4.8 percent decline). Though it is difficult to conclusively determine the reasons for this decline, meteorological causes—such as above normal rainfall—likely played a strong role. While pollution declined slightly, the region remains the most polluted in the world, with residents set to lose 3.5 years of life expectancy if South Asia does not meet the WHO guideline.

- While pollution declined in the South and Southeast Asia, pollution levels increased across the Middle East and African continent.[3] In the Middle East and North African (MENA) regions, concentrations increased by 13 percent. If pollution were reduced to meet the WHO guideline, people living in this region would gain 1.3 years of life expectancy.

3 All region definitions used in this report can be found here: AQLI AR 2024 Regions - Google Sheets

Pollution is on par with known threats to life in local regions.

- In Central and Western Africa, air pollution is now as much of a health threat as well-known killers in the region like HIV/AIDS, malaria and unsafe water. An average resident of this region will lose 1.7 years off their lives if pollution persists at current levels.

- The health threat posed by particulate pollution is greater or comparable to that of suicide and violence in many parts of South America. For example, in Boliva—the most polluted country in Latin America—its toll on life expectancy is nine times higher than that of suicide and violence. In Colombia, the impact is about comparable.

Section 1

Global pollution levels drop, but countries fail to meet their own pollution standards

PARTICULATE POLLUTION DROPPED FROM PREVIOUS YEARS BUT IS STILL FAR FROM SAFE: 2022 GLOBAL UPDATE

New and revised satellite-derived $PM_{2.5}$ data show a reduction in global population-weighted $PM_{2.5}$ levels—reducing from 26.6 µg/m³ in 2021 to 24.2 µg/m³ in 2022. The AQLI shows that reducing global $PM_{2.5}$ pollution to meet the WHO guideline would add 1.9 years onto average life expectancy, translating to a total gain of 14.9 billion years—making particulate pollution the greatest threat to human health. This burden of particulate pollution on life expectancy is comparable to that of tobacco use, 1.3 times that of childhood and maternal malnutrition, 4.4 times that of high alcohol use, 5.8 times that of transport injuries or unsafe water, handwashing and sanitation, 6.7 times that of HIV/AIDS, and 26.7 times that of nutritional deficiencies (Figure 1.1).

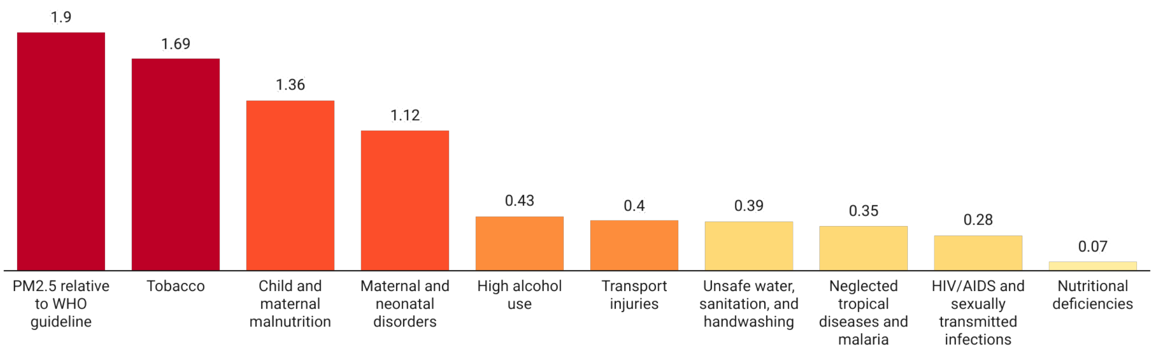
PROGRESS IN SOUTH ASIA, BUT HIGHER AIR POLLUTION IN AFRICA AND THE MIDDLE EAST

Global particulate pollution concentrations continue to remain fairly constant over the past two decades, with pollution declining in some regions and increasing in others. While China's decline in pollution continued in 2022—reducing its pollution by 41 percent since it began its "war on pollution" and extending its population's average life expectancy by 2 years if sustained— South Asia made a significant trend reversal in 2022 (Figure 1.2). Instead of its pollution steadily increasing as it has for at least the last two decades, the region saw a sharp decline in pollution of 18 percent from 2021 to 2022 (50.7 to 41.4 µg/m³) . Had the pollution levels in South Asia not declined, global pollution levels would have remained the same as last year.

The South Asian decline from 2021 to 2022 is the largest single year decline for a region in the data since the beginning of its collection in 1998. If the decline is sustained, it would translate into 0.9 years of life expectancy gained compared to 2021 levels.

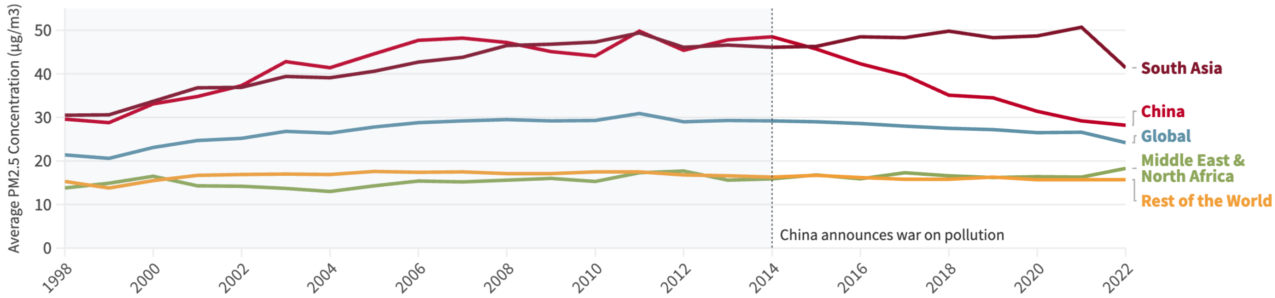
With the evidence currently available, it is difficult to conclusively determine what accounts for reduced particulate pollution levels in South Asia in 2022. $PM_{2.5}$ concentrations were lower in all South

Figure 1.1 · Selected major threats to life expectancy



Sources: Global Burden of Disease (https://vizhub.healthdata.org/gbd-results/) level-2 causes and risks data and WHO Life Tables (https://apps.who.int/gho/data/node. main.LIFECOUNTRY?lang=en) were combined with the Life table method to arrive at these results. "$PM_{2.5}$ relative to WHO Guideline" bar displays the reduction in life expectancy relative to the WHO guideline as calculated by latest AQLI (2022) data

Figure 1.2 · Global and select regional annual average $PM_{2.5}$ concentrations, 1998-2022



Note: South Asia is defined as the following countries: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka. Rest of the World refers to all regions across the globe except South Asia and China. Middle East & North Africa (MENA) is defined as the following countries: Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates, Palestine, and Yemen. Rest of the world doesn't include South Asia, China and MENA

Asian countries except Sri Lanka. At the country level, the highest decline was observed in Bangladesh followed by India and Nepal. In some districts of Dhaka and Chittagong in Bangladesh and West Bengal and Jharkhand in India, reductions in $PM_{2.5}$ concentrations relative to 2021 are higher than 20 µg/m³.

Recent evidence from India[4] suggests that favorable meteorological conditions amplified the impact of the small decreases in emissions of $PM_{2.5}$ particles and $PM_{2.5}$ precursors (SO_2, NO_x, NH_3) in the country. This coupled with the fact that the decline was region-wide, suggests that meteorology could have played a significant role in reducing pollution levels across South Asia. Evidence also points to above normal rainfall in many parts of South Asia in 2022 [5] and higher precipitation has been linked with lower pollution levels. While it is difficult to conclusively determine what reduced $PM_{2.5}$ levels across South Asia, it is safe to posit that favorable meteorological conditions may have played a part. Moving forward, continued observations, efforts towards policy enforcement and monitoring impacts of policy interventions will be critical for understanding and sustaining these reductions.

Despite this improvement, South Asia remains the world's most polluted region, with residents breathing air that is eight times more polluted than what the WHO has deemed safe. If pollution were permanently reduced to meet the WHO guideline, people living in this region could see 3.6 years added onto their lives.

While news from South Asia—the most widely covered region in the media for its air pollution challenges—was positive, $PM_{2.5}$ estimates suggest that the Middle East and North Africa is emerging as a pollution hotspot. $PM_{2.5}$ in this region increased by 13 percent compared to 2021. While difficult to conclusively determine what increased particulate concentrations in 2022, pollution in the region has been attributed to road vehicles, municipal solid waste burning, agriculture and industrial processes.[6] People in this region could live 1.3 years longer than if they were to breathe air that complies with the WHO guideline.

WIDESPREAD DIFFERENCES IN AIR QUALITY STANDARDS AND DIFFICULTIES IN ENFORCING STANDARDS

Whether pollution is increasing or decreasing, it's clear that some regions of the world are much more polluted than other regions. People living in the most polluted places (the top quintile) breathe air that is six times more polluted than the air breathed by those living in the least polluted places (bottom quintile) (Figure 1.3). That means that pollution in the most polluted places is cutting 2.7 more years off the lives of those living in them compared to those in the cleanest places.

While geographic terrain and meteorological factors can have an influence on pollution, varying policy ambitions in the form of clean air standards or emission reduction goals—and the ability of countries to enforce them—are a primary determinant of pollution levels. Policy ambitions vary significantly among countries, with some countries setting strict national air quality standards, others setting weaker ones, and still others setting none (Figure 1.4a). A national air quality standard is critical to efforts to reduce pollution because it allows policymakers to have a guidepost to use to set policy goals and evaluate their success. Out of the 252 countries and territories analyzed in this report, 94 countries that are home to more than 81 percent of the world's population have air quality standards for $PM_{2.5}$.[7]

Of course, countries set air quality standards to reflect multiple

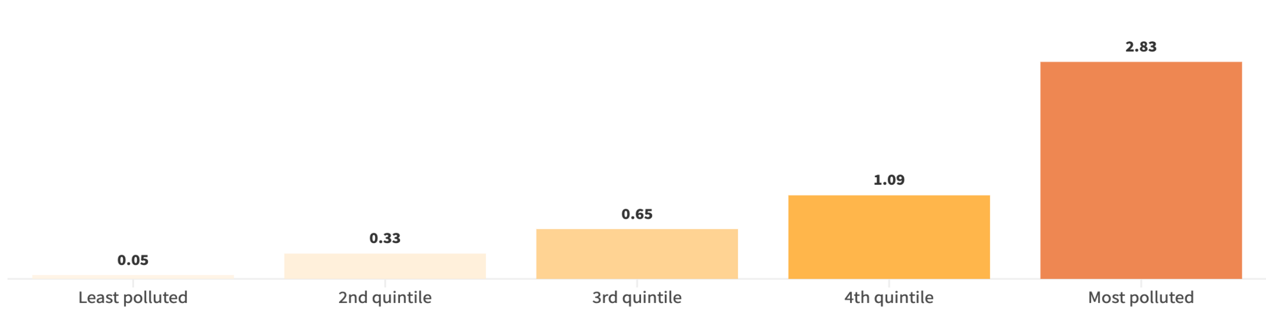
4 Yuanyu Xie, Mi Zhou, Kieran M. R. Hunt, and Denise L. Mauzerall. 2024. "Recent $PM_{2.5}$ air quality improvements in India benefited from meteorological variation" Nature Sustainability (2024). https://doi.org/10.1038/s41893-024-01366-y

5 World Meteorological Institute. 2023. "State of Climate in Asia in 2022" https://wmo.int/publication-series/state-of-climate-asia-2022 https://doi.org/10.1016/j.scitotenv.2024.170963

6 World Bank. 2022. "Middle East And North Africa Development Report: Blue Skies, Blue Seas Air Pollution, Marine Plastics, and Coastal Erosion in the Middle East and North Africa" https://openknowledge.worldbank.org/server/api/core/bitstreams/9125cb69-90b8-53b0-b645-800b33e9d1ee/content

7 Refer Footnote 2

Figure 1.3 · Difference in life expectancies of the least and most polluted regions across the world



national policy goals. For example, they may perceive that the costs from stricter air pollution policies in terms of industrialization and economic prosperity may exceed the benefits in their countries. There are also a variety of distributional considerations—factors related to fairness and equity—that enter countries' decision-making.

Countries have differing degrees of success in achieving their standards. The enforcement of standards requires commitment to enforce reductions on a multitude of polluters, both mobile (e.g., vehicles) and stationary (e.g., factories and power plants). This can be especially challenging in countries with weaker state capacity. Indeed, countries' track records are quite mixed. For instance, in India, environmental regulatory institutions are often viewed as suboptimal.[8] Despite similar governance structures for air and water pollution in India, their effectiveness varies significantly. Air pollution regulations have proven more impactful compared to water pollution regulations. This discrepancy is attributed to greater citizen engagement and judicial intervention in air pollution issues compared to water pollution.[9]

Further, environmental standards can often have unintended consequences. In the case of tightening vehicle exhaust emission standards in the United States, it has been found that while the new standards have been effective in reducing emissions from new vehicles, they have made new cars more expensive — increasing the demand for older, dirtier vehicles as an alternative. It has been estimated that more than two-thirds of pollution emissions in a year can be attributed to vehicles older than 10 years.[10] This makes a case for assessing effectiveness of tighter standards and focusing on ways in which standards can be better enforced.

These are just a few examples of the many considerations that play into a country's decision making around ambient air quality standards, thereby, resulting in countries having different standards. South Asia is a good example of these nuances. In India, where the annual $PM_{2.5}$ standard is 40 µg/m³, more than 40 percent of the population breathes air that exceeds the standard. In 2021, Bangladesh revised its annual $PM_{2.5}$ standard from 15 µg/m³ to 35 µg/m³. In 2022, 96.8 percent of Bangladesh's population breathed air that did not meet this revised standard. In Pakistan, where pollution levels are like those in India and Bangladesh, the $PM_{2.5}$ standard is much stricter (set at 15 µg/m³), and virtually the country's entire population breathes air that doesn't meet the standard.

37 out of the 94 countries and territories with standards—home to 30 percent of global population—don't meet their national standards (Figure 1.4b). If they did, an average person living in these countries could live 1.17 years longer. Iraq, Bangladesh, and Pakistan would see the highest benefits, with life expectancies increasing by 2.2 years, 1.9 years, and 2.3 years, respectively (Figure 1.4c).

However, the ability to meet standards is a problem even in regions of the world that are cleaner and that have stronger limits. While the European Union has recently set a much stricter 2030 target of 10 µg/m³ for $PM_{2.5}$, the pollution levels in the countries of Bulgaria, Croatia, Cyprus, Czechia, Greece, Hungary, Italy, Latvia, Poland, Romania, Slovakia, and Slovenia, exceed this tighter standard. More than 75 percent of the population in these countries breathes air that doesn't meet the standard. If these countries were to meet this 2030 $PM_{2.5}$ limit, the life expectancy of an average resident in these countries could go up by 4 months.

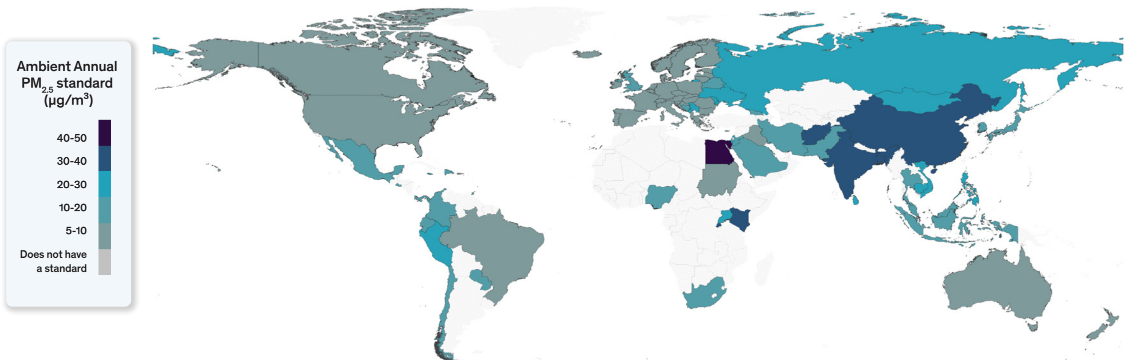
A standard—even one not quite achieved yet—is still better than no standard at all. While 94 countries and territories have a standard, even more—158—do not have a standard. Countries like the Republic of Congo, Cameroon, and Equatorial Guinea—where pollution is among the highest in the world—do not have a pollution standard. The fact that one-third of the countries without air quality

8 Center for policy research. 2022. "The State of India's Pollution Control Boards – A Series of Papers" https://cprindia.org/workingpapers/the-state-of-indias-pollution-control-boards/

9 Michael Greenstone, and Rema Hanna. 2014. "Environmental Regulations, Air and Water Pollution, and Infant Mortality in India" American Economic Review 2014, 104(10): 3038–3072" https://www.theigc.org/sites/default/files/2016/06/Greenstone_Hanna.pdf

10 Kleiman center for energy policy. 2022. "How Effective Are Vehicle Exhaust Standards?" https://kleinmanenergy.upenn.edu/wp-content/uploads/2022/12/KCEP-Digest-How-Effective-Are-Vehicle-Exhaust-Standards.pdf

Figure 1.4a · **Patchwork of standards**



standards show no evidence of government monitoring, and less than 1 percent have open data, further compounds the challenge of setting and enforcing standards.

It's important to note that particulate concentrations used to assess compliance with national air quality standards exclude contributions from dust and sea salt. While these components are not excluded in regulatory compliance assessments, our findings show that even without them, many countries still fail to meet their national standards.

The remainder of this report will describe how pollution levels have changed over time in different parts of the world, briefly explore relevant policy measures that countries have implemented, and highlight how people across the globe would live longer if they were to breathe cleaner air.

Figure 1.4b · **Countries meeting and not meeting their national air quality standards**

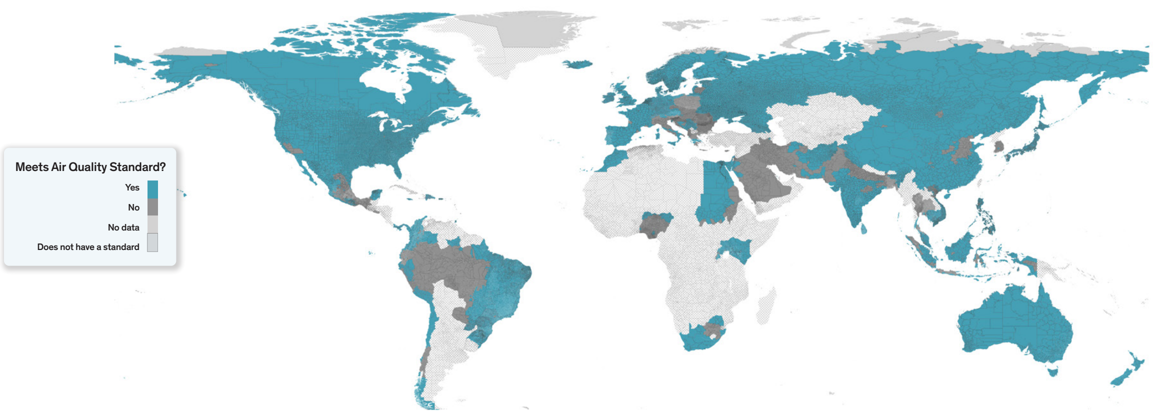
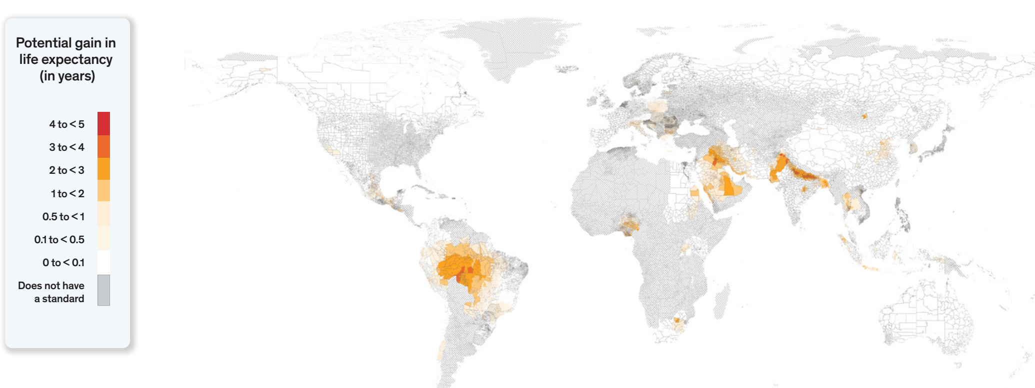


Figure 1.4c · **Potential gain in life expectancy if countries were to meet their own $PM_{2.5}$ standards**[1]



1 Particulate concentrations used to assess compliance with national air quality standards exclude contributions from dust and sea salt

Section 2

South Asia reverses its trend of year-on-year increase in pollution, but continues to breathe polluted air

After a decade of continued increase, pollution declined in South Asia in 2022. Still, people living in the region continue to breathe polluted air—with levels almost 8.5 times higher than the WHO guideline. Sustained exposure to such particulate pollution is projected to reduce the life spans of South Asians by 3.5 years. The toll is even greater in the most polluted areas..

South Asia breathed cleaner air in 2022 relative to the average particulate pollution levels over the last decade.[11] Between 2012 and 2021, the $PM_{2.5}$ levels in South Asia have averaged 48 µg/m³. In 2022, the $PM_{2.5}$ levels were 41.4 µg/m³— an approximate 14 percent decline compared to the decade's average—which is equivalent to a potential gain in life expectancy of 7.9 months, if these reductions are sustained.

Relative to 2021, $PM_{2.5}$ levels were lower in all South Asian countries with the exception of Sri Lanka. The decline in Bangladesh was the steepest, where annual $PM_{2.5}$ concentrations were lower by more than 15 µg/m³. Bangladesh was followed by India and Nepal where concentrations were lower by approximately 9 µg/m³. In Pakistan, the concentrations were lower by 4 µg/m³.

Within Bangladesh, the highest declines were observed in districts of Chandpur, Shariatpur, Madaripur, Gopalganj and Madira—with $PM_{2.5}$ concentrations dropping by over 20 µg/m³ in each of these districts. In India, the highest declines were observed in the Purulia and Bankura districts of West Bengal, followed by the Dhanbad, Purbi and Paschim Singhbhum, Paschim Medinipur, and Bokaro districts in Jharkhand. In each of these districts, $PM_{2.5}$ concentrations dropped by over 20 µg/m³.

It is difficult to precisely determine what improved South Asia's air quality in 2022, but favorable meteorological conditions in the form of above normal precipitation and reduced number of thermal inversions[12] in 2022 have been found to have amplified the impact of the small decreases in emission controls from the residential and transport sectors in India.[13, 14] The decline in emissions from the residential sector in India can largely be attributed to the nation-wide roll out of India's clean cooking programme, the Pradhan Mantri Ujjwala Yojana, and the reduction in transport-related emissions have been attributed to the decrease in use of diesel in the transport sector. In districts home to cities covered by India's flagship programme on air quality management, National Clean Air Programme (NCAP), $PM_{2.5}$ concentrations declined by 19 percent on average and in the districts not covered by the programme stood at 16 percent. Barring Dhanbad, none of the districts with the highest decline in $PM_{2.5}$ concentrations are covered by the NCAP framework.

Additionally, the World Meteorological Organisation has linked La Niña conditions with above normal rainfall over parts of South

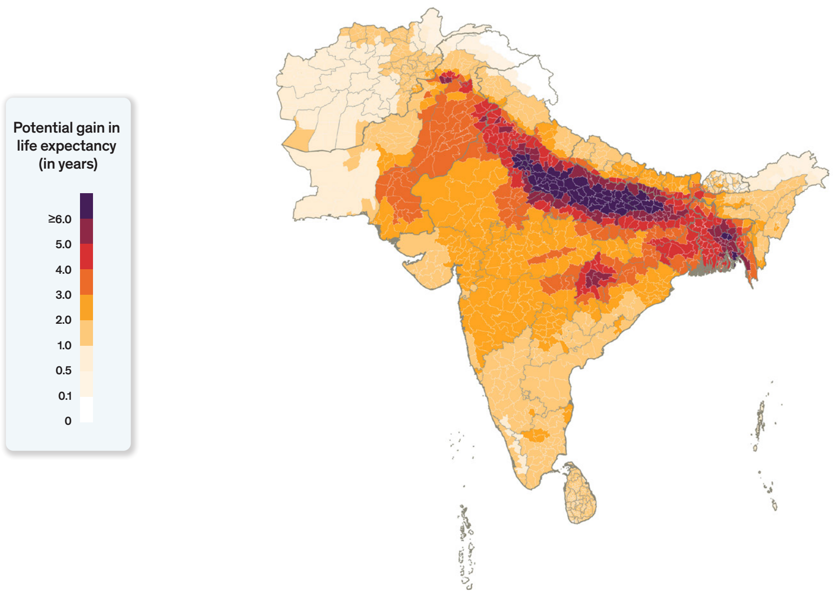
11 South Asia is defined as the following 8 countries: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka.

12 A thermal inversion layer is a layer in the atmosphere in which air temperature increases with height -c contrary to the normal tendency of the atmosphere to cool with increase in altitude. These inversion layers restrict upward movement of air-trapping pollutants near the ground, thereby increasing ground-level pollution concentrations.

13 Refer Footnote 4

14 Gufran Beig , V Anand , N Korhale , S B Sobhana , K M Harshitha , R H Kripalani. 2024. "Triple dip La-Nina, unorthodox circulation and unusual spin in air quality of India" Science of Total Environment , Volume 920, 10 April 2024, 170963 https://doi.org/10.1016/j.scitotenv.2024.170963

Figure 2.1 · Potential gain in life expectancy from permanently reducing $PM_{2.5}$ from 2022 concentration to the WHO guideline



Asia during the summer-monsoon season.[15] Pakistan was ravaged by severe floods in August 2022. In addition to a heavy monsoon spell, Bangladesh experienced a cyclonic storm and heavy rainfall in October 2022 and flood events in June and July. Afghanistan experienced flood events in May.

Available evidence explaining the reduction in India's $PM_{2.5}$ levels and the region-wide decline in South Asia suggests favorable meteorology may have contributed to the decline in South Asia's $PM_{2.5}$ concentrations in 2022. These favorable conditions may not persist year to year, and especially under expected future climate changes, suggesting that these reductions may be temporary.[16] This reinforces the need for sustained policy measures aimed at emission control across the South Asian region.

Despite having cleaner air compared to previous years, South Asia remains the world's most polluted region, accounting for 45 percent of the total life years lost globally due to high pollution. Bangladesh, India, Nepal, and Pakistan—where 23.2 percent of the global population lives—are among the most polluted countries in the world. In each of these four countries, the impact of particulate pollution on life expectancy is substantially higher than that of other large health threats (Figure 2.2). Tobacco use, for instance, reduces life expectancy in these countries by as much as 2 years; unsafe water and sanitation by as much as 1 year; and alcohol use by half a year.

The average resident of Bangladesh, India, Nepal, and Pakistan is exposed to particulate pollution levels that are 22.3 percent higher than at the turn of the century. Had pollution levels in 2000 remained constant over time, the residents in these countries would be on track to lose 2.8 years of life expectancy—not the 3.5 years that they stand to lose in 2022.[17]

Bangladesh has consistently emerged as the most polluted South Asian country. Despite a 20 percent decline in particulate concentration in 2022 relative to 2021, Bangladesh's annual average $PM_{2.5}$ level was 54.2 µg/m³ in 2022—more than 10 times the WHO guideline. Home to 166.4 million people, the average resident in Bangladesh is likely to lose 4.8 years of life expectancy if the pollution level persists. In Dhaka, the capital of Bangladesh and the second most polluted megacity in the world, with an annual average particulate pollution of 61.7 µg/m³—more than 12 times the WHO guideline—an average resident would live 5.6 years longer if the particulate levels met the WHO guideline. In the most polluted part of the country—Gazipur district in the Dhaka division—residents would live 6.3 years longer if the WHO guideline was permanently met. Even in the least polluted part of the country—Sylhet district in the Sylhet division—residents are losing more years of life expectancy than the global average compared to if they were to permanently meet the WHO guideline (2.8 years vs. 1.8 years).

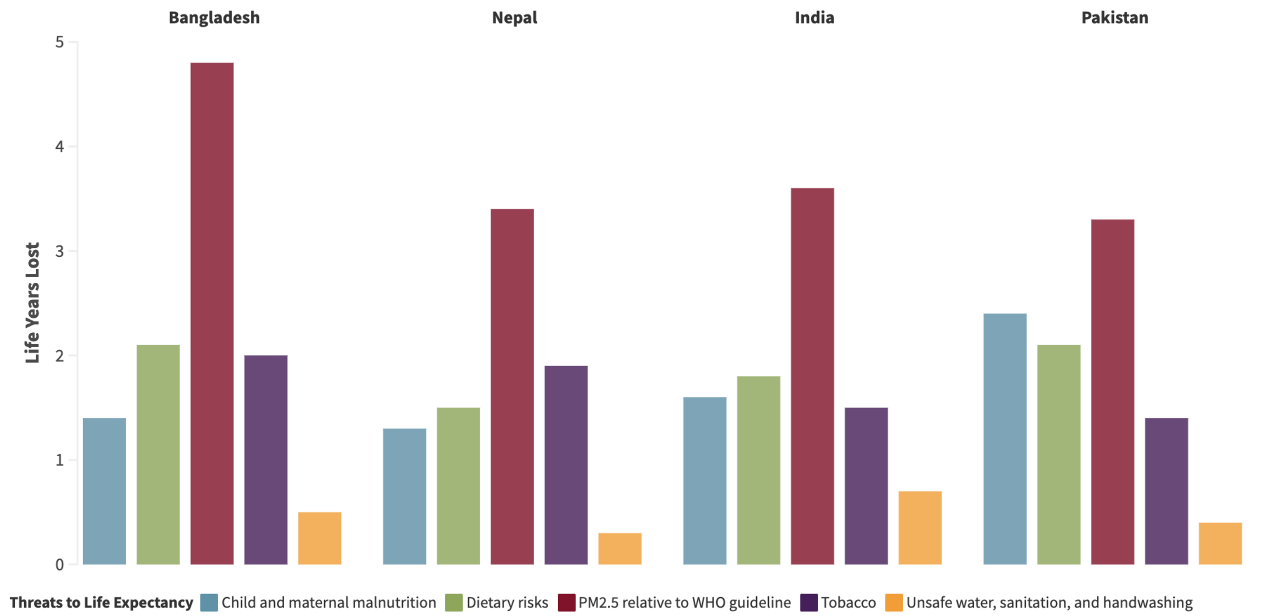
Although Bangladesh is the most polluted country overall, India faces the highest health burden of air pollution on account of the large population that is exposed. Despite a 19.3 percent drop in particulate levels in 2022 compared to 2021, an average resident in India is likely to lose 3.4 years of life expectancy if pollution levels persist. The most polluted region of India is the Northern

15 Refer to Footnote 4

16 Refer to Footnote 4

17 2022 is the latest year for which AQLI satellite derived $PM_{2.5}$ data is available.

Figure 2.2 · Comparison of selected major global threats to life expectancy in South Asian countries



Sources: Global Burden of Disease (https://vizhub.healthdata.org/gbd-results/) level-2 causes and risks data and WHO Life Tables (https://apps.who.int/gho/data/node.main.LIFECOUNTRY?lang=en) were combined with the Life table method to arrive at these results. "$PM_{2.5}$ relative to WHO Guideline" bar displays the reduction in life expectancy relative to the WHO guideline as calculated by latest AQLI (2022) data.

Plains[18], home to more than a half-billion people and almost 40 percent of the country's population. In 2022, particulate levels in this region were lower by 17.2 percent relative to 2021 levels. If these levels are sustained in the years to come, the life expectancy in the Northern Plains could increase by 1.2 years. Although 2022 was cleaner compared to previous years, the average resident in this region is still likely to lose about 5.4 years of life expectancy if the pollution level persists—which implies that there is significant scope for further strengthening mitigation efforts.

Beyond the Northern Plains, the states of Maharashtra, Madhya Pradesh and Rajasthan have the highest burden of pollution in the country. On average, the 292.3 million people living in these states are now losing 2.9 years of life expectancy.

In Nepal, where the $PM_{2.5}$ concentration was 39.2 µg/m³ in 2022—18.2 percent lower relative to 2021, the average resident would live 3.4 years longer if the country met the WHO guideline. In the most polluted parts of the country, like the districts of Mahottari and Rautahat, residents stand to gain more than 5.3 years of life expectancy from cleaner air.

In Pakistan, where the $PM_{2.5}$ concentration was 38.9 µg/m³ in 2022—10 percent lower compared to the particulate levels in 2021, the average resident would gain 3.3 years from meeting the WHO guideline. Those in Peshawar, the most polluted city in the country, would gain 5.6 years.

While the South Asian region did see a decline in pollution levels in 2022 relative to 2021, it's too soon to see if this is the beginning of a larger trend. Stepping back, pollution levels have consistently increased in the region over the last two decades. Rapid industrialization, economic development, and population growth have led to skyrocketing energy demand and fossil fuel use across the region. In India and Pakistan, the number of vehicles on the road has increased about fourfold since the early 2000s. The number of vehicles roughly tripled in Bangladesh from 2010 to 2020.[19] In Bangladesh, India, Nepal, and Pakistan combined, electricity generation from fossil fuels tripled from 1998 to 2017.[20] Crop burning, brick kilns, and other industrial activities have also contributed to rising particulate emissions in the region.

The increase in energy use has led to higher living standards and economic output, which have greatly enhanced well-being. But the concomitant rise in particulate pollution has had serious consequences. Given the energy demand in non-OECD regions is

18 We define this region as the following seven states and union territories: Bihar, Chandigarh, Delhi, Haryana, Punjab, Uttar Pradesh, and West Bengal.

19 India Ministry of Statistics and Programme Implementation. 2017. "Motor vehicles – Statistical year book India 2017. Table 20.4."; Pakistan Statistical Pocket Book. 2006. "Table 17.5." and Pakistan Today. 2019. "Registered vehicles in Pakistan increased by 9.6% in 2018."; Bangladesh Road Transport Authority. 2020. "Number of registered vehicles in the whole BD."

20 U.S. Energy Information Administration. "International: Electricity [Data set]."

projected to grow, the threat of air pollution will also grow without concerted policy action.[21,22]

Fortunately, awareness around air pollution is increasing in these countries, and governments are beginning to respond.

In Bangladesh, the most polluted country in the region and the world, the Ministry of the Environment, Forest and Climate Change published the Air Pollution (Control) Rules 2022. These rules are established under the "Bangladesh Environment Conservation Act 1995" and create the National Air Quality Control Plan and the Air Pollution Prevention Plan, identify air pollution activities, and establish standards for emissions from industry, automobiles, and specific projects (power generation, textiles, cement, fertilizers, etc.).[23] In Dhaka, Bangladesh, where brick kilns are responsible for 58 percent of the particulate pollution, the law governing brick kiln production was amended in 2019 to prohibit the establishment of brick kilns near residential, commercial, agricultural, and environmentally sensitive areas.[24] In addition, the government is planning to phase out the use of bricks in favor of concrete blocks by 2025 in order to lessen the damage to both the quality of the air and topsoil.[25] Further, Bangladesh's real-time air pollution measurements now cover eight of its cities with plans to extend it to five more cities. [26]

In India, the country with the highest health burden of pollution in South Asia, the Government launched its National Clean Air Programme ("NCAP") in 2019 with the stated goal of reducing 2017 particulate pollution levels by 20 to 30 percent by the year 2024. In 2022, the Government of India revamped its NCAP goal, aiming to achieve a 40 percent reduction in particulate pollution levels by 2026 in 131 non-attainment cities. If India were to meet this target, the residents in the non-attainment will see their life expectancy increase by 2 years compared to 2017. India' national average life expectancy will also increase by an additional 7.8 months as a result. As of 2022, pollution in the districts with non-attainment cities has declined by 18.8 percent relative to 2017, adding 10.8 months to the life expectancy of 446.7 million residents of these districts, and 4 months to India's national average life expectancy.

Nepal has instituted an Air Quality Management Action Plan for Kathmandu Valley.[27] The plan uses an integrated urban air quality management framework and calls for incorporating air quality objectives with sectoral policies. The plan also identifies transport, brick manufacturing, and construction as the most polluting industries, and adopted measures to strengthen air quality monitoring, develop emissions inventory, and conduct impact assessments along with specific policies for a sustainable transport system, emissions reduction, and eco-friendly construction.[28]

In Pakistan, the government began installing more pollution monitors[29] and shutting down factories in highly polluted districts during the winter months when energy demand for heating is high.[30] Similar to Bangladesh, the Government of Pakistan has also encouraged brick kiln owners to shift to cleaner technologies.

Although inconclusive, available evidence suggests that favorable meteorological conditions in 2022 contributed to the reduction in $PM_{2.5}$ levels across the South Asia region. Given meteorology-linked improvements may be temporary, continued efforts towards policy enforcement and rigorous monitoring of impact of these measures will be critical to sustain these reductions.

21 S & P Global. 2021. "Global energy demand to grow 47% by 2050, with oil still top source: US EIA" https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/oil/100621-global-energy-demand-to-grow-47-by-2050-with-oil-still-top-source-us-eia

22 U.S. Energy Information Administration. 2023. "International Energy Outlook 2023" https://www.eia.gov/outlooks/ieo/pdf/IEO2023_Narrative.pdf

23 Enviliance Asia. 2022. "Bangladesh publishes Air Pollution Control Rules including emission standards for mobile and stationary" https://enviliance.com/regions/south-asia/bd/report_7939

24 Dhaka Tribune. 2019. "Environment minister: Brick kilns responsible for 58% air pollution in Dhaka."

25 The Daily Star. 2019. "Checking Air Pollution: Bye bye brick!"

26 Bangladesh Ministry of Environment, Forest and Climate Change. 2018. "Ambient Air Quality in Bangladesh." The 8 cities are as follows: Dhaka, Chittagong, Narayanganj, Gazipur, Khulna, Rajshahi, Barisal and Sylhet. The 5 cities where expansion is planned are: Savar, Narsindhi, Comilla, Mymensingh, Rangpur

27 Kathmandu Valley is defined as the following districts: Kathmandu, Lalitpur, Bhaktapur

28 Nepal Ministry of Populations and Environment, Department of Environment. 2017. "Air Quality Management Action Plan for Kathmandu Valley" https://doenv.gov.np/progressfiles/Final-Report-on-AQM-Action-Plan-2017-42479-32168-1663670175.pdf

29 Hindustan Times. 2019. "Pakistan works with India to set up real-time air quality monitors" https://www.hindustantimes.com/cities/pakistan-works-with-india-to-get-air-quality-monitors/story-udFjR143uXVcz8Cwd2AUhI.html

30 AlJazeera. 2021. "Pakistan's anti-smog squads target Lahore factories for emissions"https://www.aljazeera.com/news/2021/11/25/pakistan-anti-smog-squads-lahore-factories-pollution

Section 3

Pollution emerging as a major health threat in parts of Central and West Africa

In the most polluted regions of Sub-Saharan Africa, particulate pollution is cutting life expectancy by as much as 5.1 years. This toll is higher than that of other health threats like HIV/AIDS, Malaria and unsafe water, sanitation and handwashing.

Unlike the reduced pollution levels in South Asia and Southeast Asia, 2022 did not bring substantial changes to the quality of air in the Central and West African region. The population weighted-average $PM_{2.5}$ concentration in 2022 was nearly identical to the average level in 2021, at 22.2 µg/m³—4.4 times the WHO guideline.[31]

31 Central Africa is defined as the following 11 countries: Angola, Burundi, Cameroon, Central African Republic, Chad, Republic of the Congo, Democratic Republic of the Congo, Equatorial Guinea, Gabon, São Tomé and Príncipe, Rwanda. West Africa is defined as the following 16 countries: Benin, Burkina Faso, Cabo Verde, Gambia, Ghana, Guinea, Guinea-Bissau, Côte d'Ivoire, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo.

In the Central and West Africa region—home to 660.5 million people across 27 countries—$PM_{2.5}$ levels have remained between 20 µg/m³ and 22 µg/m³ since 1998. An average resident of this region can lose 1.7 years off their lives, translating to 1.9 billion total life years lost, if these levels of pollution persist. In Menoua, Cameroon—the most polluted region—the life expectancy losses are as high as 5.1 years (Figure 3.1), comparable to the losses in the most polluted regions in the world.

The Democratic Republic of the Congo (DRC) was the most polluted

Figure 3.1 · Potential gain in life expectancy from permanently reducing $PM_{2.5}$ from 2022 concentration to the WHO guideline

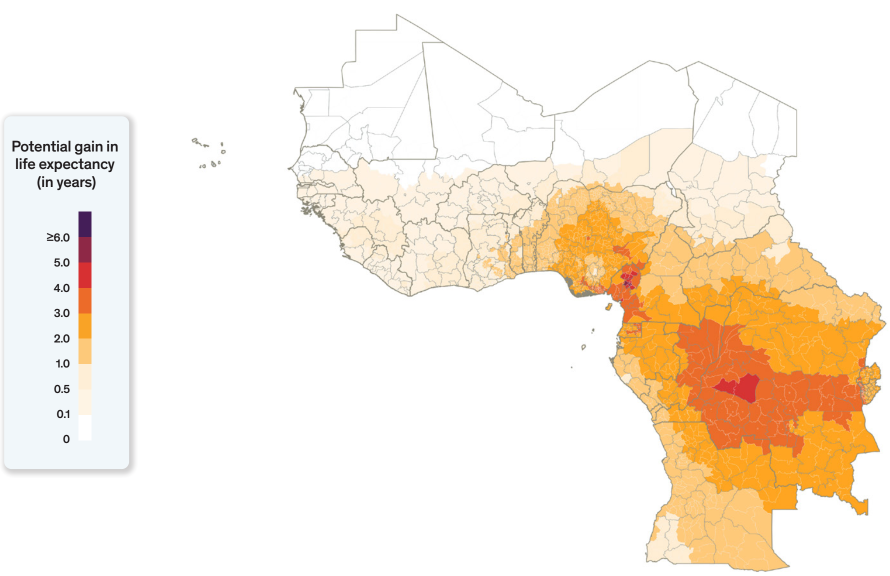
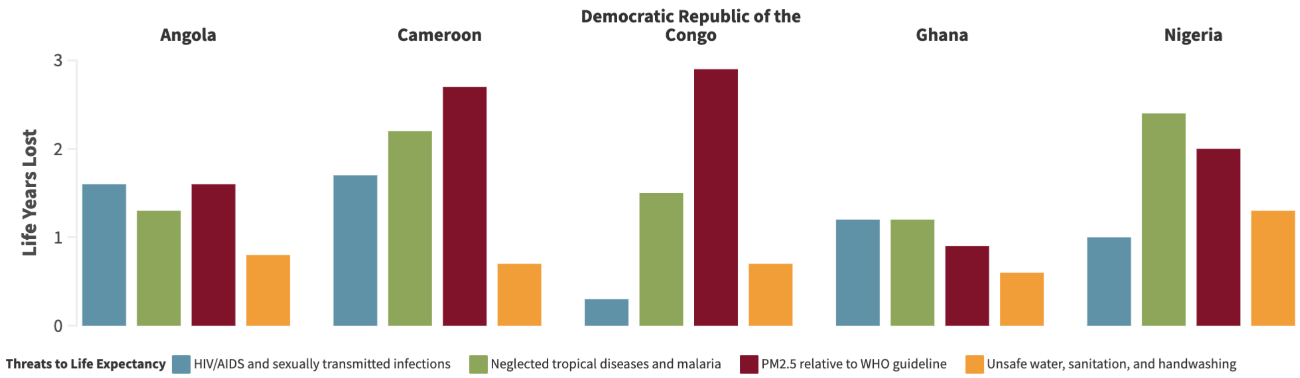


Figure 3.2 · Comparison of selected major global threats to life expectancy in the five most populous countries in Central and West Africa



Sources: Global Burden of Disease (https://vizhub.healthdata.org/gbd-results/) level-2 causes and risks data and WHO Life Tables (https://apps.who.int/gho/data/node.main.LIFECOUNTRY?lang=en) were combined with the Life table method to arrive at these results. "$PM_{2.5}$ relative to WHO Guideline" bar displays the reduction in life expectancy relative to the WHO guideline as calculated by latest AQLI (2022) data.

country on the African continent in 2022, with an annual-average particulate concentration of 34.7 µg/m³, or nearly 6.9 times the WHO guideline. As a result, average life expectancy is 2.9 years lower than what it would be if the country met the WHO guideline.

In Kinshasa, the capital and largest city of the DRC with 12.3 million people, residents are losing 3.3 years of life expectancy relative to if the city met the WHO guideline. Further, a cluster of regions to the east of Kinshasa—namely, Mai-Ndombe, Kwilu, and Kasaï—experience even higher levels of pollution, leading residents there to lose 3.7 to 3.9 years off their lives. In these regions, high air pollution levels have been largely attributed to waste burning, mining, and industrial practices such as mineral processing and cement manufacturing. Moreover, with the prevalence of dirty indoor cookstoves, residents face additional exposure to high levels of air pollution indoors as well.[32]

Following the DRC, Burundi, Rwanda, Equatorial Guinea, Cameroon, and The Republic of the Congo were the most polluted countries in Central and West Africa. These countries are also among the most polluted countries in the world. Their stories are similar. In the Republic of the Congo's capital city of Brazzaville, residents are losing 3.2 years; in Rwanda's Musanze, it is 3.1 years; in Burundi's capital of Gitega, it is 2.5 years; in Mezam, Cameroon, residents are losing 4.5 years; and in Bata, Equatorial Guinea, it is 2.6 years.

Although Central African countries experience higher levels of pollution, the West African country of Nigeria, on account of its large population, faces the highest health burden of air pollution in Africa. In 2022, the particulate pollution level in Nigeria was 25 µg/m³—5 times the WHO guideline. As a result, residents of Nigeria are losing 2 years off their lives compared to if air quality met the WHO guideline. Cumulatively, Nigeria's life years lost to pollution make up more than 20 percent of the total life years lost in all of Africa. In the Federal Capital Territory, home to Nigeria's capital city of Abuja and one of the most polluted regions in the country, residents could gain 2.7 years of life expectancy if particulate pollution were permanently reduced to meet the WHO guideline.

In Lagos, Nigeria's largest city with 21.6 million people, residents could see their life expectancy increase by 1.7 years if particulate pollution were permanently reduced to meet the WHO guideline. Following the trend from previous years, Niger River Delta—where oil refineries are linked to the grim daily reality of air pollution—faces the highest health burden due to pollution in Nigeria.[33] With an average pollution of 31.3 µg/m³, residents in these states are losing 2.6 years of life expectancy, relative to the WHO guideline.

The health discourse in Sub-Saharan Africa has largely centered around infectious diseases, like HIV/AIDS and malaria, but the data show that the health impacts of particulate pollution exposure are no less serious. AQLI's analysis suggests that in the Democratic Republic of the Congo and Cameroon— among the most polluted countries in Africa—$PM_{2.5}$ pollution is a more serious threat to life expectancy than HIV/AIDS, tropical diseases, malaria or water, sanitation and handwashing (Figure 3.2).

EARLY SIGNS OF PROGRESS

Not long ago, none of the 27 Central and West African countries

32 Interactive Country Fisches. "Democratic Republic of Congo: Pollution."

33 Niger river delta is defined as the following nine states: Rivers, Delta, Akwa Ibom, Imo, Edo, Ondo, Cross River, Abia, Bayelsa

had national standards for particulate pollution. Since 2018, two out of the 27 countries in the region have set a standard.[34,35] Across the entirety of Africa, 17 of 61 countries have adopted some legislative instruments to monitor air quality and 13 countries have set a national standard, including the most recent addition—Uganda.[36,37]

Further, an increasing number of civil society organizations are calling for action, and governments are beginning to respond with either some legislative instruments or air quality plans.[38]

Nigeria's National Environmental Standards Regulations and Enforcement Agency (NESREA) implemented an air quality regulation in 2021 and also established indoor and ambient quality standards.[39] The Republic of Rwanda enacted a law to preserve the air quality and prevent air pollution in the country in 2016 and adopted East African Standards for ambient air quality in 2018.[40,41] The Ghana Environmental Protection Agency introduced a Greater Accra Metropolitan Area (GAMA) Air Quality Management Plan (AQMP) in 2018 with the goal of bringing GAMA in compliance with the country's air quality standards and maintaining the compliance as the area grows economically.[42] Togo, in partnership with the Climate and Clean Air Coalition, implemented a National Plan for the Reduction of Air Pollutants and Short-Lived Climate Pollutants with a goal of reducing particulate pollution by 45 percent, which was formally endorsed by the Minister of Environment, Sustainable Development and the Protection of Nature in 2020.[43] From all around Africa, Morocco, Eswatini and South Africa also have national level air quality legislations while Kenya and Ethiopia have enacted Nairobi and Addis Ababa Air Quality Management plans, respectively.

Despite the progress in recent years, African countries still lack the tools and resources to manage and mitigate air pollution. African countries received only 5 percent of air quality funding between 2017 and 2021.[44,45] There is also scope for significant augmentation of the air quality data infrastructure in this region. With 13 government monitors across all countries in the region sharing data openly on a data platform such as OpenAQ, the easily available open data provided by these government monitors is comparable to Denmark which has pollution levels that are one-third the average for this region. For people in this region to live healthier and longer lives, more resources need to be injected.

34 Federal Republic of Nigeria Official Gazette. 2021. https://archive.gazettes.africa/archive/ng/2021/ng-government-gazette-supplement-dated-2021-02-17-no-161.pdf

35 East African Community. 2021. "Draft Standards Air Quality Specification Second Edition" https://bbnburundi.org/wp-content/uploads/2021/05/Air-quality-Specification-DEAS-vrai.pdf

36 UN Environment Program. 2021. "Regulating Air Quality: The First Global Assessment of Air Pollution Legislation." Please note that only a subset of these countries are a part of Central and West Africa. These 17 countries are as follows: Algeria, Benin, Burkina Faso, Côte d'Ivoire, Egypt, Eswatini, Gambia, Ghana, Kenya, Mauritius, Morocco, Mozambique, Nigeria, Rwanda, Senegal, South Africa, and the United Republic of Tanzania.

37 New Vision. 2024. "Air quality-standards-in-2024-a landmark tool for addressing Air quality in Uganda" https://www.newvision.co.ug/category/blogs/air-quality-standards-in-2024-a-landmark-tool-NV_187722

38 EPIC "EPIC Clean Air Programs – Air Quality Entities Registry" https://epic.uchicago.edu/air-quality-registry/

39 Refer Footnote 37

40 Rwanda Legal Information Institute. 2016. "Law governing the Preservation of Air Quality and Prevention of Air Pollution in Rwanda" https://rwandalii.org/akn/rw/act/law/2016/18/eng@2016-06-06#:~:text=Any%20person%20owning%20emission%20sources,activities%20that%20are%20considered%20as

41 REMA. 2018. "Inventory of Sources of Air Pollution in Rwanda" https://rema.gov.rw/fileadmin/templates/Documents/rema_doc/Air%20Quality/Inventory%20of%20Sources%20of%20Air%20Pollution%20in%20Rwanda%20Final%20Report..pdf

42 EPA Ghana. 2018. "The Greater Accra Metropolitan Areas Air Quality Management Plan" https://www.ccacoalition.org/sites/default/files/resources/2018_Greater-Accra-Region-Air-Quality-Management_EPA-Ghana.pdf

43 CCAC secretariat. 2020. "Togo's Minister of Environment endorses first National Plan to Reduce Air Pollutants and Short-Lived Climate Pollutants" https://www.ccacoalition.org/news/togos-minister-environment-endorses-first-national-plan-reduce-air-pollutants-and-short-lived-climate-pollutants

44 Clean Air Fund. 2023. "The State Of Global Air Quality Funding 2023" https://s40026.pcdn.co/wp-content/uploads/The-State-of-Global-Air-Quality-Funding-2023-Clean-Air-Fund.pdf

45 Clean Air Fund. 2023. "Philanthropic Foundation Funding For Clean Air: Advancing Climate Action, Health And Social Justice" https://s40026.pcdn.co/wp-content/uploads/Clean-Air-Fund-Philanthropic-Foundation-Funding.pdf

Section 4

Middle East and North Africa emerges as a new pollution hotbed

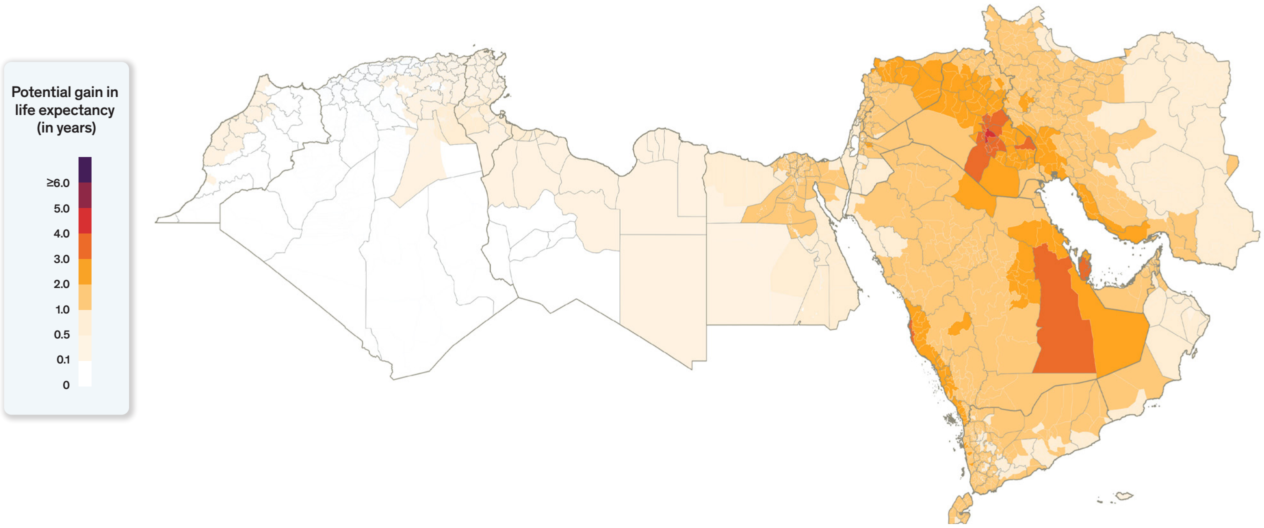
97% of the Middle East and North Africa's population lives in areas where particulate pollution exceeds the WHO guideline. The impact is much larger in the most polluted areas where residents are losing 4.1 years due to $PM_{2.5}$.

The latest satellite derived $PM_{2.5}$ data highlights the Middle East and North Africa[46] as an emerging pollution hotspot. The population-weighted average particulate pollution in 2022 was 12.9 percent higher than 2021, at 18.4 µg/m³—3.7 times the WHO guideline. The 466.5 million residents of this region stand to gain 1.3 years in life expectancy, translating to 612.6 million total life years saved, if the pollution level is reduced to meet the WHO guideline (Figure 4.1). In each of these countries, the impact of particulate pollution on life expectancy is comparable to other large health threats (Figure 4.2). The impact is significantly larger in Babil Governorate in Iraq, the region's most polluted area, where particulate pollution is taking 4.1 years off of the life expectancy of its residents.

With a particulate pollution level of 39.1 µg/m³, or nearly 7.8 times the WHO guideline, Qatar was not only the most polluted country in the Middle Eastern and North African region—it was also the fourth most polluted country globally. The resulting average life expectancy in Qatar is 3.3 years lower than what it would be if the WHO guideline were met, making particulate pollution a larger health threat here than smoking and vehicle

46 Middle East is defined as the following 13 countries: Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, Yemen. North Africa is defined as the following 6 countries: Algeria, Djibouti, Egypt, Libya, Morocco, Tunisia.

Figure 4.1 · Potential gain in life expectancy from permanently reducing $PM_{2.5}$ from 2022 concentration to the WHO guideline



injuries (Figure 4.2). In Doha, the country's capital and largest city, home to about half its population, residents stand to lose 3.4 years of life expectancy if the current pollution levels persist. Particulate pollution in Qatar has largely been attributed to industrial emissions, and construction to support the rapid urbanization.[47]

Although Qatar is the most polluted country, 39 out of the 50 most polluted regions of the Middle East and North Africa lie in Iraq. In 2022, the annual average particulate pollution levels in Iraq were 32.4 µg/m³, making it the second most polluted country of this region. Five of the country's most polluted governorates contribute more than 40 percent of the total life years lost in Iraq.[48] In Baghdad, Iraq's capital and its most populous governorate, residents stand to lose 3.5 years of life expectancy on average. The situation is even worse in the most polluted district, Al Mahawil, in the neighboring Babil governorate, where 1.3 million people are losing 4.1 years of life expectancy due to particulate pollution. Air pollution in Iraq has been attributed to vehicle exhaust, electric generators, fires at oil and gas refineries, and continuous military conflict in the region.[49]

Despite having lower average particulate pollution than Qatar and Iraq, Egypt faces the highest health burden in the region due to its large population. In 2022, the particulate pollution level in Egypt was 19.2 µg/m³—almost 4 times the WHO guideline. This means that an average resident of Egypt could live 1.4 years longer if pollution levels in Egypt were brought down to meet the WHO guideline. This would help prevent the loss of 149.7 million life years in the country. The city-governorate of Cairo, the capital of Egypt and the largest megacity in the Middle East and North Africa with a population of 10.1 million, experiences $PM_{2.5}$ levels of 22.6 µg/m³—the worst in the country. With an average resident in Cairo losing approximately 1.7 years of their life, the combined life years lost due to particulate pollution in the Greater Cairo area are 23.6 million.[50] In Alexandria, the largest city in the Mediterranean and an important tourism and industrial hub of Egypt, the condition is slightly better with 16.2 µg/m³ particulate pollution levels translating to 1.1 years of reduced life expectancy. Traffic congestion and vehicle exhaust, agriculture slash and burn practices, and coal fired power plants are major sources of particulate pollution in Egypt.[51,52]

UNEQUAL BURDEN OF PARTICULATE POLLUTION

At the regional level, particulate pollution remains highly unequal, with annual pollution levels ranging from as little as 6.1 µg/m³ in Algeria to as high as 39.1 µg/m³ in Qatar. Overall, the Middle Eastern countries have higher pollution than the North African countries. Reducing particulate pollution to meet the WHO guideline would add 10 more months onto the lives of those living in the Middle East compared to those living in North Africa. Looking at a more granular level, particulate pollution in the Middle Eastern and North African countries is also concentrated in certain areas—mostly in the area around the national capital of each country.

SIGNS OF POLICY ACTION TO CURB AIR POLLUTION

Until recently, none of the 19 Middle Eastern and North African countries had any air quality management plan. Seven out of these nineteen countries have $PM_{2.5}$ standards. However, air quality is getting more attention as five countries have implemented air quality management plans.

Iran first enacted the Law on Prevention of Air Pollution in 1995. Since then, it has been updated twice. The latest update in 2017, called the Clean Air Law, includes stricter penalties for industries or individuals that do not adhere to the pollution limits.[53, 54]

The Clean Air Law of Israel came into effect in 2012. Having undergone two revisions since then, it now includes clean air requirements for industrial facilities, measures to reduce vehicular pollution and greenhouse gasses, and renewable fuel standards for biofuels.[55]

The Lebanese Parliament enacted the Law on the Protection of the Environment. It comprises 34 articles related to air quality monitoring and management, and prevention of air pollution.[56,57]

In 2021, Morocco, in partnership with the Climate and Clean Air Coalition, finalised its national action plan to reduce short-lived climate pollutants. Full implementation of the plan can reduce particulate matter from the transport sector in Morocco

47 The Peninsula. 2024. "Signs of air quality improvement in Doha after major construction boom" https://thepeninsulaqatar.com/article/31/03/2024/signs-of-air-quality-improvement-in-doha-after-major-construction-boom

48 The five governorates are: Al Qadisiyah, An Najaf, Babil, Baghdad, Karbala

49 Ecohubmap. 2023. "Air pollution in Baghdad, Iraq" https://www.ecohubmap.com/hot-spot/air-pollution-in-baghdad-iraq/nxoml7sorv56#

50 Greater Cairo is defined as: Al Qahirah governorate, Imbabah, Giza, Shubra-al-Khaymah

51 Clean Air Fund. 2023. "From pollution to solution in Africa's cities" https://www.cleanairfund.org/clean-air-africas-cities/cairo/

52 IQAir. 2024. "Air quality in Egypt" https://www.iqair.com/us/egypt

53 FAO. 2024. "FAOLEX Database" https://www.fao.org/faolex/results/details/en/c/LEX-FAOC182168/

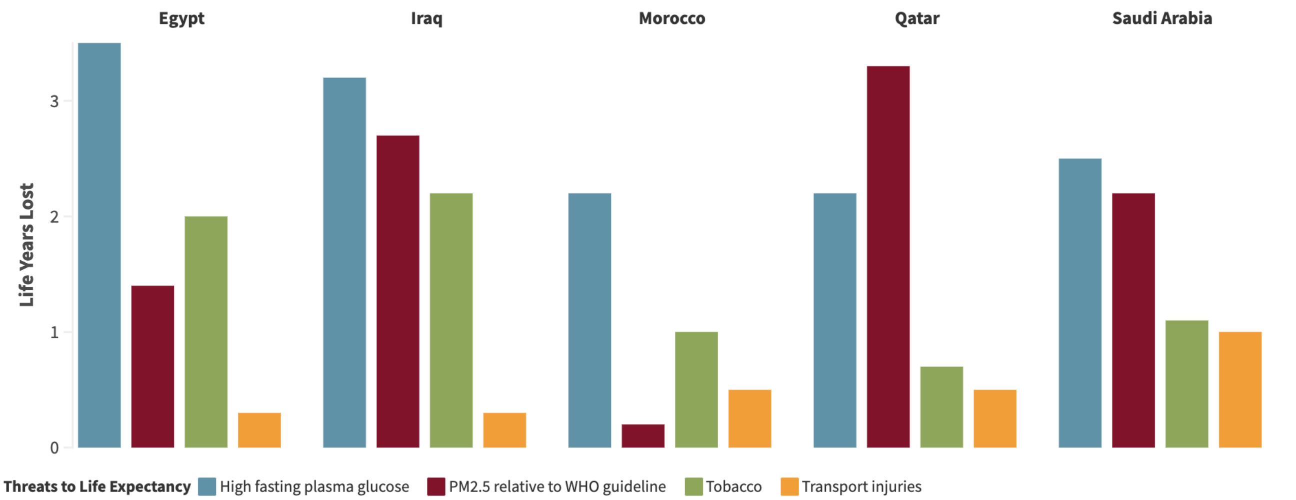
54 Radio free Europe. 2023. "Iran's Environmental Standards, Polluted Reality Mix Like Oil And Water"https://www.rferl.org/a/iran-environmental-standards-pollution-smog/32385813.html#

55 Library of congress. "Regulation of Air Pollution: Israel" https://maint.loc.gov/law/help/air-pollution/israel.php#_ftn14

56 OHCHR. "Environment management in Lebanon" https://www.ohchr.org/sites/default/files/Documents/Issues/Environment/SREnvironment/Pollution/Lebanon.pdf

57 FAO. 2019. FAOLEX Database https://www.fao.org/faolex/results/details/en/c/LEX-FAOC176635/

Figure 4.2 · **Comparison of selected major global threats to life expectancy in the five most populous countries in Middle East and North Africa**



Sources: Global Burden of Disease (https://vizhub.healthdata.org/gbd-results/) level-2 causes and risks data and WHO Life Tables (https://apps.who.int/gho/data/node.main.LIFECOUNTRY?lang=en) were combined with the Life table method to arrive at these results. "$PM_{2.5}$ relative to WHO Guideline" bar displays the reduction in life expectancy relative to the WHO guideline as calculated by latest AQLI (2022) data.

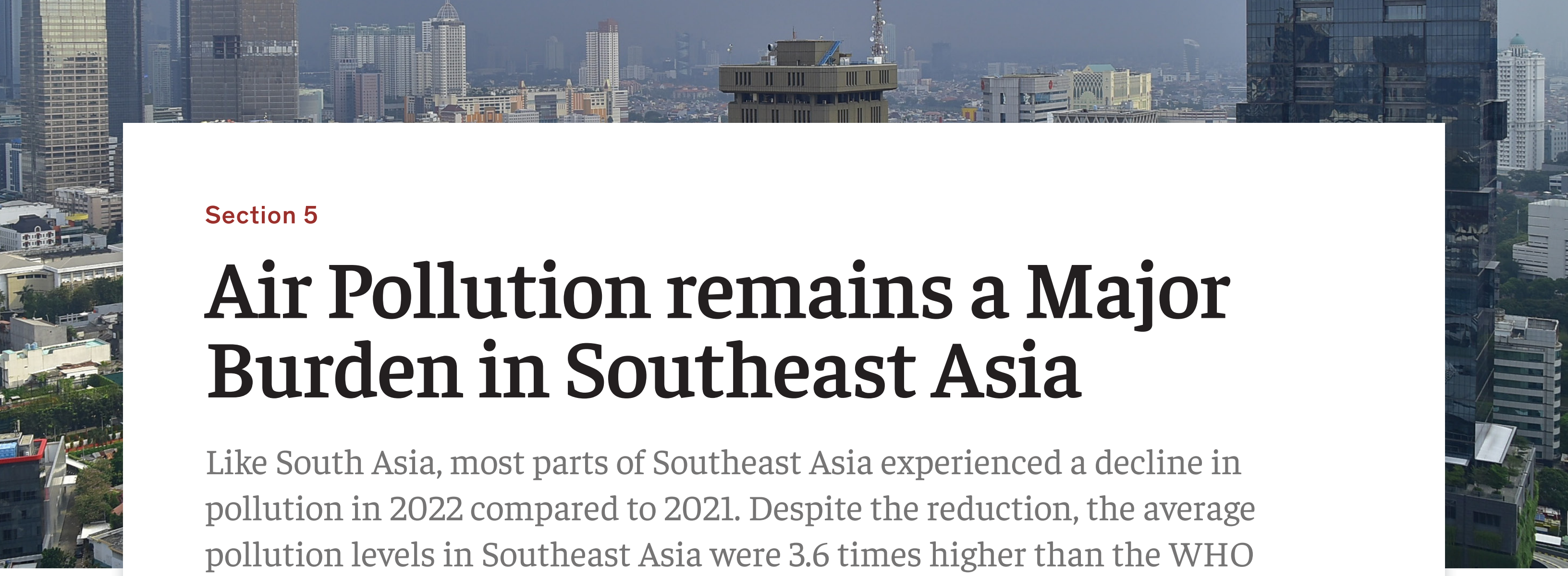
by 51.6% from 2014 levels.[58]

In 2013, the United Arab Emirates launched Vision 2021, which initiated its air quality data collection and monitoring efforts. This data was used to inform the targets of its National Air Quality Agenda 2031 plan that was released in 2023. The latest agenda focuses on reducing outdoor and indoor air pollution, reducing odors, and reducing noise pollution.[59, 60]

58 CCAC Secretariat. 2022. "Morocco's National Action Plan Signals New Era in the Country's Climate and Clean Air Commitment" https://www.ccacoalition.org/news/moroccos-national-action-plan-signals-new-era-countrys-climate-and-clean-air-commitment

59 CCAC Secretariat. 2023. "UAE Enters COP28 Leadership With National Air Quality Agenda" https://www.ccacoalition.org/news/uae-enters-cop28-leadership-national-air-quality-agenda

60 UAE MOCCE. 2023. "UAE National Air Quality Agenda 2031" UAE National Air Quality Agenda 2031" https://www.moccae.gov.ae › assets › download



Section 5

Air Pollution remains a Major Burden in Southeast Asia

Like South Asia, most parts of Southeast Asia experienced a decline in pollution in 2022 compared to 2021. Despite the reduction, the average pollution levels in Southeast Asia were 3.6 times higher than the WHO guideline. With sustained exposure to such pollution levels, an average Southeast Asian resident is likely to lose 1.2 years off their life relative to what it would be if the WHO guideline were met.

As a whole, pollution declined across Southeast Asia in 2022. The average decline in pollution levels across all Southeast Asian countries was 4.8 percent over one year, with the highest decline in Myanmar (15.7 percent) and lowest decline in Malaysia (0.8 percent). Singapore and Timor-Leste were the only countries where pollution levels increased compared to 2021. Across the region, air pollution reduces average life expectancy by 1.2 years, relative to what it would be if the WHO guideline of 5 $\mu g/m^3$ was permanently met (Figure 5.1). In the 11 countries that make up this region, an estimated 1 billion total life years are lost due to air pollution.[61]

While average pollution decreased slightly in 2022, pollution levels in Southeast Asia have remained largely unchanged for two decades, generally fluctuating between 17 and 22 $\mu g/m^3$—almost 3.5 times the WHO guideline. Virtually all, 99.9 percent, of Southeast Asia's roughly 681.3 million people breathe air that WHO deems polluted. Simeulue and Kepulauan Mentawai in Indonesia, and Turtle Islands and Kalibato Lake in Philippines are the only regions where air quality meets the WHO guideline.

In 2022, the population-weighted particulate concentration in Myanmar, the most polluted Southeast Asian country, was 28.6 $\mu g/m^3$—5 times the WHO guideline. Because pollution surpasses the WHO guideline, residents of Myanmar are losing 2.9 years of life expectancy. This is significantly more than other health threats in Myanmar such as child and maternal malnutrition (1.4 years) or respiratory infections and tuberculosis (1.4 years) (Figure 5.2). In Yangon and Mandalay, the most populated regions in Myanmar, average pollution levels were 27.8 and 33.8 $\mu g/m^3$ in 2022, respectively. If the WHO guideline were met in Yangon and Mandalay, residents would gain 2.2 and 2.8 years, respectively.

While Indonesia's pollution has remained largely consistent over the past decade— fluctuating between 18 and 22 $\mu g/m^3$—during dry seasons, fires in Indonesia cause sudden spikes in pollution for the country and its downwind neighbors like Malaysia. The impact of fewer fires in the region in 2022 compared to the most recent active wildfire season in 2019, a year characterized by thousands of fires on the Indonesian islands of Sumatra and Borneo, bears out in the data.[62] Indonesia saw a 17.2 percent decrease in particulate pollution in 2022 compared to 2019, while Malaysia experienced a 33.9 percent decrease.

In the Indonesian island of Java, the country's population and industrial center, pollution levels dipped slightly in 2022 compared to 2019. In the region surrounding the megacity of Jakarta (including Bogor, Depok, Bekasi, and Tangerang), the average annual $PM_{2.5}$ concentration fell roughly 6.3 percent in 2022 to 28.2 $\mu g/m^3$. Still, if the region met the WHO guideline, the roughly 24.9 million residents would gain an average of 2.2 years in life expectancy. In 2022, North Sumatra—among the most polluted regions in Indonesia—also saw a decrease relative to 2019. Medan, for example, experienced pollution levels of 33.0 $\mu g/m^3$—significantly down from 2019 levels of 40.2 $\mu g/m^3$. Here, residents stand to gain 2.7 years of life expectancy if pollution were to be reined in to meet the WHO guideline.

61 Southeast Asia includes the following countries: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, The Philippines, Singapore, Thailand, Timor-Leste, Vietnam

62 Mongabay. 2024. "2023 fires increase fivefold in Indonesia amid El Niño" https://news.mongabay.com/2024/01/2023-fires-increase-fivefold-in-indonesia-amid-el-nino/

Figure 5.1 · Potential gain in life expectancy from permanently reducing $PM_{2.5}$ from 2022 concentration to the WHO guideline

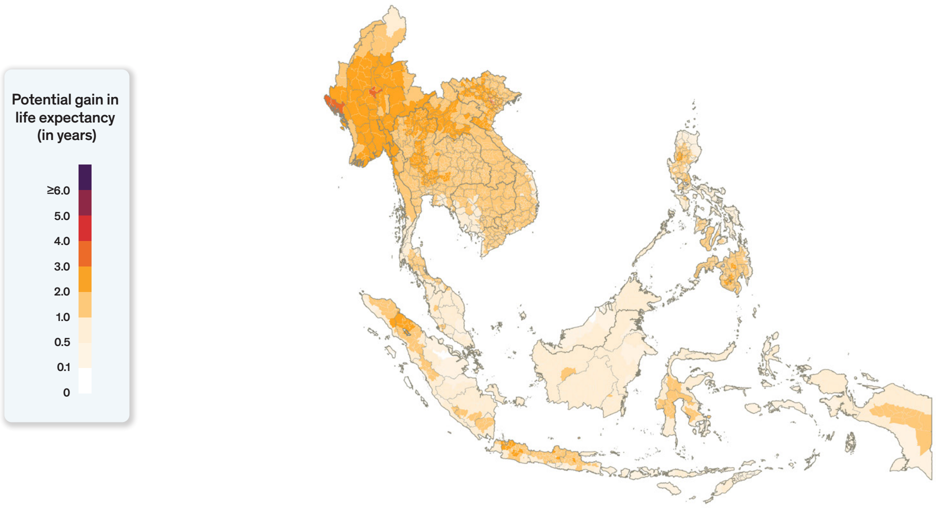
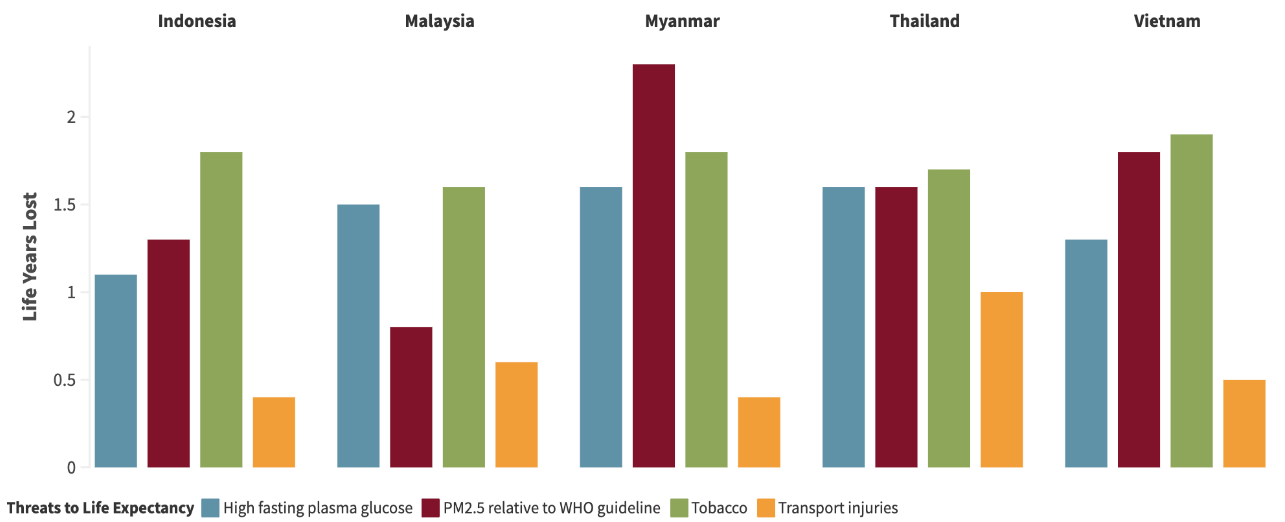


Figure 5.2 · Comparison of selected major global threats to life expectancy in Southeast Asian countries



Sources: Global Burden of Disease (https://vizhub.healthdata.org/gbd-results/) level-2 causes and risks data and WHO Life Tables (https://apps.who.int/gho/data/node.main.LIFECOUNTRY?lang=en) were combined with the Life table method to arrive at these results. "$PM_{2.5}$ relative to WHO Guideline" bar displays the reduction in life expectancy relative to the WHO guideline as calculated by latest AQLI (2022) data.

In Thailand, particulate pollution decreased 5.3 percent from 2021. The national average was 21.2 µg/m³ in 2022, a level that has been roughly constant since the mid-2000s. But overall, particulate pollution concentrations varied widely in 2022, ranging from 31.1 µg/m³ in Phayao in the North, to 19.1 µg/m³ in the metropolis of Bangkok, to 11.6 µg/m³ in Phuket in the South. This variation is partly due to fires in Thailand's northern region (including the regions surrounding Chiang Mai, Chiang Rai, Saraburi, and Phayao, for instance) that have increased the amount of regional air pollution, reducing life expectancy by up to 2.8 years relative to life expectancy under the WHO guideline. Meanwhile, in Thailand's largest urban area, Bangkok, residents would gain 1.4 years if pollution levels met the WHO guideline.

In Vietnam, there are even sharper differences between regions. In the capital city of Hanoi, home to more than 8 million people and one of Vietnam's major industrial centers, life expectancy would increase by 3 years if air quality met the WHO guideline. The impacts of air pollution are much lower in many of Vietnam's southern regions, where coastal provinces such as Phu Yen would see 0.9 years of added life expectancy if air quality met the WHO guideline. Overall, the average Vietnamese citizen stands to gain 2 years in life expectancy, if pollution was permanently reduced to the WHO guideline. This threat to life expectancy is significantly larger than other health threats in Vietnam such as diabetes (1.1 years) or respiratory infections and tuberculosis (0.84 years) (Figure 5.2.).

HOW CAN COUNTRIES IN THIS REGION TACKLE AIR POLLUTION?

The countries in this region must work together to reduce biomass, farm, forest and peatland fires. In 2023, at the 18th Meeting of the Committee Under the Conference of the Parties to ASEAN Agreement on Transboundary Haze Pollution (COM-18) in Laos[63], the second Roadmap on ASEAN Cooperation towards Transboundary Haze Pollution Control with Means of Implementation (Haze-Free Roadmap) (2023-2030) was adopted. The roadmap works on implementation of actions across ASEAN member states to prevent and control land fires. The roadmap also stressed the need for satellites and applications to use for fire and haze monitoring, as well as the Malaysian Meteorological Department's refinement of the Southeast Asia Fire Danger Rating System to increase the number of weather stations, implementation of a new fire danger code for northern the ASEAN region, and the simulation of the 7-day forecast.

Alongside reducing biomass, forest and peatland fires—tighter fuel emissions standards offer another area of potential improvement. In contrast to China and India, where fuel standards are at least as stringent as those adopted by the European Union (Euro-6), the fuel standards are much lower in Indonesia and Thailand. Vehicles are only required to meet Euro-4 standards, which allow for up to 3 times more diesel NO_x emissions, and 5 times more sulfur content. The Thai government, which had plans to adopt the Euro-5 standards in 2021, had delayed the adoption of the standards to 2024 due to COVID-19 restrictions and their subsequent impact on the private sector's readiness to practically implement those standards.[64] On January 1, 2024, Thailand officially adopted the Euro-5 standard for diesel vehicles.[65] The standard was adopted after the Thai Industrial Standards Institute accepted applications from February to December 2023 and recorded 50 applications from 25 automobile manufacturers. The Energy ministry plans to propose EURO 6 standards by January 1, 2025. Vietnam brought Euro-5 standards into effect on January 1, 2022.[66]

Industrial emissions make up another area of potential improvement. Indonesia's coal-fired power plants—of which there are around ten within a 100-kilometer radius of Jakarta[67] —are allowed to emit 3 to 7.5 times more particulate matter, NO_x, and SO_2 than China's coal plants, and 2 to 4 times more than India's plants installed between 2003 and 2016.[68] NO_x and SO_2, once emitted into the atmosphere, can form particulate matter.

IMPROVING COMPLIANCE WITH INDUSTRIAL EMISSION STANDARDS: EXAMPLES FROM INDIA

The Indian state of Gujarat launched the country's first clean air market in 2019, in the form of a large-scale pilot programme on industrial emission trading in Surat, Gujarat. The state's pollution regulating authority, Gujarat Pollution Control Board, is carrying out the emissions trading program with the help of a team of researchers from the Energy Policy Institute at the University of Chicago (EPIC), Economic Growth Center at Yale University, and The Abdul Latif Jameel Poverty Action Lab (J-PAL). Through the Emission Trading Programme, the government sets a cap on emissions and allows industries to buy and sell below the cap. The researchers are evaluating the program's benefits and costs, relative to the status quo, using a randomized controlled trial, and have found that this approach has proven to be successful with pollution decreasing by 20-30 percent and industry abatement costs declining by 11% at a constant level of emissions.[1]

Another randomized evaluation from the same state of Gujarat finds that strengthening third-party audits of industrial emission reports can reduce pollution. One way environmental regulators monitor compliance with industrial emission standards is through third party auditors. In most instances, auditors are compensated by and accountable to the company they audit, leading to a potential conflict of interest. This arrangement might incentivize auditors to manipulate or falsify their reports. And, if auditors fail to report accurately, the regulated parties have no motivation to comply with regulations, as the regulators lack the necessary information to enforce penalties. To address this problem, Gujarat Pollution Control Board (GPCB) collaborated with the same group of researchers as above to help reform the audit market by improving accuracy of audit reports, thereby, improving industrial compliance. GPCB and the researchers created a reformed audit system in which auditors were randomly assigned to the industrial plants they would monitor, paid from a common pool, and monitored for accuracy. The researchers found that with the auditors working in treatment plants (reformed audit system) were 80 percent less likely to falsely report emission readings and average pollution from industrial units in the treatment group dropped with highest reduction concentrated in plants that reported highest readings.[2]

1 Greenstone, M., Pande, R., Sudarshan, A., & Ryan, N. (2023). Can Pollution Markets Work in Developing Countries? Experimental Evidence from India. https://www.anantsudarshan.com/uploads/1/0/2/6/10267789/ets_paper.pdf

2 Esther Duflo, Michael Greenstone, Rohini Pande, Nicholas Ryan, Truth-telling by Third-party Auditors and the Response of Polluting Firms: Experimental Evidence from India*, The Quarterly Journal of Economics, Volume 128, Issue 4, November 2013, Pages 1499–1545, https://doi.org/10.1093/qje/qjt024

63 ASEAN. 2023. "17th ASEAN Ministerial Meeting on the Environment and the 18th Meeting of the Conference of the Parties to the ASEAN Agreement on Transboundary Haze Pollution"

64 China Daily. 2023. "Thailand approves delay on imposing Euro 5 emission standard on new vehicles."

65 The Nation. 2024. "Auto industry complies with Euro 5 standard of diesel fuel" https://www.nationthailand.com/thailand/policies/40034316

66 Transport Policy. 2022. "As of January 1, 2022, 4-wheeled light-duty vehicles in Vietnam are regulated under the Euro 5 standard."

67 Reuters. 2019. "Asia's coal addiction puts chokehold on its air-polluted cities."

68 Zhang, Xing. 2016. "International Energy Agency Clean Coal Centre – Emission standards and control of $PM_{2.5}$ from coal fired power plants."

To control industrial pollution, Indonesia will have to enforce the country's stationary source emission standards. In 2021, Indonesia's Ministry of Environment and Forests introduced a new regulation towards integrating pollution control systems.[69] The new regulation requires the ten highly polluting industrial categories[70] that are mandated to monitor their emissions using the Continuous Emissions Monitoring System to integrate their data into the Information on Continuous Industrial Emission Monitoring System no later than 1 January 2023. Beyond continuous monitoring, there are ways to further improve compliance with industrial emission standards. A few of these methods are discussed in the highlight box.

Across the region, awareness is rising for the need for urgent clean air action, in many cases driven by community advocates. In 2021, for example, a Jakarta court ruled in favor of a citizen-led lawsuit claiming that the government had failed to deliver safe, clean air to its citizens. In 2022, the grassroots organization Thailand Clean Air Network submitted the first citizen-driven draft legislation to the Thai Parliament aiming to create a Thai Clean Air Act. Separately, in November 2023, the Thai cabinet adopted a draft Clean Air Act to put in place a legislative framework to mitigate air pollution.[71] In fact, at present, Thailand has seven different drafts legislating for clean air, including drafts presented by the Government, the opposition and civil society.[72] In January 2024, the Thai cabinet voted to accept in principle all seven drafts of the Clean Air Bill. A parliamentary committee will now be set up to consolidate the different efforts and make amendments to the Cabinet's draft before it is presented to the Parliament for further debate.[73]

69 Ministry of Environment and Forestry. 2021. "Industrial Continuous Emission Monitoring Information System (SISPEK)" https://ditppu.menlhk.go.id/portal/sispek/?token=4aSpjX66PhcYoEWi4fOB

70 Iron and steel smelting, pulp & paper, rayon, carbon black, oil and gas, mining, thermal waste processing, cement, thermal power plants, fertilizers and ammonium nitrate

71 Reuters. 2023. "Thai cabinet approves draft clean air act to reduce pollution" https://www.reuters.com/world/asia-pacific/thai-cabinet-approves-draft-clean-air-act-reduce-pollution-2023-11-28/

72 Stockholm Environment Institute. 2024. "Empowering change – Thailand's pioneering citizen-led legislation for cleaner air" https://www.sei.org/features/podcast-th-legislation-cleaner-air/

73 The Nation. 2024. "Lawmakers accept unanimously all 7 drafts of Clean Air Bill" https://www.nationthailand.com/thailand/general/40034803

Section 6

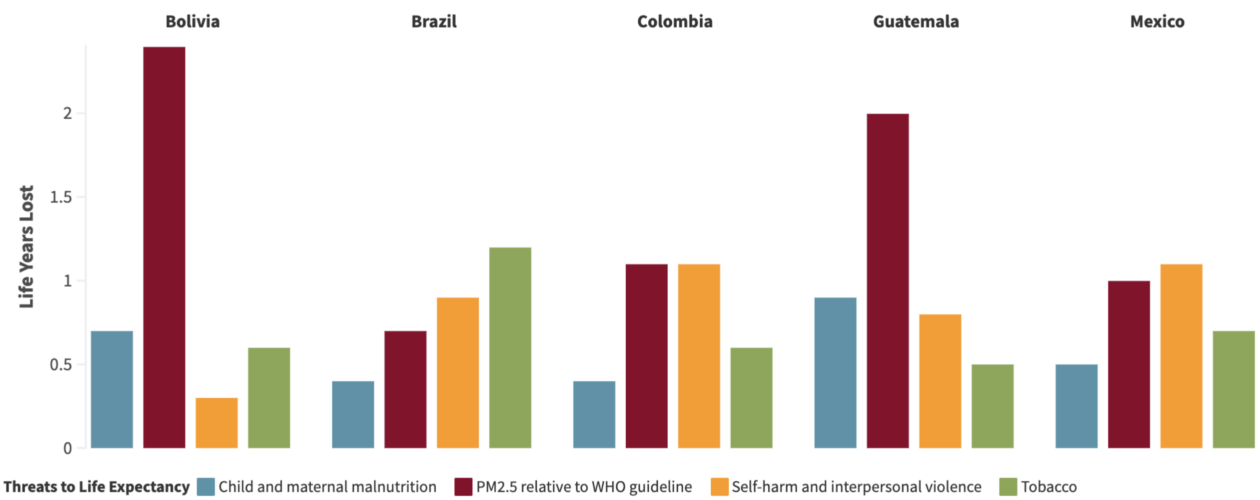
Most Latin Americans are Breathing Air Exceeding the WHO Guideline

The vast majority of Latin America's 645.9 million people breathe air that exceeds what the WHO considers safe. In the most polluted locations in the region, air pollution is reducing people's lives by 4 years — comparable to some of the most polluted regions in Bangladesh, India and Nepal.

New and revised 2022 satellite-derived $PM_{2.5}$ data reveal that 96.3 percent of Latin America's 645.9 million people are exposed to particulate pollution levels that exceed the WHO guideline of 5 µg/m³.[74] The health threat posed by particulate pollution is comparable to other large threats to life in the region such as self-harm and interpersonal violence (Figure 6.1). There has been a rise in the annual average $PM_{2.5}$ concentration across Latin America by 4.8 percent from 2021 levels and 3 percent from 1998 levels. Although the average gain in life expectancy from cleaning up the air is relatively low—at just under 1 year on average across Latin America (Figure 6.2), the gain is substantially higher in regional hotspots—Guatemala, Bolivia and Peru (Figure 6.3). Sixty of the

74 Latin America region is defined as the following 20 countries and territory: México, Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, Panama, Colombia, Venezuela, Ecuador, Peru, Bolivia, Brazil, Paraguay, Chile, Argentina, Uruguay, Cuba, Haiti, Dominican Republic, Puerto Rico.

Figure 6.1 · Comparison of selected major global threats to life expectancy in some of the most populous and polluted countries in Latin America



Sources: Global Burden of Disease (https://vizhub.healthdata.org/gbd-results/) level-2 causes and risks data and WHO Life Tables (https://apps.who.int/gho/data/node.main.LIFECOUNTRY?lang=en) were combined with the Life table method to arrive at these results. "$PM_{2.5}$ relative to WHO Guideline" bar displays the reduction in life expectancy relative to the WHO guideline as calculated by latest AQLI (2022) data.

most polluted regions in Latin America are in these three countries.

According to the latest satellite derived $PM_{2.5}$ data, Bolivia is the most polluted country in Latin America, with an annual average particulate pollution level of 29.6 µg/m³—6 times the WHO guideline. The situation is much worse in the most polluted region in Bolivia and all of Latin America—the city of Marban in the Department of Beni. There, the average particulate pollution level was 45.7 µg/m³ in 2022—or 9.1 times the WHO guideline. If the region cleaned up its air to permanently meet the WHO guideline, residents could see their life expectancy increase by 4 years.

Rural residents in Bolivia also face high levels of particulate pollution. For example, in Mamoré (Department of Beni)—a rural region containing some of the country's worst air quality—the average level of particulate pollution in 2022 was 41.8 µg/m³. Residents there are losing 3.6 years of life expectancy due to this unclean air, relative to if the WHO guideline was met.

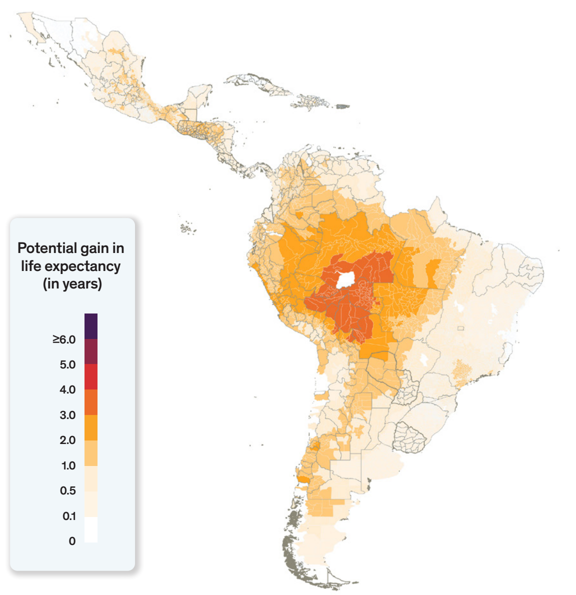
In Guatemala, which is one of the countries in the Central American Volcanic arc, particulate pollution is one of the greatest threats to human health. The average life expectancy in Guatemala is 2.1 years lower than what it would be if the WHO guideline were met—making particulate pollution a larger health threat than interpersonal violence, tuberculosis and tobacco use (Figure 6.3). Mixco, Guatemala, is the country's most polluted city, where residents are losing 3.8 years off their lives. Latin America's air pollution is not only limited to its cities. In Brazil, Latin America's most populous country, 216.9 million people could gain 8.4 months of life expectancy—or a total of 151.8 million life years gained—if particulate pollution were reduced to meet the WHO guideline. The situation is significantly worse in the Rondônia state—one of the Amazonian states of Brazil where 1.7 million residents are losing 3.2 years of life expectancy to polluted air. In the state of Amazonas, particulate pollution levels are 6.4 times the WHO guideline, primarily due to the burning of the rainforests. The fires are a result of deforestation and illegal fires set to clear land for farming and cattle grazing.[75] The 4.1 million residents of the area could gain 2.7 years of life expectancy if pollution was reduced to permanently meet the WHO guideline.

PROGRESS TOWARDS REDUCING AIR POLLUTION

Vehicle emissions are primarily responsible for poor air quality in Latin America's major hotspot cities in Guatemala, Bolivia, and Peru among others.[76] In recent decades, several Latin American cities like Bogotá, Mexico City, Santiago de Chile, and Quito have implemented policy instruments to reduce urban air pollution and traffic congestion such as license plate-based restrictions on car use,[77] Bogota's bus rapid transit (BRT) system (largest in the world), dedicated bus lanes and BRT routes in Brazil's Curitiba are other examples of Latin American cities taking measures to reduce vehicular pollution. Brazil's PROCONVE program, initiated in 1987, also aims to reduce vehicle emissions. Vehicles are required to comply with Euro VI standards, with increasingly stringent requirements. PROCONVE phase L-7 standards started on January 1, 2022, and phase L-8 will enforce fleet-average emissions limits by 2025.[78, 79]

As a result of these measures, pollution levels in most of these cities (except Santiago de Chile) have either declined or remained stable over the past 15 years, indicating a positive trend in managing air quality. For instance, residents of Brazil's Sao Paulo are breathing air with particulate concentrations that are 5 percent lower compared to the average of the past 15 years. In Colombia's capital city of Bogota, particulate levels have remained between 19 µg/m³ and 20

Figure 6.2 · Potential gain in life expectancy from permanently reducing $PM_{2.5}$ from 2022 concentration to the WHO guideline



75 Rainforest Foundation US. 2024. "Amazon Rainforest Fires" https://rainforest-foundation.org/engage/brazil-amazon-fires/

76 Guatemala: International Women's Media Foundation. 2018. "How Outdated Cars Live On in a Smoggy Afterlife."; Bolivia: Mardoñez, V., Uzu, G., Andrade, M., Borlaza, L. J. S., Pandolfi, M., Weber, S., Moreno, I., Jaffrezo, J.-L., Besombes, J.-L., Alastuey, A., Perez, N., Močnik, G., and Laj, P., 2022; Peru: Pinedo-Jáuregui, C., Verano-Cachay, J., Barrantes-Santos, V., 2020.

77 Boso, À., Oltra, C., Garrido, J. et al., 2023. "Understanding Public Acceptance of Automobile Restriction Policies: A Qualitative Study in Four Latin American Cities."

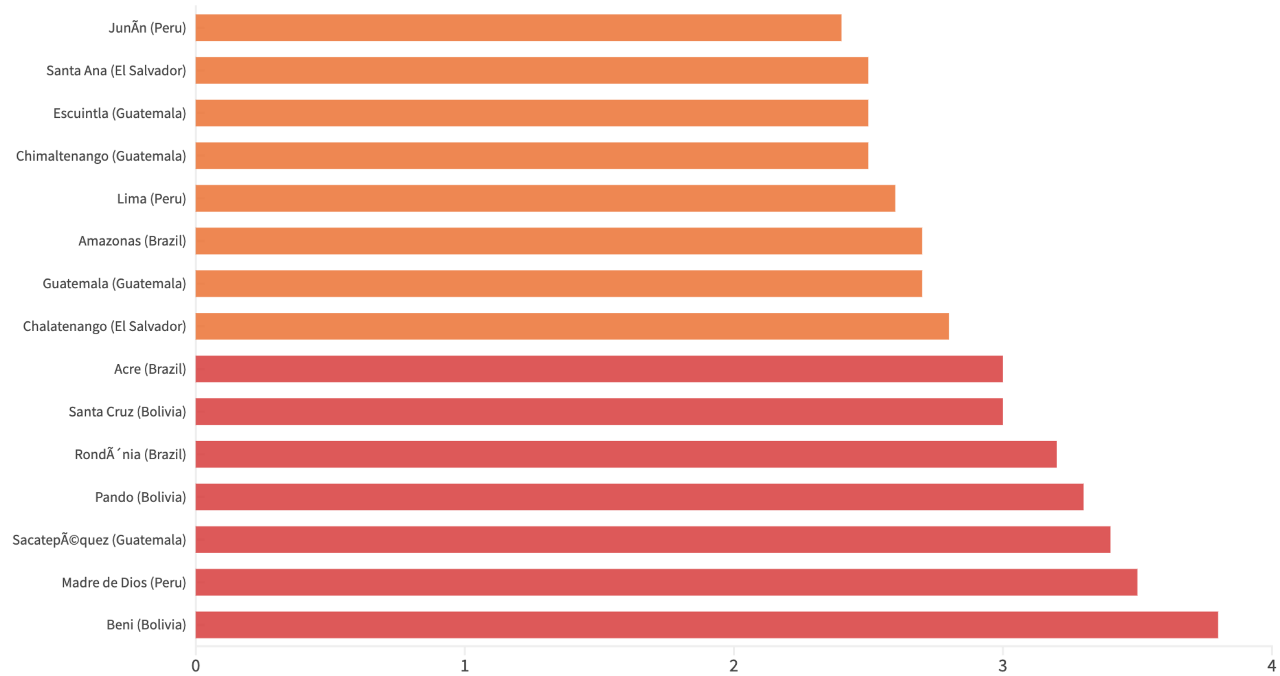
78 Brazilian Institute of Environment and Renewable Natural Resources. 2011. "Air Pollution Control Program by Motor Vehicles" https://www.ibama.gov.br/phocadownload/veiculosautomotores/manual%20proconve%20promot_english.pdf

79 Climate and Clean Air Coalition (CCAC). 2024. "Brazil" https://www.ccacoalition.org/partners/brazil

μg/m³ over the last 15 years. In Ecuador's capital Quito, particulate levels have remained between 17 μg/m³ and 18 μg/m³. In 2021, the pollution levels dropped to 15.6 μg/m³ but increased to 17.4 μg/m³ in 2022.

While these cities have managed to plateau their increasing pollution levels, there is significant scope for reducing their pollution. If pollution were reduced to permanently meet the WHO guidelines, an average resident in each of these cities would live over a year longer.

Figure 6.3 · Potential gain in life expectancy from permanently reducing $PM_{2.5}$ from 2022 levels to the WHO guideline in the 15 most polluted regions of Latin America



Section 7

China continues to make progress in reducing pollution

While China has substantially reduced its pollution in recent years, there continue to be regions in the country where air pollution is taking off more than 4 years from people's lives.

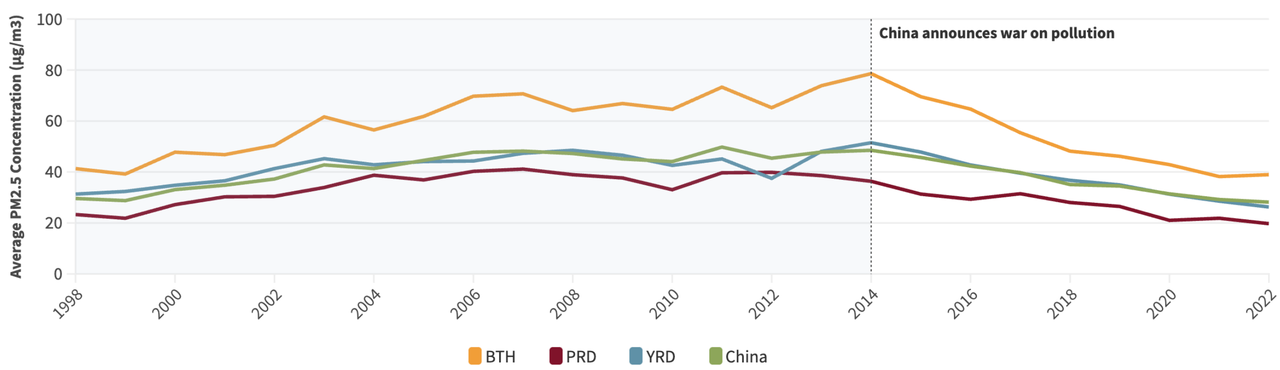
Home to almost 18 percent of the world's population, China accounts for 20 percent of air pollution related health burden. But, thanks to stringent policy action, China has managed to reduce its air pollution by 41 percent between 2013 and 2022. Within the country, Beijing province experienced the largest decline in pollution, dropping 54.1 percent in just nine years (Figure 7.1). Because of these air quality improvements, the average Chinese citizen can expect to live 2 years longer, provided the reductions are sustained. In Beijing, the average person can expect to live 3.9 years longer. In Shanghai, where $PM_{2.5}$ fell from 45.3 to 23.0 µg/m³, the average person could expect to live 2.2 years longer (Figure 7.2).

China has had such success in reducing pollution because of strict public policies. After China reached its highest pollution levels in 2013, the public began to call for change. China responded with a National Air Quality Action Plan in the fall of 2013, laying out specific targets to improve air quality by the end of 2017, including a USD 270 billion initiative to reduce pollution in densely populated regions.

To meet the goals laid out in its National Air Quality Action Plan, the government began to restrict the number of cars on the road in large cities such as Beijing, Shanghai, and Guangzhou. In the industrial sector, iron and steel making capacity was reduced. New coal plants were banned in the Beijing-Tianjin-Hebei (BTH), Pearl River Delta (PRD) and Yangtze River Delta (YRD) regions. Existing plants were mandated to reduce their emissions or switch to natural gas and renewable energy sources, while others were closed or relocated. In addition, coal-fired boilers used for heating homes in the north were replaced with gas or electric heaters.

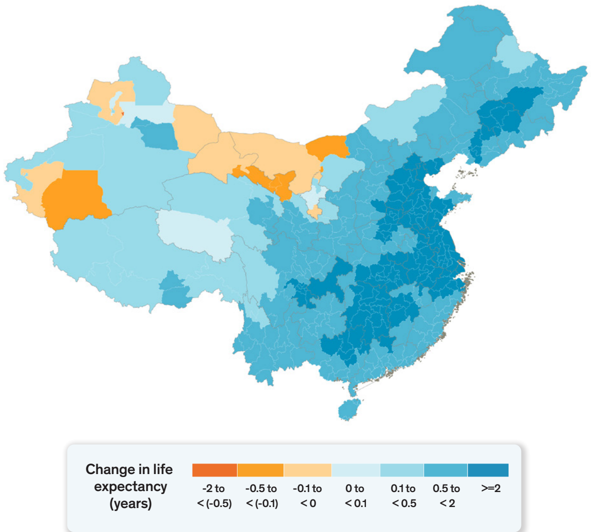
Thanks to these and other strict pollution policies, China's annual

Figure 7.1 · Annual average $PM_{2.5}$ concentrations in major regions in Mainland China, 1998-2022



Note: PRD stands for Pearl River Delta, and it includes the dense network of cities that covers nine prefectures of the province of Guangdong, namely Dongguan, Foshan, Guangzhou, Huizhou, Jiangmen, Shenzhen, Zhaoqing, Zhongshan and Zhuhai and the Special Administrative Regions of Hong Kong and Macau. YRD stands for Yangtze River Delta, and it includes Shanghai, Jiangsu and Zhejiang. BTH stands for Beijing-Tianjin-Hebei. It is important to note that our definition of the YRD region includes all regions in the Jiangsu and Zhejiang provinces. Others may define the YRD region differently than how we have defined it in this report.

Figure 7.2 · Improvements in life expectancy due to reduced pollution between 2014 and 2022 in China



Note: Virtually all Chinese residents are projected to see their life expectancy improve (blue) due to recent reductions in particulate pollution since 2014, if those reductions persist

average pollution level now meets the national standard of 35 µg/m³. However, the pollution in China is still 5.6 times higher than the WHO guideline and remains one of the top threats to life expectancy in the country. If China were able to reduce its pollution from 2022 level to meet the WHO guideline, and those reductions were permanently sustained, the average person in China would see their life expectancy increase further by 2.3 years. This threat falls just behind the threat from tobacco and high blood pressure in the country, which takes 3 years of life expectancy (Figure 7.3).

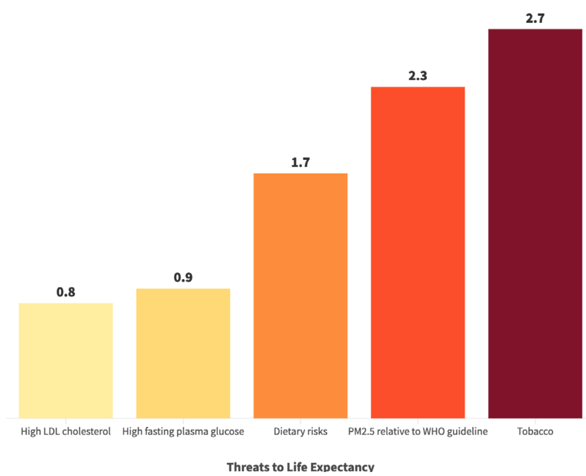
UNEQUAL BURDEN OF AIR POLLUTION

While the overall pollution level in the country has declined since 2013, residents in the more heavily polluted provinces of Hebei, Tianjin, Henan, and Shandong stand to gain between 3 and 3.4 additional years of life expectancy if pollution levels in these regions were brought down to meet the WHO guidelines. The health threat is even larger in the 54 prefectures that do not meet China's national standard of 35 µg/m³. With an annual average particulate pollution of 40.5 µg/m³, 318.1 million residents in these 54 prefectures would live 3.5 years longer if the WHO guideline was permanently met. Additionally, 33 out of these 54 prefectures experienced an increase in particulate pollution in 2022 compared to 2021.

Across the entire country, 112 prefectures reported an increase in particulate pollution from 2021 to 2022. Out of these, 24 prefectures in northern and western China reported an increase compared to 2013. In other words, these prefectures are more polluted now than they were when China began its war on pollution. Reducing pollution to meet the WHO guideline can add 1.5 years to the life expectancy of 29.7 million residents in these prefectures. These prefectures are distributed across the provinces of Gansu, Heilongjiang, Nei Mongol, Ningxia Hui, Qinghai, Xinjiang Uygur. Among these provinces, Hebei, Xinjiang Uygur, and Sichuan also face the most unequal burden of air pollution, with the potential gain in life expectancy in China ranging between 2.4 months to 4.4 years across them (outlined in black in Figure 7.2).

While China has made significant improvements in reducing its pollution, there is more to be done. In November 2023, China published its third pollution control plan.[80] The plan sets a 2025 target of reducing particulate pollution in all cities at the prefecture level and above by 10 percent compared to 2020. It targets a 20 percent reduction in the $PM_{2.5}$ level of the BTH region and a 15 percent reduction in the pollution level of the Fenwei Plain compared to its 2020 level. If the pollution reductions are successful, they will add 10 months to the average life expectancy in the BTH region and 6.9 months in the Fenwei Plain.[81] Time will tell how China responds to these new targets in the coming years..

Figure 7.3 · Top 5 threats to life expectancy in China



Source: Global Burden of Disease (https://vizhub.healthdata.org/gbd-results/) level-2 causes and risks data and WHO Life Tables (https://apps.who.int/gho/data/node.main.LIFECOUNTRY?lang=en) were combined with the Life table method to arrive at these results. "PM2.5 relative to WHO Guideline" bar displays the reduction in life expectancy relative to the WHO guideline as calculated by latest AQLI (2022) data.

80 Dialogue earth. 2023. "New air pollution control plan released" https://dialogue.earth/en/digest/new-air-pollution-control-plan-released/

81 Fenwei Plain is defined as the following prefectures: Xi'an, Baoji, Xianyang, Weinan, Tongchuan in Shaanxi province; Jinzhong, Luliang, Linfen, Yuncheng in Shanxi province; Luoyang, Sanmenxia in Henan province. Source: Liu, S.; Ju, T.; Pan, B.; Li, M.; Peng, S. 2022 "Aerosol Analysis of China's Fenwei Plain from 2012 to 2020 Based on OMI Satellite Data." Atmosphere 13(10): 1728. https://www.mdpi.com/2073-4433/13/10/1728

Section 8

Stricter air pollution standards reveal air pollution inequalities in the United States and Europe

Both the United States and Europe have further tightened their pollution standards but several regions are unable to meet them. If pollution levels in these regions were to meet the new standards, Europe and the US could respectively gain an additional 7.2 months and 2.4 months of life expectancy.

Both the United States and Europe have been largely successful in creating and enforcing stringent pollution control measures after decades of breathing polluted air. In the United States, legislative measures like the Clean Air Act have helped to reduce pollution by 67.2 percent since 1970, extending the average lifespan by 1.5 years. Only one county—Pierce County in Washington state—experiences pollution levels that are higher in 2022 than their estimated levels in 1970 (Figure 8.1).[82] In Europe, policies such as the European Union's Air Quality Framework Directive have helped reduce pollution by 30.2 percent since 1998, helping residents gain 5.6 months (Figure 8.2).[83] Barring some residents living in Andorra, Greece, Italy, Malta, and Spain, most European residents have seen air quality improvements that have extended their life expectancy. Primarily due to these pollution reductions, the United States and Europe—which make up 15.3 percent of the world's population—account for only about 3.9 percent of the health burden from particulate pollution.[84]

But, the latest scientific evidence suggests that pollution is harmful to human health at even the low levels that exist in much of the United States and Europe today. With this new evidence now built into the WHO's guideline, the 2022 data reveal that 94 and 96.8 percent of people in the United States and Europe, respectively, live in areas with pollution levels greater than 5 $\mu g/m^3$—deemed unsafe by the WHO.

In the United States, average pollution was 6.9 $\mu g/m^3$ in 2022, slightly above the WHO guideline of 5 $\mu g/m^3$, but meeting the newly revised national annual-$PM_{2.5}$ standard of 9 $\mu g/m^3$. At this level, residents could expect to gain roughly 2.2 months if the air they breathed permanently met the WHO guideline, or 62.6 million total life years.

The average European resident in 2022 was exposed to a particulate pollution concentration of 11.1 $\mu g/m^3$, meeting the European Union's annual $PM_{2.5}$ limit of 25 $\mu g/m^3$ and the stage 2 limit of 20 $\mu g/m^3$, but falling short of the revised WHO guideline as well as the newly adopted EU 2030 limit of 10 $\mu g/m^3$.[85,86] If particulate pollution were to meet the revised WHO guideline, average life expectancy across Europe would improve by 7.2 months, or 515.9 million total life years.

UNEQUAL BURDEN OF AIR POLLUTION

Specific areas of the United States and Europe face much higher levels of pollution than the average, having a significant impact on life expectancy.

82 Our 1970 US estimates are based on only 237 US counties for which 1970 PM2.5 concentrations could be approximated. It should be noted that not all states include counties with data available from 1970. Here we are comparing 1970s imputed PM2.5 data for those 237 counties with 2021 PM2.5 data, which are available for all 3,136 US counties. For further information, see the Technical Appendix available at https://aqli.epic.uchicago.edu/policy-impacts/united-states-clean-air-act/.

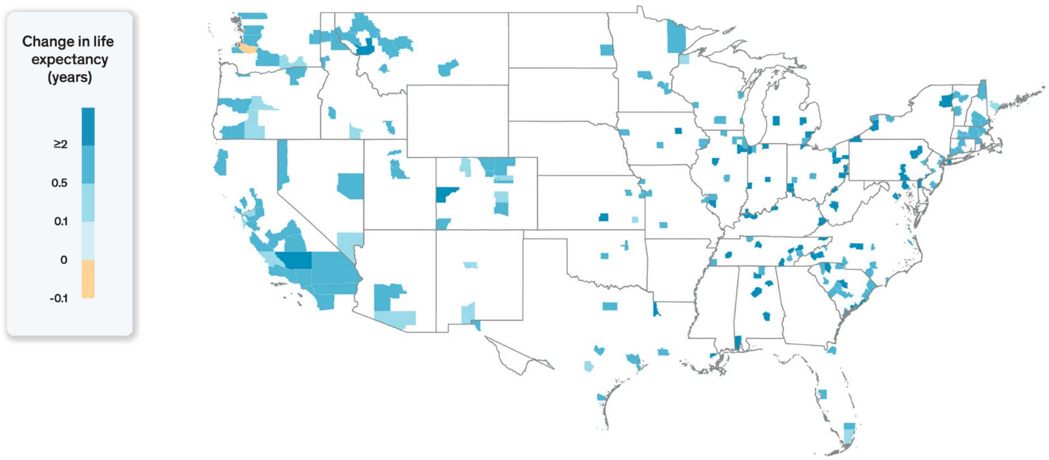
83 European Commission. 2008. "DIRECTIVE 2008/50/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on ambient air quality and cleaner air for Europe."

84 Europe is defined as the 53 countries listed in the following file: https://drive.google.com/file/d/1CpDGkKu96HcKr5xCZ3QozldnozJMetrH/view?usp=drive_link

85 Although the EU $PM_{2.5}$ standard only applies to a subset of the countries in Europe that are in the EU, we use it as a reference point for all of Europe's 53 countries, in this report.

86 Council of the Europen Union. 2024. "Air quality: Council and Parliament strike deal to strengthen standards in the EU" https://www.consilium.europa.eu/en/press/press-releases/2024/02/20/air-quality-council-and-parliament-strike-deal-to-strengthen-standards-in-the-eu/

Figure 8.1 · Change in life expectancy due to change in $PM_{2.5}$ concentration in 235 counties in the United States between 1970 and 2022



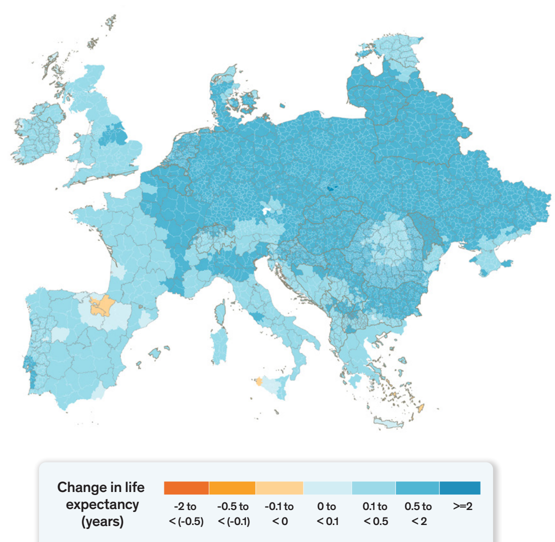
Note: Only one county (in yellow) is losing life years due to particulate pollution increasing in 2022 compared to 1970—Pierce (Washington).

This comparison can only be made for the 237 US counties for which 1970 PM2.5 concentrations could be estimated from available data. The two counties of Anchorage (Alaska) and Honolulu (Hawaii) were excluded in this figure due to limited space; however, they also experienced declines in particulate pollution in 2022 relative to 1970 resulting in gains of 7.2 months and 3.1 months respectively. For further information, see the Technical Appendix available at https://aqli.epic.uchicago.edu/policy-impacts/united-states-clean-air-act/.

In recent years, rising wildfires in the Western United States have caused air pollution levels to rise in the region. Residents of California's Central Valley are now exposed to average particulate pollution levels above both the WHO guideline and the nation's own air quality standard. In 2022, while Fairbanks North Star Borough in Alaska was the most polluted county-equivalent where residents stand to gain 10 months if WHO guideline was met, nine out of ten most polluted counties were in California. There, average pollution concentrations ranged from 4.3 µg/m³ in Del Norte County to 11.6 µg/m³ in Kern County. (Figure 8.3).

Like the United States, the burden of air pollution is unequal in Europe as well, with the eastern portions of the continent reporting higher pollution levels (Figure 8.4). If both Eastern and Western Europe were to meet the WHO guideline, Eastern Europe would gain 4.8 months more on to their life expectancy compared to Western Europe.[87] The East European nation of Bosnia and Herzegovina is the most polluted country in Europe, and virtually all of Poland, Belarus, Slovakia, Hungary, Lithuania, and Armenia exceed the WHO guideline. If particulate pollution was reduced to meet the WHO guideline, an average resident of these countries would gain an additional 10.2 months of life expectancy—equivalent to the addition of 61.3 million life years. The cities of Tuzla and Zenica-Doboj in Bosnia and Herzegovina and their surrounding areas see particularly high levels of particulate pollution, comparable to the wildfire ravaged Brazilian Amazonas. If pollution were reduced to meet the WHO guideline, residents in Tuzla, the most polluted region

Figure 8.2 · Change in life expectancy due to change in $PM_{2.5}$ concentration in Europe between 1998 and 2022



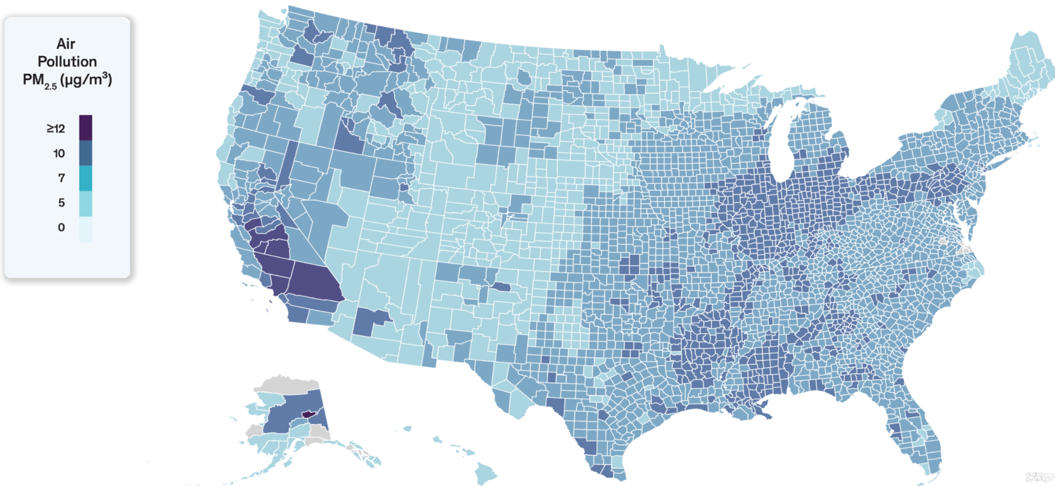
Note: Virtually all European residents will see their life expectancy improve (blue) due to reductions in particulate pollution, if those reductions persist.[1,2]

1 Refer Footnote 72

2 This map excludes the regions of Islas Canarias (in Spain), and Azores and Madeira (in Portugal) due to space limitations. But all underlying calculations include these regions. See Footnote 4 for the definition of Eastern vs Western Europe

87 The definition of Eastern v/s Western Europe can be found here. This definition is used only when comparing Eastern and Western Europe in this report (both in text and figure 8.4). All other types of calculations follow the original definition of Europe (which includes a couple more countries) as listed in this sheet

Figure 8.3 · Wildfire ravaged California is home to 9 of the 10 most polluted counties in the US



in the country, would gain 2.5 years in life expectancy.

Outside of Eastern Europe, pollution remains high in areas such as Italy's Po Valley. In Milan, the city with the highest pollution in Western Europe, residents would gain 1.7 years if particulate pollution levels were reduced to meet the WHO guideline.

ACTION TOWARDS STRENGTHENING AIR QUALITY STANDARDS

In the wake of the revised WHO guideline in 2021, both the United States and European Union have been taking steps to strengthen their $PM_{2.5}$ standards. As of May 6, 2024, the United States Environmental Protection Agency implemented a new annual $PM_{2.5}$ standard of 9 μg/m³, replacing its standard of 12 μg/m³.[88] In 2022, all states in the US met the old standard. Despite the more stringent standard, the pollution levels in only 13 out of the 3,142 counties in the United States were higher than the new standard. Nine of these counties are in the state of California. If these counties were to meet the revised standards, an average resident in these parts of the US would gain an additional 1.3 months of life expectancy, adding 1.9 million life years nationally.

Meanwhile, in late 2022, the European Commission proposed ratcheting down the European Union's current $PM_{2.5}$ standard of 25 μg/m³ to 10 μg/m³ by 2030.[89] In February 2024 the European parliament struck a provisional agreement with EU countries in this regard.[90] As per the latest AQLI data, 12 of the 27 member countries of the EU exceed the 2030 stricter limit. If these 12 countries were to reduce their pollution levels to meet the limit, the average citizen living in these countries would gain 4 months of life expectancy on average, which is equivalent to gaining 55.8 million total life years for the population of those 12 countries.[91]

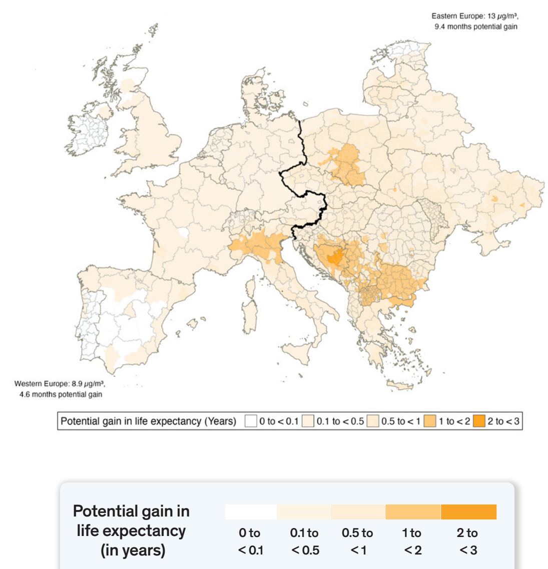
88 USEPA. 2024. "Final Rule to Strengthen the National Air Quality Health Standard for Particulate Matter" https://www.epa.gov/system/files/documents/2024-02/pm-naaqs-overview.pdf

89 European Commission. 2022. "DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on ambient air quality and cleaner air for Europe (recast)."

90 European parliament news. 2024. "Air pollution: Deal with Council to improve air quality" https://www.europarl.europa.eu/news/en/press-room/20240219IPR17816/air-pollution-deal-with-council-to-improve-air-quality

91 Twelve countries exceeding the proposed stricter standard: Bulgaria, Croatia, Cyprus, Czechia, Greece, Hungary, Italy, Latvia, Poland, Romania, Slovakia, Slovenia.

Figure 8.4 · Potential gain in life expectancy from permanently reducing $PM_{2.5}$ from 2022 concentration to the WHO guideline, comparing Eastern Europe versus Western Europe (demarcated by heavy black line)[1]



1 Refer Footnotes 72 and 79

Conclusion

In 2022, global pollution levels declined, including in South Asia where air pollution has been on the rise for almost a decade. Despite this decline, people worldwide are losing an average of 1.9 years of life expectancy due to polluted air. In the most polluted regions, individuals are losing more than 5 years of life expectancy.

The impacts of air pollution are highly unequal, with South Asia and Sub-Saharan Africa bearing the brunt. Significant disparities also exist within regions. For instance, while China has reduced its particulate pollution levels by over 40 percent since 2013, more than 20 percent of China's population still breathes air that does not meet the country's standard.

National standards are an important tool to improve air quality. If countries adopt more ambitious air quality targets and implement policies to achieve these targets, life expectancy would significantly improve. Yet, more than 30 percent of the world's population lives in regions that don't meet their country's national standard. But if those countries did meet their own benchmarks, it would add more than 3 billion life-years globally. Further, almost half of all countries around the world don't have a pollution standard at all, and many of them are among the most polluted countries in the world. The latest AQLI report emphasizes the disparity of air pollution around the world, the impacts on human health, and the policies helping to reverse these disparities.

Appendix I: Methodology

The life expectancy calculations made by the AQLI are based on a pair of peer-reviewed studies, Chen et al. (2013) and Ebenstein et al. (2017), co-authored by Michael Greenstone, that exploit a unique natural experiment in China. By comparing two subgroups of the population that experienced prolonged exposure to different levels of particulate air pollution, the studies were able to plausibly isolate the effect of particulate air pollution from other factors that affect health. Although the study was based solely on a Chinese setting, together, the regions and years covered in the study saw a wide range of pollution levels - spanning 27-307 µg/m³ of PM10 (approximately equivalent to 18-200 µg/m³ of $PM_{2.5}$). Thus, the relationship between life expectancy and particulate pollution that underlies the AQLI is derived from a $PM_{2.5}$ distribution similar to the observed global distribution, providing a credible basis for generalizing the measured pollution-life expectancy relationship from Ebenstein et al. (2017).

We'd like to note that the global $PM_{2.5}$ annual average measurements in this AQLI update range from less than 1 µg/m³ to 84 µg/m³. For life expectancy estimates for regions with particulate concentrations lower than those in Ebenstein et al. (2017) - home to approximately 40 percent of the world population, the AQLI assumes the same linear relationship between long-term exposure to $PM_{2.5}$ and life expectancy, as the rest of the concentration range. Though it is possible that the pollution-life expectancy relationship is nonlinear over certain ranges of $PM_{2.5}$ concentrations and/or that there is a threshold below which $PM_{2.5}$ has no effect, we are unaware of credible empirical evidence that would cause a rejection of the linearity assumption.

Ebenstein et al. (2017) found that sustained exposure to an additional 10 µg/m³ of PM_{10} reduces life expectancy by 0.64 years. In terms of $PM_{2.5}$, this translates to the relationship that an additional 10 µg/m³ of $PM_{2.5}$ reduces life expectancy by 0.98 years. This metric is then combined with sea-salt and mineral dust removed satellite-derived $PM_{2.5}$ data. All 2022 annual average $PM_{2.5}$ values are population-weighted and AQLI's source of population data is https://landscan.ornl.gov/. We are grateful to the Atmospheric Composition Analysis Group, based at the Washington University in St. Louis for providing us with the satellite data. The original dataset can be found here: https://sites.wustl.edu/acag/datasets/surface-pm2-5/.

To learn more deeply about the methodology used by the AQLI, visit: aqli.epic.uchicago.edu/about/methodology

Appendix Table · 2022 Annual Average $PM_{2.5}$ Pollution Concentrations by Country and Corresponding Potential Life Expectancy Gains, if WHO Guideline or National Standard Were Met

Country	$PM_{2.5}$ concentration 2022 (in µg/m³)	National Standard (in µg/m³)	Life Expectancy Gains (in years) from reducing $PM_{2.5}$ from 2022 Concentrations to the WHO Guideline of 5 µg/m³	Life Expectancy Gains (in years) from reducing $PM_{2.5}$ from 2022 Concentrations to the National Standard
Afghanistan	17	35	1.2	0
Akrotiri and Dhekelia	13.4	*	0.8	
Åland	4	*	0	
Albania	12.6	10	0.7	0.25
Algeria	6.1	*	0.1	
American Samoa	1.4	9	0	0
Andorra	8.7	25	0.4	0
Angola	21.1	*	1.6	
Anguilla	1.7	*	0	
Antigua and Barbuda	1.8	*	0	
Argentina	12.5	*	0.7	
Armenia	19.5	*	1.4	
Aruba	3.4	*	0	
Australia	3.4	8	0	0
Austria	9.5	10	0.4	0
Azerbaijan	11.9	*	0.7	
Bahamas	3.1	*	0	
Bahrain	22.8	25	1.7	0
Bangladesh	54.2	35	4.8	1.88
Barbados	2	10	0	0
Belarus	9.8	15	0.5	0
Belgium	8.8	10	0.4	0
Belize	9.9	*	0.5	
Benin	17.3	*	1.2	
Bermuda	2.8	*	0	
Bhutan	22.8	*	1.7	
Bolivia	29.6	*	2.4	
Bonaire, Sint Eustatius and Saba	3.3	*	0	
Bosnia and Herzegovina	23.9	20	1.9	0.39
Botswana	12.5	*	0.7	
Bouvet Island	*	5	*	
Brazil	12.1	10	0.7	0.2
British Indian Ocean Territory	*	*	*	
British Virgin Islands	1.5	*	0	
Brunei	6.3	*	0.1	
Bulgaria	18.8	10	1.4	0.87
Burkina Faso	8.7	*	0.4	
Burundi	34	*	2.8	
Cabo Verde	2.2	*	0	
Cambodia	16.9	25	1.2	0
Cameroon	32.6	*	2.7	
Canada	6	8.8	0.1	0
Cayman Islands	8	*	0.3	
Central African Republic	25	*	2	
Chad	11.3	*	0.6	
Chile	22.8	20	1.7	0.28
China	28.2	35	2.3	0
Christmas Island	2.9	*	0	
Clipperton Island	*	*	*	
Cocos Islands	1.7	*	0	
Colombia	16.2	20	1.1	0
Comoros	7	*	0.2	
Cook Islands	1.1	*	0	
Costa Rica	12.6	*	0.7	
Côte d'Ivoire	10.4	*	0.5	
Croatia	14.1	10	0.9	0.41
Cuba	6.3	*	0.1	
Curaçao	3.7	*	0	
Cyprus	14.7	10	1	0.46
Czechia	11.5	10	0.6	0.15
Democratic Republic of the Congo	34.7	*	2.9	
Denmark	7.1	10	0.2	0
Djibouti	18.4	*	1.3	
Dominica	2.3	*	0	
Dominican Republic	7.9	15	0.3	0
Ecuador	18.3	15	1.3	0.33
Egypt	19.2	50	1.4	0
El Salvador	27.4	15	2.2	1.22
Equatorial Guinea	32.9	*	2.7	
Eritrea	14.4	*	0.9	
Estonia	5.6	10	0.1	0
Ethiopia	16.9	*	1.2	
Falkland Islands	2.6	*	0	
Faroe Islands	2.6	*	0	
Fiji	3.2	*	0	
Finland	4.4	10	0	0
France	8.4	10	0.3	0
French Guiana	5.5	*	0	
French Polynesia	1.5	*	0	
French Southern Territories	*	*	*	
Gabon	25.7	*	2	
Gambia	6.9	*	0.2	
Georgia	13.7	20	0.9	0
Germany	8.5	10	0.3	0
Ghana	13.7	*	0.9	
Gibraltar	7.3	*	0.2	
Greece	12.6	10	0.7	0.25
Greenland	1.1	*	0	

* No national standard specified and/or data not available.

Country	$PM_{2.5}$ concentration 2022 (in µg/m³)	National Standard (in µg/m³)	Life Expectancy Gains (in years) from reducing $PM_{2.5}$ from 2022 Concentrations to the WHO Guideline of 5 µg/m³	Life Expectancy Gains (in years) from reducing $PM_{2.5}$ from 2022 Concentrations to the National Standard
Grenada	2.2	*	0	
Guadeloupe	2.3	*	0	
Guam	1.2	9	0	0
Guatemala	25.1	*	2	
Guernsey	6.9	*	0.2	
Guinea	9.8	*	0.5	
Guinea-Bissau	7.9	*	0.3	
Guyana	7.2	*	0.2	
Haiti	9.9	*	0.5	
Heard Island and McDonald Island	*	*	*	
Honduras	24.5	*	1.9	
Hungary	11.9	10	0.7	0.19
Iceland	2.9	10	0	0
India	41.4	40	3.6	0.14
Indonesia	18.3	15	1.3	0.32
Iran	18.8	12	1.4	0.67
Iraq	32.4	10	2.7	2.2
Ireland	5.4	10	0	0
Isle of Man	5.4	*	0	
Israel	14.3	25	0.9	0
Italy	13.1	10	0.8	0.3
Jamaica	13.2	12	0.8	0.11
Japan	11.3	15	0.6	0
Jersey	6.9	*	0.2	
Jordan	19.7	15	1.4	0.46
Kazakhstan	12	*	0.7	
Kenya	16.5	35	1.1	0
Kiribati	0.9	*	0	
Kosovo	15.5	*	1	
Kuwait	21.7	*	1.6	
Kyrgyzstan	12.1	*	0.7	
Laos	23.5	*	1.8	
Latvia	12.2	10	0.7	0.21
Lebanon	18.6	*	1.3	
Lesotho	27.9	*	2.2	
Liberia	9.4	*	0.4	
Libya	8.9	*	0.4	
Liechtenstein	10.8	*	0.6	
Lithuania	9.6	10	0.5	0
Luxembourg	8	10	0.3	0
Macedonia	19	*	1.4	
Madagascar	9.7	*	0.5	
Malawi	17.6	*	1.2	
Malaysia	13.3	15	0.8	0
Maldives	8.2	*	0.3	

Country	$PM_{2.5}$ concentration 2022 (in µg/m³)	National Standard (in µg/m³)	Life Expectancy Gains (in years) from reducing $PM_{2.5}$ from 2022 Concentrations to the WHO Guideline of 5 µg/m³	Life Expectancy Gains (in years) from reducing $PM_{2.5}$ from 2022 Concentrations to the National Standard
Mali	6.6	*	0.2	
Malta	7.2	10	0.2	0
Marshall Islands	1	*	0	
Martinique	2.7	*	0	
Mauritania	3.5	*	0	
Mauritius	5.7	*	0.1	
Mayotte	8.1	*	0.3	
México	15.6	12	1	0.36
Micronesia	0.9	*	0	
Moldova	11.5	25	0.6	0
Monaco	9.9	*	0.5	
Mongolia	30.1	25	2.5	0.5
Montenegro	15.1	25	1	0
Montserrat	2.3	*	0	
Morocco	7.1	*	0.2	
Mozambique	12.7	*	0.8	
Myanmar	28.6	*	2.3	
Namibia	14.5	*	0.9	
Nauru	1.2	*	0	
Nepal	39.2	*	3.4	
Netherlands	8.5	10	0.3	0
New Caledonia	4.3	*	0	
New Zealand	3.7	10	0	0
Nicaragua	14.6	*	0.9	
Niger	10.6	*	0.5	
Nigeria	25	20	2	0.49
Niue	1.2	*	0	
Norfolk Island	1.6	*	0	
North Korea	18.6	*	1.3	
Northern Cyprus	14.5	*	0.9	
Northern Mariana Islands	1.1	9	0	0
Norway	4.9	5	0	0
Oman	13.4	*	0.8	
Pakistan	38.9	15	3.3	2.34
Palau	2.4	12	0	0
Palestine	14	*	0.9	
Panama	9.7	15	0.5	0
Papua New Guinea	14.5	*	0.9	
Paracel Islands	4	*	0	
Paraguay	13.2	15	0.8	0
Peru	25.5	25	2	0.05
Philippines	19.2	25	1.4	0
Pitcairn Islands	2.5	*	0	
Poland	14.1	10	0.9	0.4
Portugal	5.7	10	0.1	0

* No national standard specified and/or data not available.

Country	$PM_{2.5}$ concentration 2022 (in µg/m³)	National Standard (in µg/m³)	Life Expectancy Gains (in years) from reducing $PM_{2.5}$ from 2022 Concentrations to the WHO Guideline of 5 µg/m³	Life Expectancy Gains (in years) from reducing $PM_{2.5}$ from 2022 Concentrations to the National Standard
Puerto Rico	2.2	9	0	0
Qatar	39.1	*	3.3	
Republic of the Congo	31.9	*	2.6	
Réunion	2.7	*	0	
Romania	13.7	10	0.9	0.36
Russia	9.3	25	0.4	0
Rwanda	33.4	35	2.8	0
Saint Helena, Ascension and Tris	2.7	*	0	
Saint Kitts and Nevis	2.4	*	0	
Saint Lucia	2	*	0	
Saint Pierre and Miquelon	3.4	*	0	
Saint Vincent and the Grenadines	2.1	*	0	
Saint-Barthélemy	2	*	0	
Saint-Martin	1.8	*	0	
Samoa	1.7	*	0	
San Marino	13.5	*	0.8	
São Tomé and Príncipe	10.3	*	0.5	
Saudi Arabia	27.5	15	2.2	1.23
Senegal	5.7	*	0.1	
Serbia	16.9	25	1.2	0
Seychelles	5	*	0	
Sierra Leone	9.9	*	0.5	
Singapore	13.9	10	0.9	0.38
Sint Maarten	2	*	0	
Slovakia	12.1	10	0.7	0.21
Slovenia	12.3	10	0.7	0.23
Solomon Islands	7	*	0.2	
Somalia	8.9	*	0.4	
South Africa	23.3	20	1.8	0.32
South Georgia and the South Sand	*	*	*	
South Korea	20.8	15	1.5	0.57
South Sudan	16	*	1.1	
Spain	7.5	10	0.2	0
Spratly Islands	0	*	0	
Sri Lanka	19.1	25	1.4	0
Sudan	10.2	10	0.5	0.02
Suriname	6.1	*	0.1	
Svalbard and Jan Mayen	*	*	*	
Swaziland	16.4	*	1.1	
Sweden	4.9	10	0	0
Switzerland	8.7	10	0.4	0
Syria	22.8	*	1.7	
Taiwan	17.3	*	1.2	
Tajikistan	17.1	*	1.2	

Country	$PM_{2.5}$ concentration 2022 (in µg/m³)	National Standard (in µg/m³)	Life Expectancy Gains (in years) from reducing $PM_{2.5}$ from 2022 Concentrations to the WHO Guideline of 5 µg/m³	Life Expectancy Gains (in years) from reducing $PM_{2.5}$ from 2022 Concentrations to the National Standard
Tanzania	18.2	*	1.3	
Thailand	21.2	15	1.6	0.6
Timor-Leste	11	*	0.6	
Togo	15.6	*	1	
Tokelau	1.6	*	0	
Tonga	2	*	0	
Trinidad and Tobago	3.9	15	0	0
Tunisia	10.2	*	0.5	
Turkey	21.1	*	1.6	
Turkmenistan	10.4	*	0.5	
Turks and Caicos Islands	2.7	*	0	
Tuvalu	1.5	*	0	
Uganda	27.8	25	2.2	0.28
Ukraine	10.8	25	0.6	0
United Arab Emirates	20.7	*	1.5	
United Kingdom	8.3	20	0.3	0
United States	6.9	9	0.2	0
United States Minor Outlying Islands	3.2	*	0	
Uruguay	9.1	*	0.4	
Uzbekistan	18.6	*	1.3	
Vanuatu	5.1	*	0	
Vatican City	11.1	*	0.6	
Venezuela	12	*	0.7	
Vietnam	23.6	25	1.8	0
Virgin Islands, U.S.	1.8	9	0	0
Wallis and Futuna	1.8	*	0	
Western Sahara	4.9	*	0	
Yemen	16.8	*	1.2	
Zambia	22.2	*	1.7	
Zimbabwe	16	*	1.1	*

* No national standard specified and/or data not available.

Appendix II: The Evolution of Satellite-Derived $PM_{2.5}$ Data

Reliable, geographically extensive pollution measurements are critical to understanding the extent of air pollution and its health impacts. Unfortunately, many areas around the world either lack extensive pollution monitoring systems or did not begin monitoring $PM_{2.5}$ until recently, making it impossible to track long-term global trends. To construct a single dataset of particulate pollution and its health impacts that is global in coverage, local in resolution, consistent in methodology, and that spans many years to reveal pollution trends over time, the latest AQLI data incorporates satellite-derived annual ambient $PM_{2.5}$ concentration estimates spanning 25 years from 1998-2022 by the Atmospheric Composition Analysis Group at the University of Washington (methodology described in van Donkelaar et al. (2021) and Donkelaar et al. (2024).

The latest raw dataset (version: V6.GL.01) is publicly accessible at: https://sites.wustl.edu/acag/datasets/surface-pm2-5/#V6.GL.02. The AQLI uses a version of this data that excludes sea salt and dust.

There are differences between the satellite-derived PM2.5 dataset used in this report and those used in previous AQLI reports. For example, in the new and revised 2022 dataset used this year, the estimated global population-weighted average $PM_{2.5}$ concentration for the year 2019 has been revised downwards (from 28.5 µg/m³ to 27.2 µg/m³) relative to the 2021 dataset used in our 2023 AQLI update (Figure A.1)

According to van Donkelaar et al. (2021), satellite-derived $PM_{2.5}$ data were constructed by converting measurements of aerosol optical depth (AOD) over each grid cell into $PM_{2.5}$ measurements using a chemical transport model called GEOS-Chem. These estimates were then subsequently calibrated to regional ground-based observations of both total and compositional mass using a Geographically Weighted Regression (GWR). Over time, improvements in the model and calibration inputs, alongside growing ground level monitoring coverage necessitate periodic updates to the historical $PM_{2.5}$ dataset.

In Figure A.1, we plot and compare the global population-weighted $PM_{2.5}$-time trends using various years' versions of the annual average $PM_{2.5}$ dataset. Although the new and revised $PM_{2.5}$ dataset yields global average concentration levels that are lower on average than those estimated using the 2020 and 2021 datasets and higher on average than the 2016 reference datasets, the overall picture remains the same. The global annual average $PM_{2.5}$ level has shifted between 3.8 to 7.2 times the WHO guideline, making air pollution the greatest external threat to human health globally.

Figure A.1 · Comparing latest (2022 reference dataset) global annual average $PM_{2.5}$ concentration time series with various historical reference datasets

Note: The "2022 dataset" line plots the global population-weighted annual average $PM_{2.5}$ trend using data accessible from https://sites.wustl.edu/acag/datasets/surface-pm2-5/#V6.GL.02 and methodology described in van Donkelaar et al. (2021) and Donkelaar et al. (2024). The "2021 dataset" line plots the global population-weighted average PM2.5 trend using data from van Donkelaar et al. (2021). The "2020 dataset" line plots the analogous trend using data from Hammer et al. (2020). The "2016 dataset" plots the trend using data from van Donkelaar et al. (2016). Note that the AQLI uses a version of all datasets that excludes sea salt and dust. To learn more about these versions, visit: https://sites.wustl.edu/acag/datasets/surface-pm2-5/.

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ABOUT THE AIR QUALITY LIFE INDEX

The AQLI is a pollution index that translates particulate air pollution into perhaps the most important metric that exists: its impact on life expectancy. Developed by the University of Chicago's Milton Friedman Distinguished Service Professor in Economics Michael Greenstone and his team at the Energy Policy Institute at the University of Chicago (EPIC), the AQLI is rooted in recent research that quantifies the causal relationship between long-term human exposure to air pollution and life expectancy. The Index then combines this research with hyper-localized, global particulate measurements, yielding unprecedented insight into the true cost of particulate pollution in communities around the world. The Index also illustrates how air pollution policies can increase life expectancy when they meet the World Health Organization's guideline for what is considered a safe level of exposure, existing national air quality standards, or user-defined air quality levels. This information can help to inform local communities and policymakers about the importance of air pollution policies in concrete terms.

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ABOUT EPIC

The Energy Policy Institute at the University of Chicago (EPIC) is confronting the global energy challenge by working to ensure that energy markets provide access to reliable, affordable energy, while limiting environmental and social damages. We do this using a unique interdisciplinary approach that translates robust, data-driven research into real-world impacts through strategic outreach and training for the next generation of global energy leaders.

The EPIC Clean Air Program is working to bring actionable information about the quality of the air we breathe and its impact on our health to every corner of the globe in order to motivate action and lay guideposts for efficient air pollution policies. This work includes an Air Quality Fund to bring high quality and high frequency air pollution monitoring and data access to the places of the world where it is needed most; the Air Quality Life Index (AQLI), which uses air pollution data to translate the impact of pollution on a person's life expectancy; and several particulate pollution trading markets being piloted in Indian cities in coordination with state governments.

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