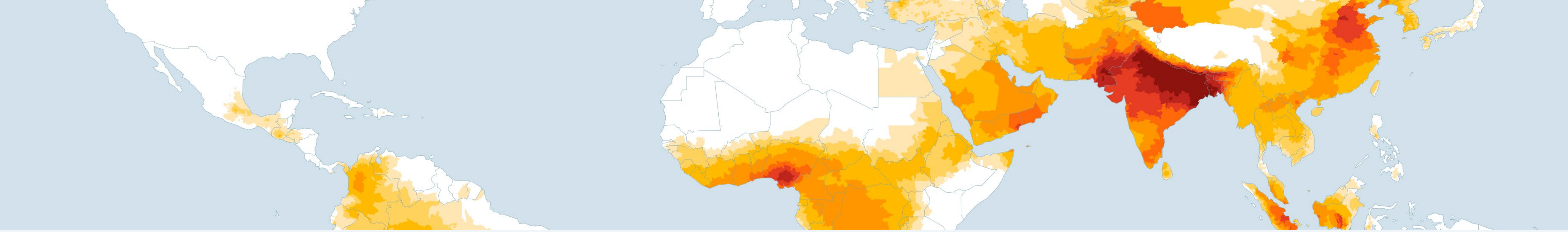
AIR QUALITY LIFE INDEX® | SEPTEMBER 2021

Annual Update

By Ken Lee and Michael Greenstone



Executive Summary

Over the past year, Covid-19 lockdowns shut industries down and forced vehicles off the roads, momentarily bringing blue skies to some of the most polluted regions on Earth. In India, clean air allowed some communities to view the snow-capped Himalayas for the first time in years. But on the other side of the world, a different story unfolded. Cities like Chicago, New York, and Boston—where blue skies have been the norm for decades, due to strong clean air policies—experienced pollution warnings as wildfires, exacerbated by a drier and hotter climate, sent clouds of smoke to cities thousands of miles away.

These remarkable events illustrate that air pollution is not only a global challenge, but is also intertwined with climate change. Both challenges are primarily caused by the same culprit: fossil fuel emissions from power plants, vehicles and other industrial sources. More than ever before, the world urgently needs strong policies to reduce its dependence on fossil fuels. The data supports this need. The Air Quality Life Index (AQLI) shows that strong pollution policies pay back in additional years of life for people across the world. The AQLI's latest data reveals that reducing air pollution to meet the World Health Organization's (WHO) guideline would add 2.2 years onto global life expectancy.

China is an important model of progress. In 2013, China experienced some of its highest pollution levels to that point, and public awareness and criticism reached new heights. The following year, Chinese Premier Li Keqiang declared a "war against pollution," allocating substantial public resources to combating pollution. China's strict policy action led to a swift reduction in pollution. Since 2013, particulate pollution in China has declined by 29 percent, adding about 1.5 years onto average life expectancy assuming these reductions are sustained. To place China's success into context, it took several decades and recessions for the United States and Europe to achieve the same pollution reductions that China was able to accomplish in 6 years, even as it continued to grow its economy.

China's war against pollution demonstrates that progress is indeed possible, even in the world's most polluted countries. In this report, we utilize updated AQLI data to illustrate the opportunities that countries have to allow their people to enjoy healthier and longer lives.

In no region of the world are these opportunities greater than South Asia, which includes four of the five most polluted countries in the world. In Bangladesh, India, Nepal, and Pakistan, the AQLI data reveal that the average person would live 5.6 years longer if pollution were reduced to meet the WHO guideline. Due to South Asia's high population and pollution concentrations, the region accounts for 58 percent of total life years lost due to particulate pollution exceeding the WHO guideline. The benefits of clean air policy are even greater in the Indo-Gangetic plains of Northern India, where 480 million people regularly breathe pollution levels that exceed those found in Europe and North America by an order of magnitude.

Air pollution is also a major threat in the Southeast Asian metropolises of Bangkok, Ho Chi Minh City, and Jakarta. In these cities, the average resident stands to gain 2 to 5 years of life expectancy if pollution levels were reined in to meet the WHO guideline. Meanwhile, in Central and West Africa, the effects of particulate pollution on life expectancy are comparable to those of well-known threats like HIV/AIDS and malaria. In the Niger Delta region of Nigeria, the air quality is on par with South Asia, with the average resident on track to lose nearly 6 years of life expectancy if pollution trends continue.

The AQLI data is yet another warning that the stakes are higher than ever to reduce fossil fuel emissions. Working unseen inside the human body, the deadly effects of $PM_{2.5}$ on the heart, lungs, and other systems have a more devastating impact on life expectancy than communicable diseases like tuberculosis, behavioral killers like cigarette smoking, and even war. Without strong policies to reduce fossil fuels and bring global air pollution levels down to meet the WHO guideline, billions of life-years will be lost. At the same time, climate-induced wildfires will only worsen air pollution, along with other dire climate consequences.

Note: The WHO changed its particulate pollution guidance on September 22, 2021. The data here reflects the previous guidance.

The contrasting experiences of blue skies in polluted regions and hazy skies in normally clean regions offer up two visions of what the future could hold. The difference between those futures lies in policies to reduce fossil fuels.

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 Milton Friedman Distinguished Service Professor in Economics Michael Greenstone, that draw on 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 are able to plausibly isolate the effect of particulate air pollution from other factors that affect health. The more recent of the two studies found that sustained exposure to an additional 10 μg/m3 of PM10 reduces life expectancy by 0.64 years. Calculated in terms of $PM_{2.5}$, this means that each additional 10 μg/m3 of $PM_{2.5}$ exposure reduces life expectancy by 0.98 years. The AQLI applies this relationship to global, satellite-derived $PM_{2.5}$ measurements to determine the gains in life expectancy that could be achieved from cleaner air in communities around the world.

Wildfires burning out of control across the Western United States cause hazy skies throughout New York City, July 20, 2021 Source: Getty Images

View from Pathankot in Punjab, India after Covid-19 lockdowns reduced air pollution, April 2020. Some residents reported seeing the peaks of the Himalayas for the first time in 30 years. Source: Twitter @PARASRISHI

Section 1

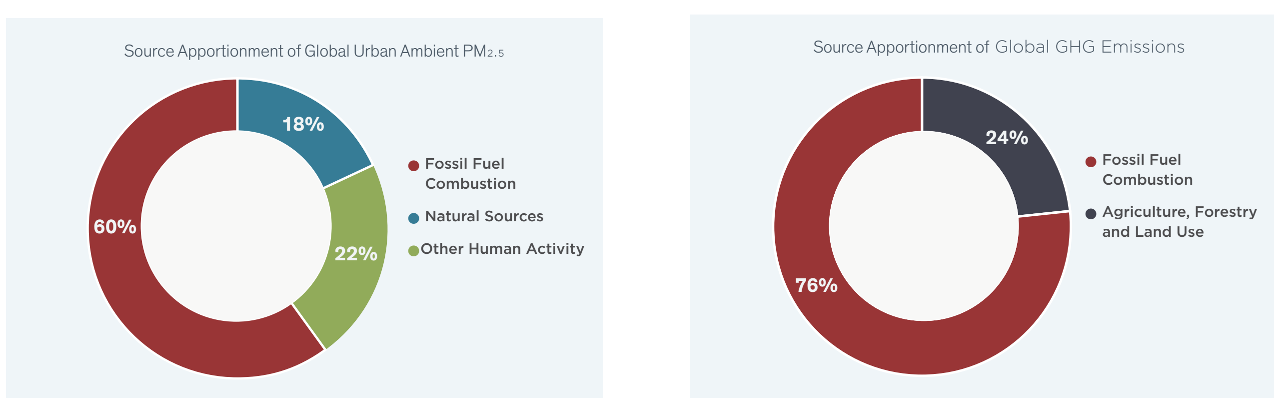
Climate Change is Exacerbating Air Pollution

Particulate pollution is primarily caused by the burning of fossil fuels. According to some estimates, fossil fuels account for 60 percent of urban ambient PM2.5 in 2014, with the remaining sources being attributed to natural sources and other human activities. At the same time, fossil fuel combustion is also the primary cause of climate change, which is already causing temperatures to rise, winter snowpacks to melt earlier, droughts to become more severe, and wildfire seasons to become longer.

As the planet becomes hotter, drier soil and vegetation conditions will expose even more areas to the risk of wildfires, many of which are triggered by human activities. Indeed, rampant wildfires have been witnessed across the globe in recent years. As is revealed in satellite PM2.5 data, surges in air pollution levels are noticeable in years with a particularly high number of fire events, not just in California, but also in the Amazon, the islands of Kalimantan and Sumatra in Indonesia, Northern Thailand, and the Congo Basin, among others.

In Southeast Asia, fire events are particularly high during El Nino years. In 2015 in Indonesia, for example, there were over 100,000 fires, making it one of the worst fire seasons on record[1].

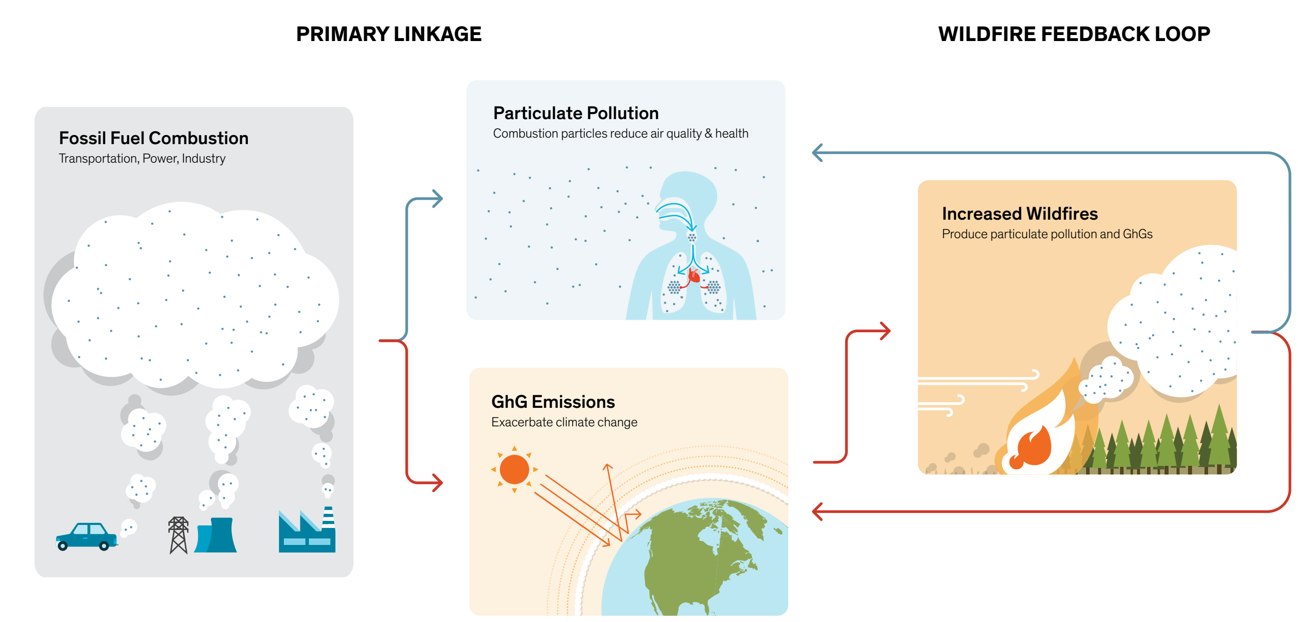
Figure 1 ·Fossil Fuel Combustion is the Primary Contributor to both Particulate Pollution and Climate Change



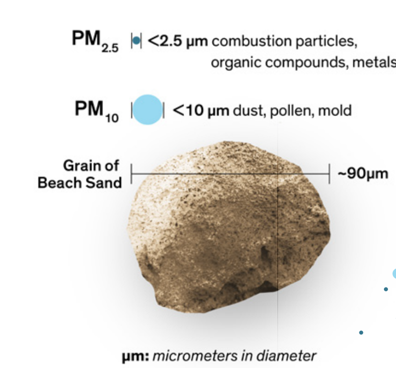
Note: Philip et al. (2014) and IPCC (2014)

1 https://www.bbc.com/news/business-35770490

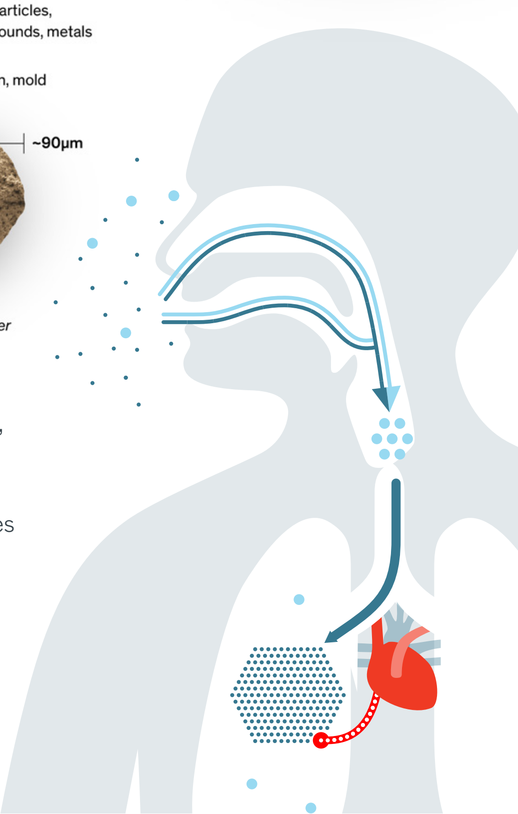
Figure 2 ·The Link Between Fossil Fuels, Particulate Pollution, and Climate Change



What is particulate pollution and where does it come from?



Particulate matter (PM) refers to solid and liquid particles—soot, smoke, dust, and others—that are suspended in the air. Some have their origin in natural sources such as dust, sea salt, and wildfires. But most come from the combustion of fossil fuels—such as from vehicle engines and power plants—and the combustion of biomass—such as through household wood and crop burning. These microscopic particles enter the respiratory system along with the oxygen that the body needs. When PM is breathed into the nose or mouth, each particle's fate depends on its size: the finer the particles, the farther into the body they penetrate. $PM_{2.5}$—or particles with a diameter of less than 2.5 µm, just 3 percent the diameter of a human hair—is the most deadly. They penetrate deep into the lungs, bypassing the body's natural defenses. From there they can enter the bloodstream, causing lung disease, cancer, strokes, and heart attacks. There is also evidence of detrimental effects on cognition. The tiny size of $PM_{2.5}$ particles not only makes them harmful from a physiological perspective, but also allows these particles to stay in the air for weeks and to travel hundreds or thousands of kilometers. This increases the likelihood that the particles will end up inhaled by humans before falling to the ground.

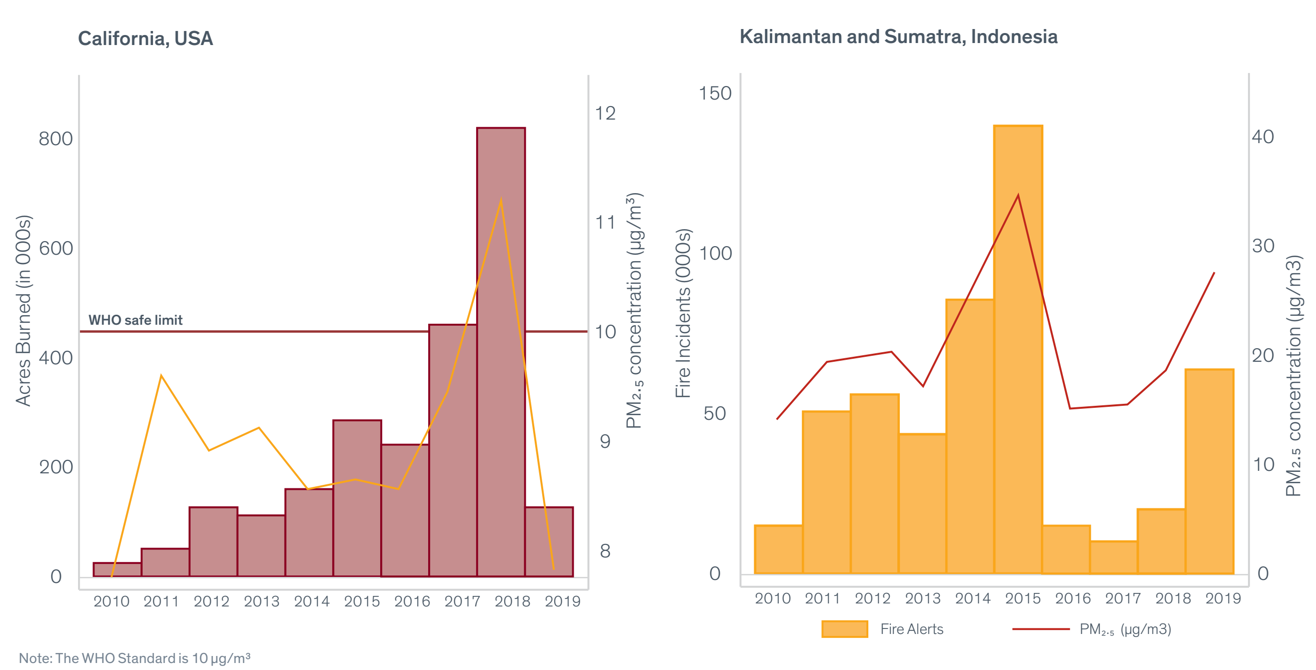


To learn more about particulate pollution, visit: https://aqli.epic.uchicago.edu/pollution-facts/

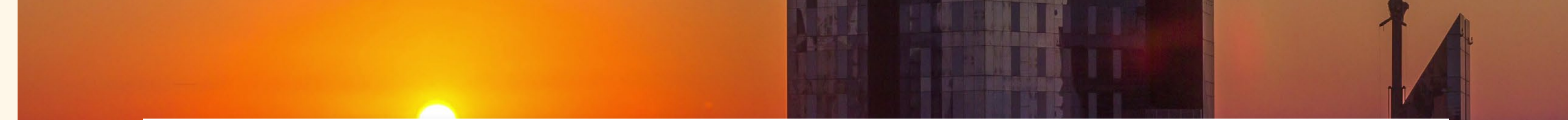
Compared to 2013, the population weighted average $PM_{2.5}$ inIndonesia was over 30% higher in 2015, reaching nearly 40 µg/m3. If this were a permanent increase, there would be a 0.9 year decline in average life expectancy in Indonesia, according to the AQLI data. And since air pollution from fires typically travels across national boundaries, they produce spillover effects affecting the health of people in neighboring countries and regions. Similarly, California has experienced a rising number of fires since 2016, and particularly in 2018. In a number of counties across Northern California, population weighted average $PM_{2.5}$ levels more than doubled in 2018 compared to 2017. If those were permanent differences, they would translate into a reduction in average life expectancy of 0.6 to 0.8 years (see Figure 2).

Thus, fossil fuel combustion not only directly contributes to $PM_{2.5}$, it also indirectly causes air pollution through its effect on climate change (see Figure 3). In addition, if adaptation to rising temperatures results in increased energy consumption, for instance through the mass adoption of air conditioners in the developing world, then the feedback loop will only worsen. Given the role that climate change will play in exacerbating air pollution, it is imperative that policies are introduced today to reduce our dependence on fossil fuels.

Figure 3 · Rising Wildfires, and Particulate Air Pollution in California, and Kalimantan and Sumatra



Note: The WHO Standard is 10 µg/m³



Section 2

Air Pollution is a Global Health Threat

The AQLI reveals that the average person is losing 2.2 years of life expectancy due to particulate pollution exceeding the World Health Organization (WHO) guideline. The impact of particulate pollution is greater than the effects of devastating communicable diseases like tuberculosis and HIV/AIDS, behavioral killers like cigarette smoking, and even war.

The average global citizen is exposed to particulate pollution concentrations of 32 µg/m3—over 3 times the World Health Organization's guideline of 10 µg/m3[2]. If this level of particulate pollution persists, the health consequences of air pollution could shave 2.2 years off global life expectancy compared to a world in which all countries met the WHO guideline. In other words, permanently reducing air pollution to the WHO guideline could increase global average life expectancy from roughly 72 to 74 years, and in total, the world's population could gain 17 billion life-years.

Figure 4 (a) · Global Average Gain in Life Expectancy from Reducing $PM_{2.5}$ Concentrations to the WHO Guideline, 1998-2019

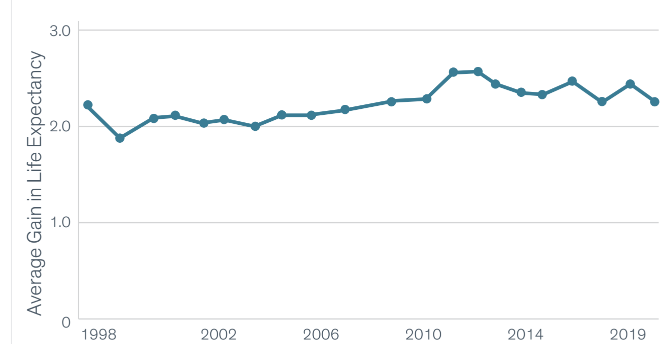
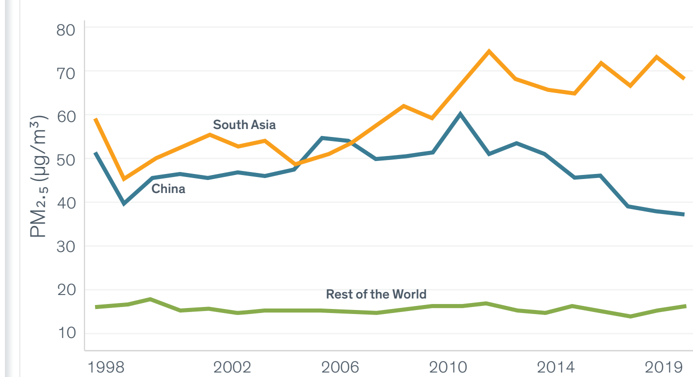
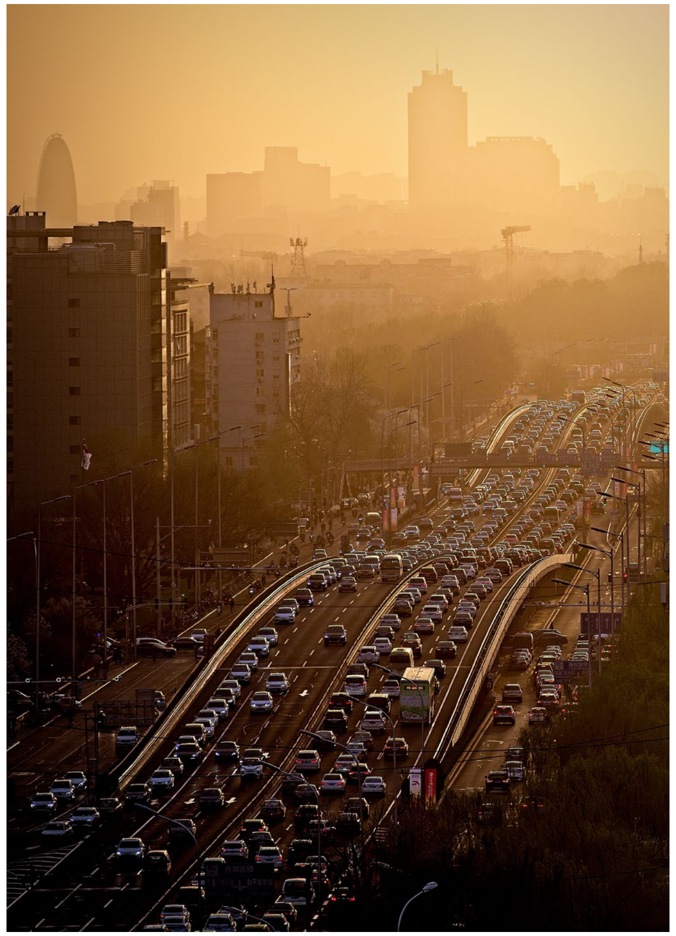


Figure 4 (b) · Global Trends in $PM_{2.5}$ Concentrations, 1998-2019



2 The effects on life expectancy from causes and risks of death other than ambient $PM_{2.5}$ air pollution are calculated from mortality rate data from the Global Burden of Disease 2017. For details, see https://aqli.epic.uchicago.edu/about/methodology/.



Beijing, China

Measured in terms of life expectancy, ambient particulate pollution is consistently the world's greatest risk to human health. First-hand cigarette smoke, for instance, reduces global average life expectancy by about 1.9 years. Alcohol use reduces life expectancy by 9 months; unsafe water and sanitation, 7 months; HIV/AIDS, 4 months; malaria, 3 months; and conflict and terrorism, just 7 days (see Figure 5). Thus, the impact of particulate pollution on life expectancy is comparable to that of smoking, almost three times that of alcohol and drug use and unsafe water, five times that of HIV/AIDS, and 114 times that of conflict and terrorism.

Air pollution is so deadly because for the majority of people living in polluted countries, it is nearly impossible to avoid. Whereas it is possible to quit smoking or take precautions against diseases, everyone must breathe air. Thus, air pollution affects many more people than any of these other conditions. Across the world, 6.2 billion people—82 percent of the global population, live in areas where $PM_{2.5}$ exceeds the WHO guideline. Other risk factors such as HIV/AIDS, tuberculosis, and war have a larger impact among the affected, but they affect far fewer people. In 2017, for example, the people who died from HIV/AIDS died prematurely by roughly 53 years. And although 36 million people were afflicted with this condition, the number of people affected is just a fraction of the 6.2 billion people breathing polluted air.

Figure 5 · Life Expectancy Impact of $PM_{2.5}$ and Unassociated Causes/Risks of Death

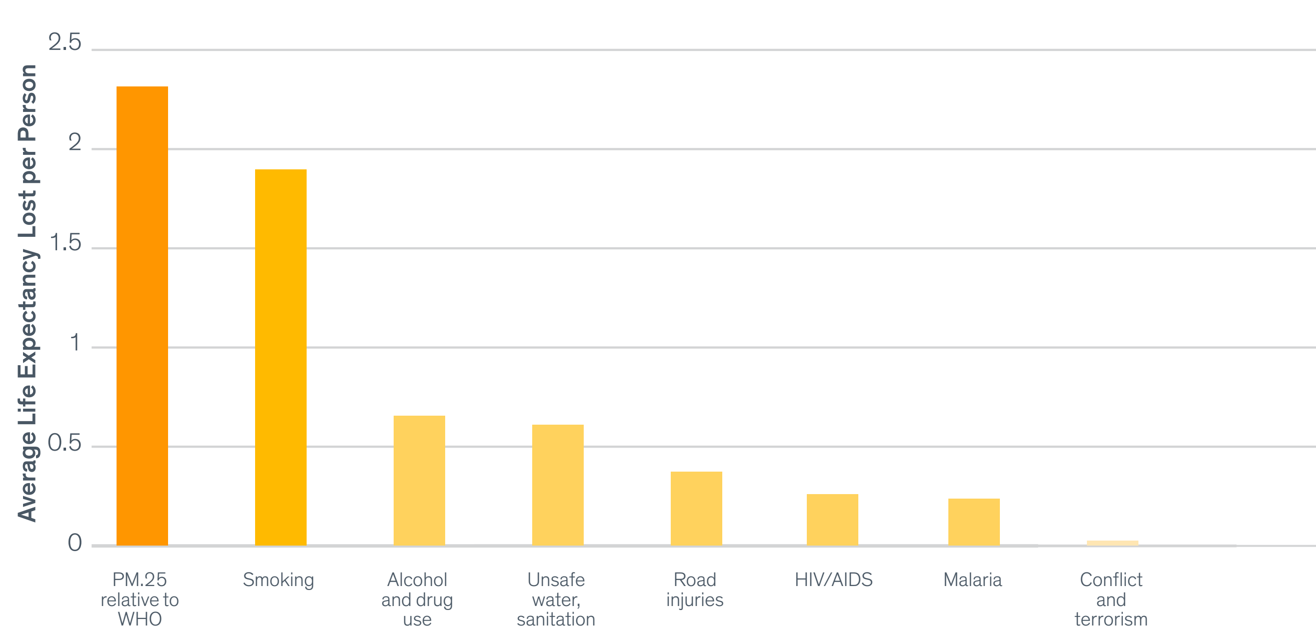
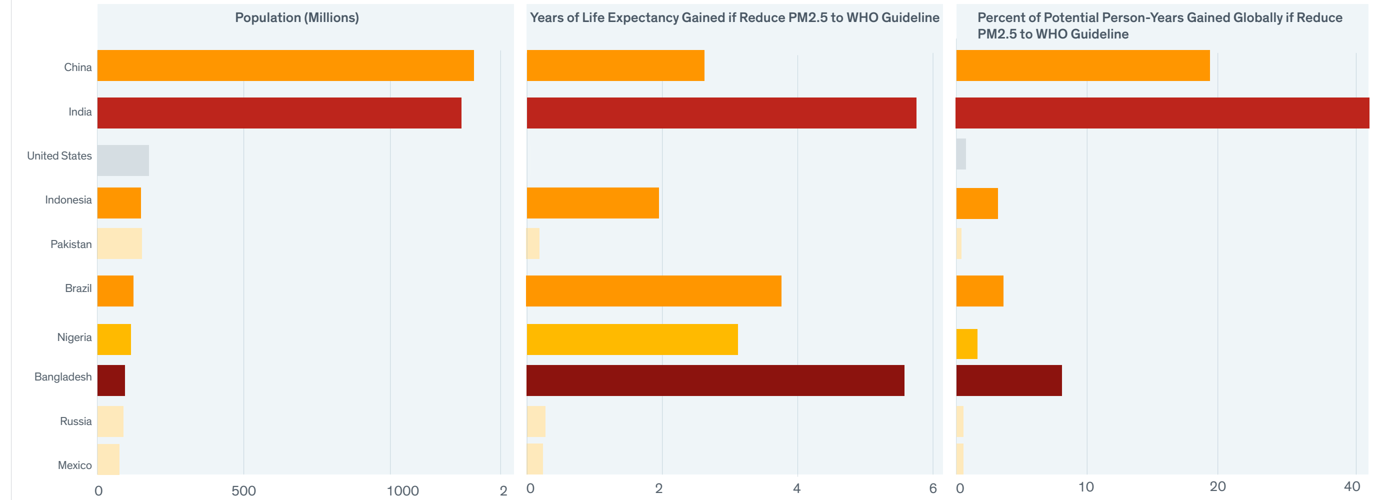


Figure 6 · Potential Gain in Life Expectancy from Permanently Reducing $PM_{2.5}$ from 2019 Concentrations to the WHO Guideline in the Most Populated Countries in the World



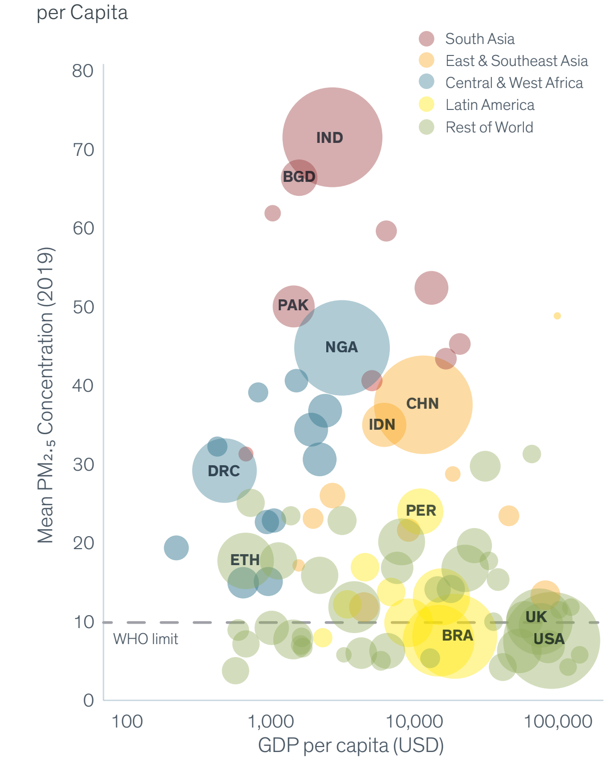
Fortunately, strong clean air policies—particularly those targeting fossil fuel combustion—can reduce particulate pollution concentrations and increase life expectancies, along with the co-benefit of reducing the greenhouse gas emissions that cause climate change.

Since 2011, pollution concentrations have declined in China and other countries due to changes in air quality policies. Based on 2011 particulate pollution concentrations in China, average life expectancy would be 4.7 years lower relative to what it would be if air quality met WHO standards. Based on 2019 concentrations, however, the impact on life expectancy is 2.6 years. In other words, China's clean air policies have improved average life expectancy by roughly 2.6 years.

The improvement in air quality in some locations, coupled with the spike in pollution in other areas, is evidence of the fact that air pollution is a stubborn problem. Although global pollution concentrations have declined since 2011, the decrease is almost entirely attributed to China. In fact, three-quarters of the world's reductions in pollution have come from China since they began their "war against pollution" in 2013. South Asia, in contrast, experienced stable or rising air pollution levels over that same period (see Figures 4(a) and 4(b)).

Overall, global particulate pollution concentrations are roughly the same today, at 32 µg/m3, as they were in 1998. Though pollution has fluctuated over time and across regions, the most extreme levels of pollution today are consistently found in the industrializing countries of the developing world. These countries are burning high amounts of fossil fuels without the policy safeguards that are in place in many developed countries (see Figure 7). The remainder of this report will further describe where pollution has increased and decreased over time, and what this means in terms of the most important measure that exists: longer lives.

Figure 7 · Particulate Pollution Concentrations in 2019 and GDP per Capita



Section 3

The Greatest Impacts of Air Pollution Remain Concentrated in South Asia

South Asia is home to the most polluted countries on Earth, with prolonged exposure to air pollution cutting life expectancy short by 5.6 years if current levels persist. The estimated impacts are even greater across Northern India, the region that experiences the most extreme levels of air pollution in the world.

Bangladesh, India, Nepal and Pakistan account for nearly a quarter of the global population and consistently rank among the top five most polluted countries in the world. As a result, South Asia accounts for 60 percent of the person-years that are expected to be lost globally due to pollution levels exceeding the WHO guideline. Average life expectancy across these four countries would be 5.6 years higher if pollution concentrations complied with the WHO guideline.

India is the most polluted country in the world, with more than 510 million people—or about 40 percent of the country's population—living in the Indo-Gangetic plains of Northern India where pollution levels regularly exceed those found anywhere else in the world by an order of magnitude. The residents of this region, which includes the megacities of Delhi and Kolkata, are on track to lose more than 9 years of life expectancy if 2019 concentrations persist (See Figure 6).

Alarmingly, India's high levels of air pollution have expanded geographically over time. Compared to a couple decades ago, particulate pollution is no longer a feature of the Indo-Gangetic plains alone. Pollution has increased so much in the states of Maharashtra and Madhya Pradesh, for example, that the average person in those states is now losing an additional 2.5 to 2.9 years of life expectancy, relative to the early 2000s.

Trailing close behind India is Bangladesh, where residents could live 5.4 years longer if pollution levels met the WHO guideline. In the most polluted part of the country, Dhaka, residents could live 7.7 years longer. In Nepal, the average resident could live 5 years longer, with those in the highly-polluted outer Terai region standing to gain 6.7 years, if the WHO guideline were met. In Pakistan, the average resident could live 4.2 years longer, with those in Lahore, the second largest city, living 5 years longer.

In each of these countries, the impact of air pollution on life expectancy is substantially higher than that of other large health threats. Smoking, for instance, reduces life expectancy in these countries by as much as 1.8 years; unsafe water and sanitation by as much as 1.2 years; and alcohol and drug use by about a year of lost life years.

Figure 8 · Change in Potential Gain in Life Expectancy from Reducing $PM_{2.5}$ to the WHO Guideline in South Asia, 2000-2019

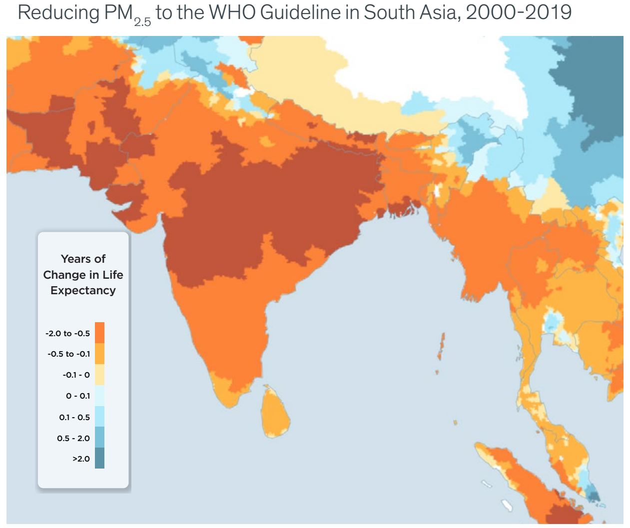
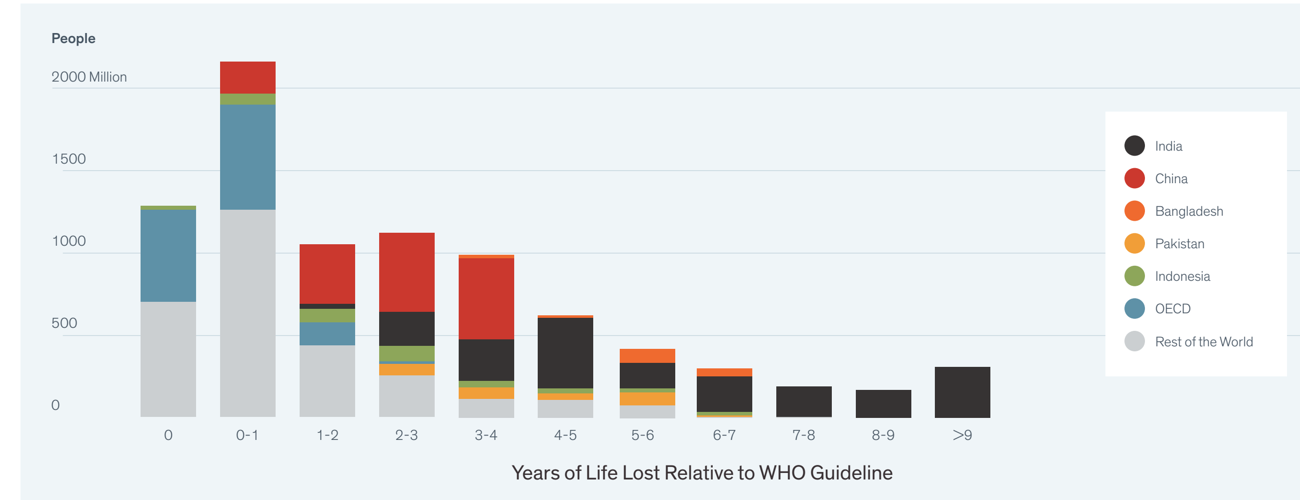


Figure 9 · Distribution of Person-Years Gained if $PM_{2.5}$ is Reduced to WHO Guideline Around the World



Note: India, China, Bangladesh, Indonesia, and Pakistan rank as the top five countries globally in terms of the gain in person-years from reducing $PM_{2.5}$ concentrations to the WHO guideline.

The average resident of these four countries is exposed to particulate pollution levels that are 35 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 4.8 years of life expectancy—not the near 6 years that they stand to lose today.

The increase in South Asian air pollution over time is not surprising. Over the last two decades, 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 four-fold since the early 2000s. In Bangladesh, the number of motor vehicles roughly tripled from 2010[3] to 2020. In Bangladesh, India, Nepal, and Pakistan combined, electricity generation from fossil fuels tripled from 1998 to 2017[4]. Crop burning, brick kilns, and other industrial activities have also contributed to rising particulates in the region.

The increase in energy use has led to higher living standards and economic output, which have undoubtedly enhanced well-being. Yet the concomitant rise in particulate pollution has had serious consequences, and energy demand in non-OECD regions is only projected to continue growing. Without concerted policy action, the threat of air pollution will also grow.

Fortunately, more and more people in these countries are recognizing the severity of the problem, and governments are beginning to respond. In 2019, for example, the Government of India declared a "war on pollution" and launched its National Clean Air Programme (NCAP) with the stated goal of reducing 2017 particulate pollution levels by 20 to 30 percent by the year 2024. Since then, India has adopted fuel emissions standards that are on par with European Union standards. Although the NCAP targets are non-binding, achieving and sustaining such a reduction would increase India's national life expectancy by as much as 1.7 years, and by as much as 3.1 years for residents of Delhi.

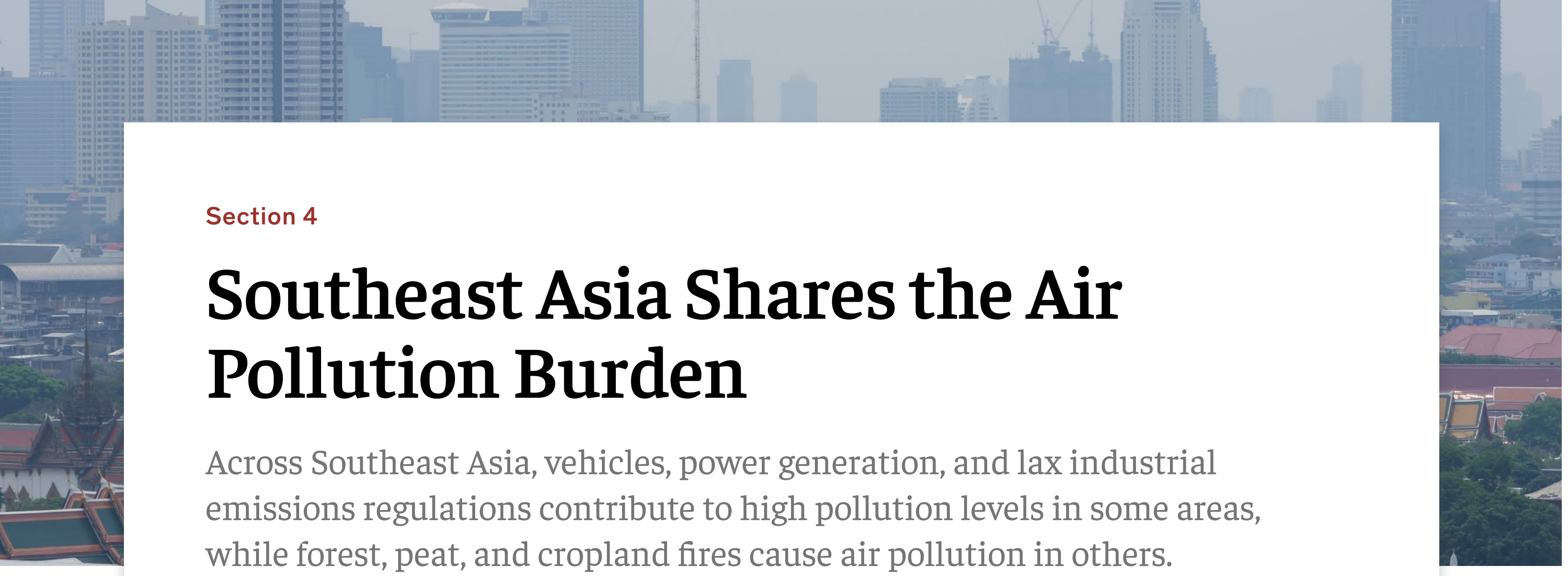
Other countries across South Asia are beginning to take policy actions as well. In Pakistan, the government began installing more pollution monitors and shutting down factories in highly polluted districts during the winter months, when energy demand for heating is high. Similarly, Bangladesh is expanding its monitoring capacity and real-time air pollution measurements are expected to soon cover eight cities, up from the four that are covered today[5].

Pakistan and Bangladesh have both encouraged brick kiln owners to shift to cleaner technologies. In Bangladesh, where brick kilns are responsible for about 60 percent of the particulate pollution in Dhaka, 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. 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.

3 Statistical Year Book of India, 2017, Table 20.4; Pakistan Statistical Pocket Book, 2006, Table 17.5 and Pakistan Today, 2019; Bangladesh Road Transport Authority, 2020.

4 US Energy Information Administration.

5 Ministry of Environment and Forests, Government of People's republic of Bangladesh



Section 4

Southeast Asia Shares the Air Pollution Burden

Across Southeast Asia, vehicles, power generation, and lax industrial emissions regulations contribute to high pollution levels in some areas, while forest, peat, and cropland fires cause air pollution in others. In the Southeast Asian metropolises of Bangkok, Ho Chi Minh City, and Jakarta, residents stand to gain 2 to 5 years of life expectancy if pollution levels were reined in to meet the WHO guideline.

Ninety percent of Southeast Asia's 650 million people live in areas where particulate pollution exceeds the WHO guideline. Across the region, air pollution reduces average life expectancy by 1.7 years, relative to what it could be if the WHO guideline was met. In the 11 countries that make up this region, an estimated 1.1 billion person-years are lost due to air pollution.

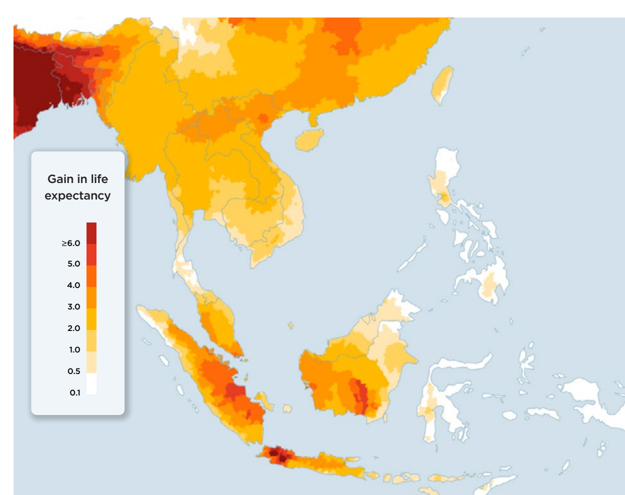
In the city-state of Singapore, the AQLI's satellite-derived data indicate that particulate pollution levels are similar to those in Beijing and Mumbai. This makes it the fifth most polluted country in the world. Singapore's 6 million residents stand to gain 3.8 years of life expectancy if its air quality met the WHO guideline.

The burden of air pollution is also high in the densely populated and industrialized regions of other Southeast Asian countries. On the island of Java, Indonesia's population and industrial center, the 11 million residents of Jakarta could gain an average of 5.5 years in life expectancy if particulate pollution met the WHO guideline. There are similar life expectancy benefits to cleaning up the air in Bogor, South Tangerang, Bandung, and Bekasi.

On mainland Southeast Asia, Vietnam has the highest overall levels of particulate pollution, although there are sharp differences between regions. In the northern Red River Delta region, which surrounds the capital city of Hanoi, home to 7 million people, life expectancy would increase 3.4 years if air quality met the WHO guideline. The impacts are much lower in the southern regions, where the air quality is better. Overall, the average Vietnamese citizen stands to gain 1.6 years in life expectancy if particulate pollution were permanently addressed.

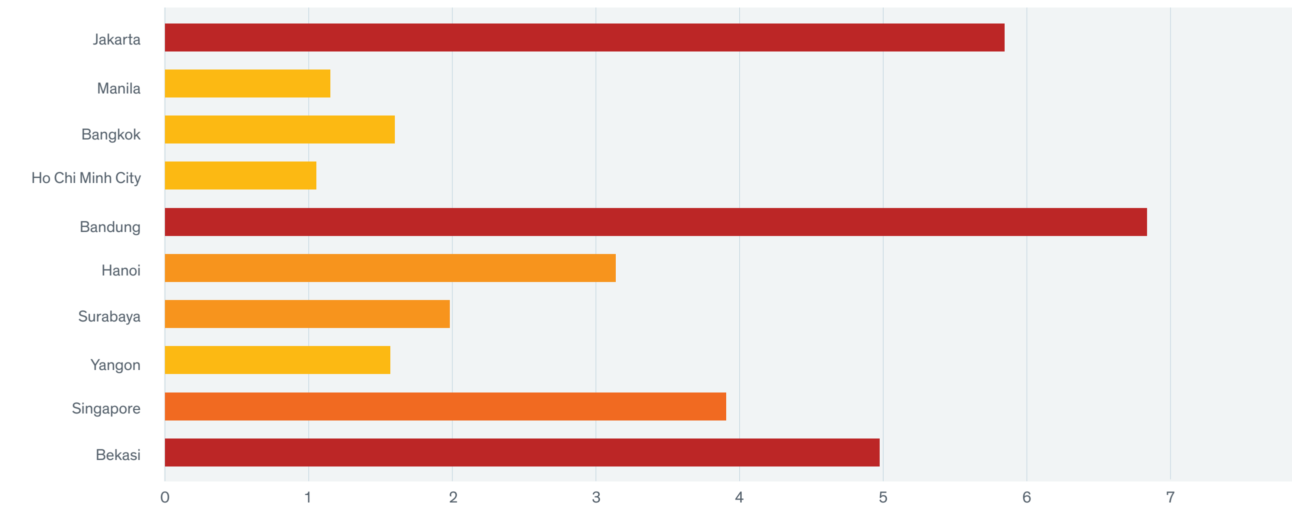
In Thailand, the residents of Bangkok would gain 1.5 years if pollution levels met the WHO guideline. Forest fires in Thailand's northern region have increased the amount of regional air pollution, reducing life expectancy by 2 years[6]. In Myanmar and Cambodia, air pollution is not as severe as in other Southeast Asian countries, but it is on the rise. Between 1999 and 2019, particulate pollution in Myanmar and Cambodia increased by 60 and 51 percent, respectively, resulting in a marginal reduction in average life expectancy of 0.9 and 0.6 years, relative to 1999 levels.

Figure10 · Potential Gain in Years of Life Expectancy Through Permanently Reducing $PM_{2.5}$ from 2019 Concentrations to the WHO Guideline



6 Affected provinces include Chiang Rai, Chiang Mai, Lampang, Phrae, Nan, Phayao, Sukhothai and Kamphaeng Phet.

Figure 11 · Potential Gain in Years of Life Expectancy Through Permanently Reducing $PM_{2.5}$ from 2019 Concentrations to the WHO Guideline, in 10 Largest Cities in Southeast Asia



How can countries in this region tackle this problem? Tighter fuel emissions standards offer one area of potential improvement. In contrast to China and India, where fuel standards are at least as stringent as those (Euro-6) adopted by the European Union, the fuel standards are much lower in Indonesia, Vietnam, and Thailand. Vehicles there are only required to meet Euro-4 standards, which allow for up to 3 times as much diesel NOx emissions, and 5 times as much sulfur content. That said, Vietnam is set to bring Euro-5 standards into effect in 2022[7].

Industrial emissions make up another area of potential improvement. Indonesia's coal-fired power plants — of which there are around ten within a 100km radius of Jakarta[8]—are currently allowed to emit 3 to 7.5 times more particulate matter, NOx, and SO2 than China's coal plants, and 2 to 4 times more than India's plants installed between 2003 and 2016[9]. NOx and SO2, once emitted into the atmosphere, can form particulate matter.

Aside from vehicles, coal, and industrial plants, biomass burning is a source of intense seasonal air pollution across much of the region. On the Indonesian islands of Sumatra and Kalimantan, forest and peatland fires, which are often set illegally to clear land for agricultural plantations, create annual haze events. Although the intensity and location of these fires vary over time, the fact that they are recurring means that people living in the surrounding region are exposed to high long-term average pollution concentrations. In the Indonesian cities of Palangka Raya, Central Kalimantan, and Palembang, South Sumatra, average particulate pollution over the past decade is about 3 times the WHO guideline. For the residents of these cities, life expectancy is about 2 years lower than what it could be if air quality met the WHO guideline.

Indonesia's fires create transboundary pollution challenges with significant repercussions in neighboring countries downwind. During the 2015 Southeast Asian Haze event, for example, Malaysia was forced to close 7,000 schools as well as businesses and government offices due to wildfire smoke from Indonesia[10]. In years where forest fires spike, particulate pollution worsens. Particulate pollution in Malaysia was about 40 percent higher in 2006 than in 2005 or 2007; and in 2015, it was 12 and 35 percent higher than in 2014 and 2016, respectively[11]. Today, very little fire-resistant forest remains in Indonesia's peatlands, suggesting that the annual haze events that have plagued the past may become more frequent and dangerous in the future[12].

7 Vietnam Plus, 2021.
8 Taylor, 2019.
9 Zhang, 2016.

10 Straits Times, 2015.

11 In addition to local and transboundary air pollution, the burning of forests and carbon-rich peatlands in Indonesia are a significant contributor to climate change. For example, the 2015 fires are calculated to have emitted more CO_2 per day than the European Union (Huijnen et al., 2016).
12 Nikonovas et al., 2020.

Section 5

Air Pollution Rivals Communicable Diseases in Central and West Africa

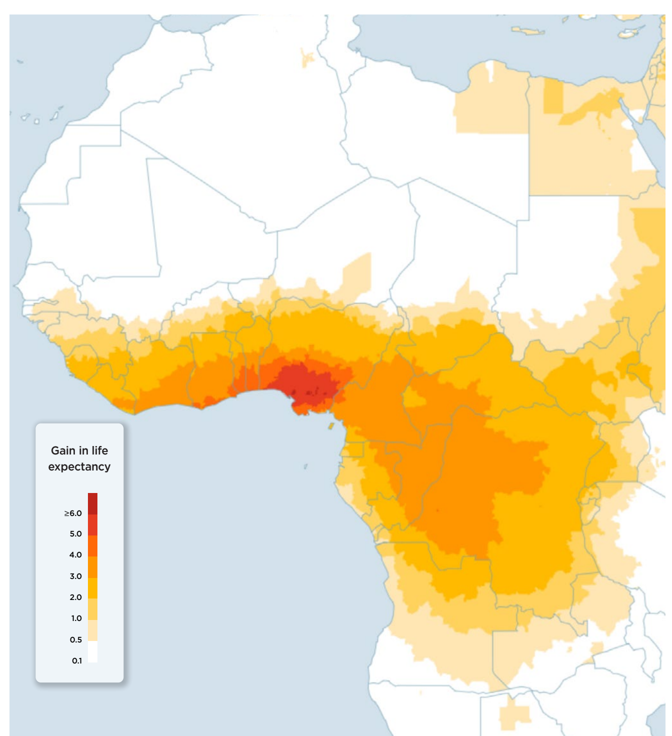
Particulate pollution is a rising health threat in Central and West Africa, where more than 94 percent of people are exposed to pollution levels that exceed the WHO guideline for safe air. As a result, average life expectancy in the region is 2 to 5 years shorter than what it would be if the WHO guideline were met, making particulate pollution a greater threat to human health than well-known killers, like HIV/AIDS and malaria.

The health discourse in Sub-Saharan Africa has centered on infectious diseases, like HIV/AIDS and malaria. However, the health impact of particulate air pollution is no less serious. Across the region, home to more than 600 million people in 27 countries, the average person is exposed to particulate pollution levels that are 3 times as high as the WHO guideline[13]. If air quality met the WHO guideline, average life expectancy across the region could be 2.1 years higher—translating into a total of 1.2 billion person-years saved. While Asian countries rightly receive the most media coverage about air pollution, African countries like Nigeria, Benin, and Togo, also feature in the list of the top ten most polluted countries in the world.

Nigeria is the region's pollution hotspot. In Lagos, home to 20 million people, vehicle emissions due to long commutes and high sulfur content fuel, industrial emissions, and the use of diesel generators in the face of unreliable electricity supply contribute to high levels of urban air pollution[14]. Nigerians could see their life expectancy increase by 4.3 years if particulate pollution were permanently reduced to meet the WHO guideline.

In the Niger Delta, where oil refineries—many illegal—are linked to the grim daily reality of air pollution, life expectancy is 4.7 years lower than what it could be under the WHO guideline. In Onitsha, the most polluted city in Nigeria, residents are losing 5.8 years of life expectancy. There is a similar story across the region. In Lomé, Togo, residents are losing 3.7 years; in Kinshasa, Democratic Republic of the Congo, home to more than 10 million people, it is 2.6 years; and in Abidjan, Côte d'Ivoire, a city of 5 million, the impact is 2.9 years.

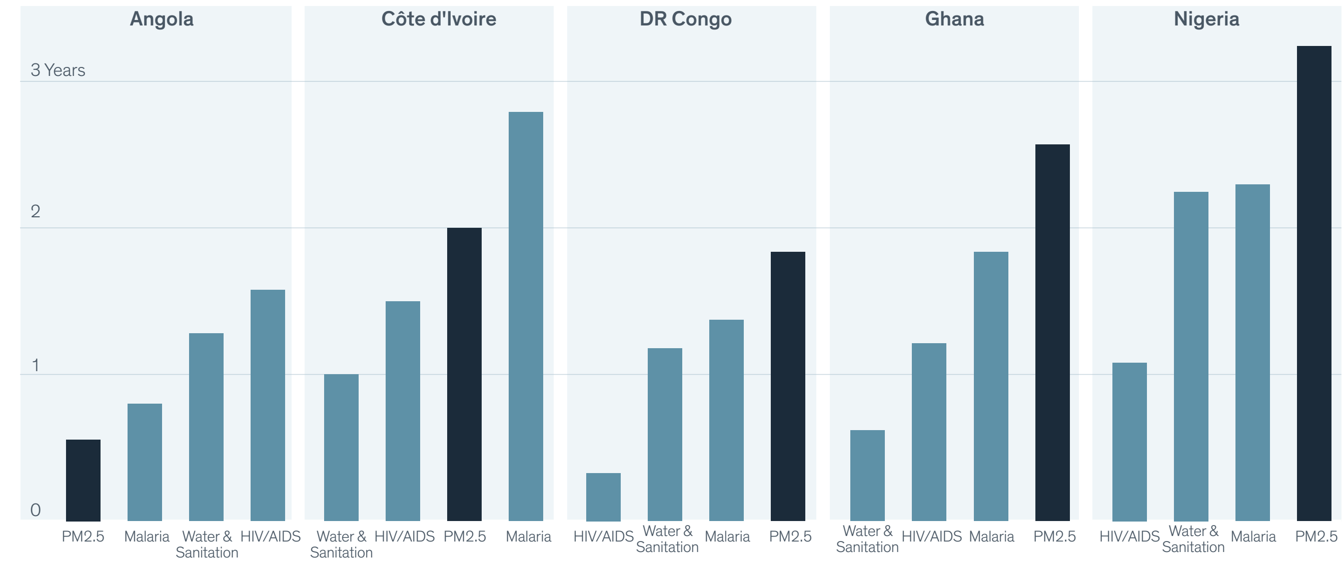
Figure 12 · Potential Gain in Years of Life Expectancy Through Permanently Reducing $PM_{2.5}$ from 2019 Concentrations to the WHO Guideline



13 Central Africa is here defined as the 11 countries in the Economic Community of Central African States. West Africa is defined following the United Nations' definition, which includes 16 countries.

14 Croituru et al, World Bank 2020.

Figure 13 · Life Expectancy Impacts of Particulate Pollution and Other Health Threats in the Five Most Populous Countries in Central and West Africa



Note: "DR Congo" refers to the Democratic Republic of the Congo.

Compared to other environmental health risks and prominent communicable diseases in Nigeria and the Democratic Republic of Congo, air pollution is the biggest threat in terms of its impact on life expectancy—shaving off more years than HIV/AIDS, unsafe water and sanitation and malaria (see Figure 9). In Ghana, it ranks as the deadliest of threats, while in Cote d'Ivoire it is second to malaria and shaves 2 years off of life expectancy[15]. Yet, while about 10 percent of health expenditures in sub-Saharan Africa are targeted towards combating HIV/AIDS or malaria, air pollution is rarely acknowledged as a problem in the region[16]. For example, when the Niger Delta city of Port Harcourt was covered in soot beginning in November 2016, it took 4 months and public outcry before a state of emergency was declared—this in a country where the government's response to the Ebola crisis has been praised for its promptness and effectiveness.

In Ghana, particulate pollution is more than 3 times the WHO's guideline. The average resident stands to gain 2.6 years in life expectancy if pollution is reduced to meet that guideline. Pollution levels are higher in the large cities, most notably Accra, where residents stand to gain 3 years. Like other developing country cities, vehicle emissions are a major contributor to air pollution due to the widespread use of older and more polluting two-stroke engines. In addition, accounts of waste burning have consistently risen, and could become worse due to ongoing urbanization.

Out of the 27 Central and West African countries, only one—Cameroon—has set a national standard for particulate pollution. Further, only three real-time air quality monitoring stations exist throughout the entire region, resulting in a near total lack of transparent and actionable pollution data[17]. In comparison, about 200 real-time monitors exist in India, which has a smaller land mass than Central and West Africa.

In Africa, energy consumption is expected to grow more rapidly than ever before: the projected increase in coal consumption between 2017 and 2040 is expected to be more than 3 times the increase observed between 1995 and 2017; and natural gas consumption is projected to increase by more than twice that observed from 1995 to 2017[18]. Unless actions are taken to address this growth in future emissions, air pollution will only become a greater problem in Africa.

15 Life expectancy impacts of causes and risks of death besides ambient $PM_{2.5}$ air pollution are calculated from mortality rate data from the Global Burden of Disease 2017. For details, see https://aqli.epic.uchicago.edu/about/methodology/.

16 $18 billion of combined domestic and foreign aid money was spent to combat HIV/AIDS in 2015, and $2.7 billion to combat malaria in 2016. Total health spending for sub-Saharan Africa was $194 billion. (Dieleman et al., 2018; Haakenstad et al., 2019).

17 UNICEF, 2019.

18 BP Energy Outlook 2019.

Section 6

More than Half of Latin Americans are Breathing Polluted Air

Particulate pollution levels vary greatly across Latin America. In countries like Argentina, Paraguay, and Costa Rica, air quality generally meets the WHO guideline. However, other countries like Peru, Colombia, Bolivia, and Brazil feature pollution hotspots, where particulate pollution concentrations are 2 to 3 times greater than the WHO guideline. In these hotspots, the average resident stands to gain 1 to 2 years of life expectancy from cleaner air.

More than half of the 611 million people in Latin America are exposed to $PM_{2.5}$ levels that exceed the WHO guideline. Although the average gain in life expectancy from cleaning the air is relatively low across the continent (roughly 5 months), the number is substantially higher in Latin America's hotspots. For instance, it is 4.7 years in Lima, the capital of Peru; and 1.8 and 2.2 years in the Colombian cities of Bogota and Medellin, respectively.

Vehicle emissions are primarily responsible for poor air quality in Latin America's major hotspot cities. For example, in 2019, Bogota and Cali ranked first and tenth in the world in average commute duration[19]. Long commutes are indicative of high levels of traffic congestion and higher levels of individual pollution exposure since commuters end up spending more time outside and on the roads. Across the region, driving restrictions have been a popular policy prescription. For example, license plate-based restrictions were introduced in Santiago, Chile in 1986, and in Mexico City in 1989. Following these two programs, several more Latin American cities introduced similar restrictions.

Latin America's air pollution is not only limited to its cities. Rural residents in Colombia also face high levels of $PM_{2.5}$. For example, in Tolima, a rural region that is also the most polluted department in Colombia, the average level of particulate pollution in 2019 was 33 µg/m3. The use of household solid fuels is a major contributor to air pollution in these areas.

In Brazil, particulate pollution levels are twice the WHO recommended threshold across the Amazonas, 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. The 4.2 million residents of the area can gain up to a year of life expectancy if the WHO guideline was permanently met.

Mexico City, Mexico

19 INRIX, 2020

Figure 14 · Potential Gain in Years of Life Expectancy Through Permanently Reducing $PM_{2.5}$ from 2019 Concentrations to the WHO Guideline, in 10 Largest Cities in Latin America

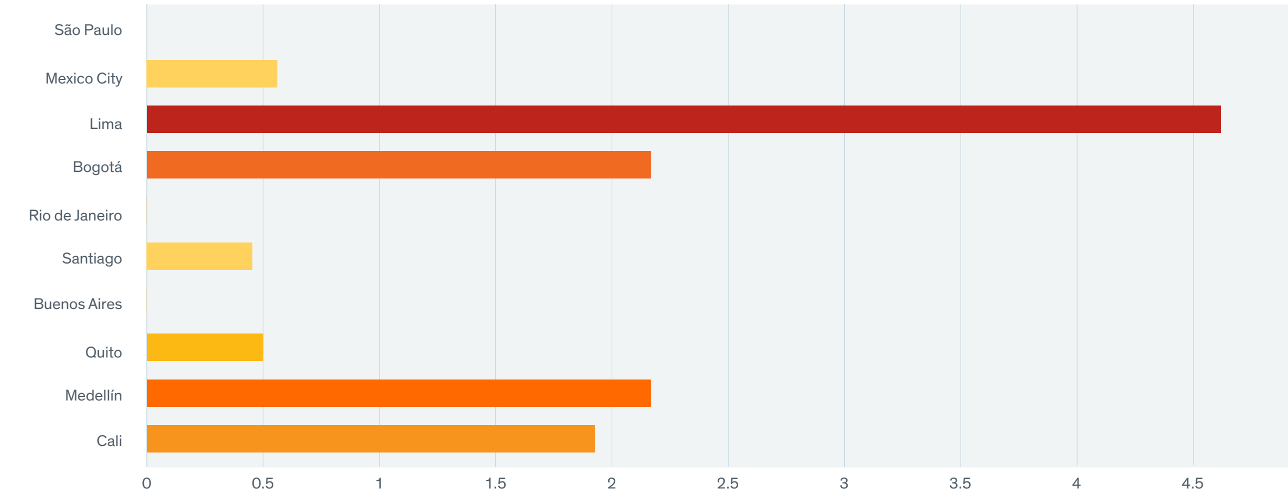
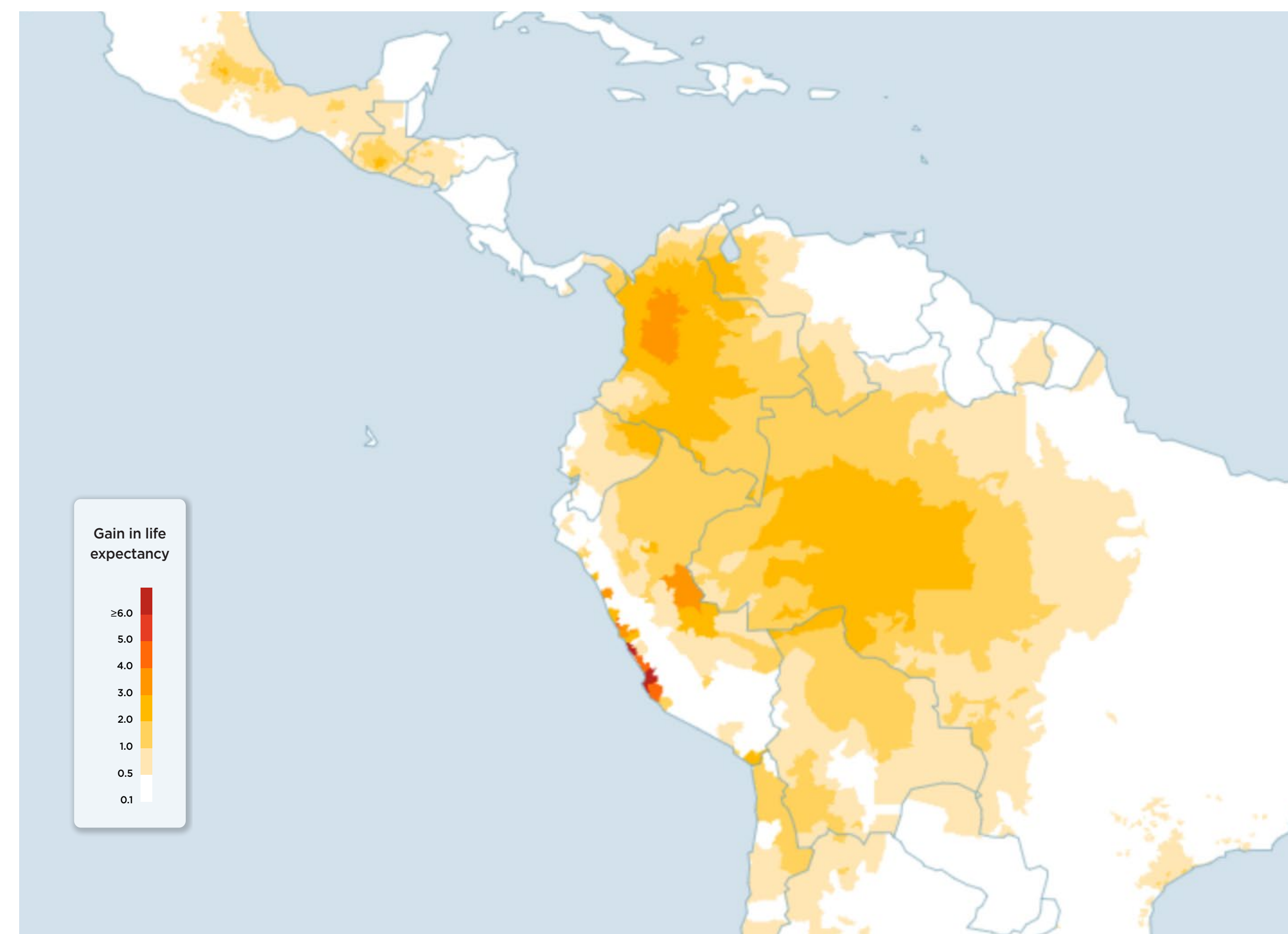


Figure 15 · Potential Gain in Life Expectancy from Permanently Reducing $PM_{2.5}$ from 2019 Concentrations to the WHO Guideline



Section 7

China is Winning its "War Against Pollution"

China was able to reduce its particulate pollution by 29 percent between 2013 and 2019—dropping the country from its top five ranking in recent years and making up three-quarters of the reductions in air pollution across the world. If these reductions are sustained, China's people can expect to live 1.5 years longer. To put China's success into context, it took several decades and recessions for the United States and Europe to achieve the same pollution reductions.

In China, public concern about worsening air pollution began rising in the late 1990s. Beginning in 2008, the U.S. embassy in Beijing began publicly posting readings from its own air quality monitor on Twitter and the State Department website, and residents quickly pointed out discrepancies between the embassy data and the local government's air quality reports. In 2013, China experienced some of its highest pollution levels to that point, and public criticism reached new heights. At the same time, Chen et al. (2013) published their Huai River study, which found that high air pollution had cut the lifespans of people in northern China by about 5 years compared to those living in the south. The severity of the problem was clear.

The very next year, Premier Li Keqiang declared a "war against pollution." The National Air Quality Action Plan set aside $270 billion and the Beijing city government set aside an additional $120 billion to reduce ambient air pollution. Across all urban areas, the Plan aimed to reduce particulate matter (PM10) by 10 percent in 2017, relative to 2012 levels. The most heavily polluted areas in the country, including Beijing-Tianjin-Hebei, the Pearl River Delta, and the Yangtze River Delta, were given specific targets.

The government's strategies for achieving these goals included building pollution reduction into local officials' incentives, so promotions depended on both environmental audits and economic performance; prohibiting new coal-fired plants in some regions and requiring existing coal plants to reduce emissions or be replaced with natural gas; increasing renewable energy generation; reducing iron and steel making capacity in industry; restricting the number of cars on the road in large cities; and increasing transparency and better enforcing emissions standards. In 2013-2014, the government rolled out a nationwide network of air quality monitors that report pollution readings automatically. Statistical analysis shows that this network has alleviated the problem of underreporting of pollution concentrations by government officials, hence making accurate real-time air pollution information available to the public so they can take appropriate defensive measures[20].

Due to these actions, all of the targets set by the National Air Quality Action Plan, which expired in 2017, were met. As a result, between 2013 and 2019, particulate pollution exposure declined by an average of 29 percent across the Chinese population. China was among the five most polluted countries in the world each year from 1998 to 2016, but fell out of the top five after 2017 thanks to this reduction. If the reduction is sustained, it would equate to a gain in life expectancy of 1.5 years (Figure 12, Table 1). The Beijing-Tianjin-Hebei area, one of China's most polluted areas in 2013, saw a 33 percent reduction in particulate pollution, translating into a gain of 2.6 years of life expectancy for its 109 million residents, if sustained.

20 Greenstone et al., 2020

Figure 16 · Change in Potential Gain in Life Expectancy from Reducing $PM_{2.5}$ to the WHO Guideline in China, 2013-2019

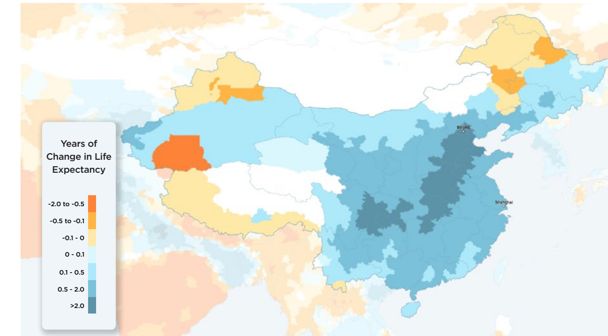
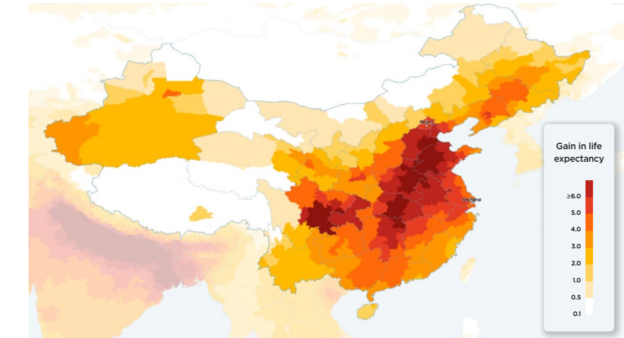


Figure 17 · Potential Gain in Years of Life Expectancy Through Permanently Reducing $PM_{2.5}$ from 2019 Concentrations to the WHO Guideline.



To put the scale and speed of China's progress into context, it's useful to compare it to the United States and Europe after their periods of industrialization. In the United States, following the passage of the Clean Air Act, it took almost three decades and five recessions to achieve about the same percent decline. In Europe, after their environment agency was created, it took about two decades and two recessions to achieve approximately China's percent reduction. While China reduced its pollution by 29 percent, real per capita gross domestic product grew by 45.5 percent.

China's government, however, remained acutely aware that the country's air pollution was still a serious problem—the average particulate pollution concentration in 2019 was still more than 3 times the WHO guideline. Reducing pollution to meet that guideline would mean an additional increase in life expectancy for the Chinese people of 2.6 years (see Figure 17). In Hebei and Henan provinces, home to much of the country's coal and steel industries, residents could see their life expectancies rise by up to an additional 4 years if pollution declined to meet the WHO guideline. To achieve further improvements, the Chinese government announced in July 2018 a new plan for 2018-2020. Regions that did not meet the national air quality standard of 35 µg/m3 would need to reduce their particulate pollution levels by 18 percent relative to 2015 concentrations[21]. In the provinces of Tianjin, Hebei, Henan, and Beijing, a decrease of such a scale would allow residents to gain a year of life expectancy. Although the national targets are less ambitious than those set for 2013-2017, some prefectures set more stringent targets for themselves in their local five-year plans. Beijing, for example, committed itself to a 30 percent reduction from 2015 levels by 2020, which if sustained would translate into a life expectancy benefit of 1.7 years. Tianjin, Hebei, Beijing, Shanghai, and other provinces have already reduced their particulate pollution levels by more than 18 percent, relative to 2015 levels.

Table 1 · 10 Most Populous Prefectures

Prefecture	Population (Millions)	2015 $PM_{2.5}$ Concentration (µg/m³)	Potential Life Expectancy Gains from an 18% Reduction, relative to 2015 Levels	2019 $PM_{2.5}$ Concentration (µg/m³)	Percent Decrease in $PM_{2.5}$ since 2013	Years of Life Expectancy Gained between 2013 and 2019
Chongqing	30.0	42	0.7	34	41	2.3
Shanghai	24.1	48	0.8	33	26	1.1
Beijing	20.5	58	1.0	44	36	2.4
Chengdu, Sichuan	13.9	54	1.0	45	45	3.6
Tianjin	13.6	66	1.2	49	41	3.3
Guangzhou, Guangdong	13.2	34	0.6	33	16	0.6
Baoding, Hebei	11.6	70	1.2	57	32	2.7
Harbin, Heilongjiang	11.1	55	1.0	42	9	0.4
Suzhou, Jiangsu	10.8	53	0.9	39	29	1.6
Shenzhen, Guangdong	10.8	29	0.5	26	22	0.7

21 China Ministry of Ecology and Environment, 2018.

Section 8

Decades of Reducing Pollution in the United States, Europe and Japan Deliver Benefits

After sustained enforcement of strong air pollution policies, the United States, Europe, and Japan have seen significant reductions in particulate pollution, and their citizens are living longer because of it. Their experience provides case studies of success.

Europe, Japan, and the United States, which make up 16 percent of the world's population, account for about 2 percent of the health burden from particulate pollution. However, it was not always this way. Places like London—once known as "the big smoke"—Los Angeles—dubbed the "smog capital of the world"—and Osaka—once the "big smoke"—used to be as polluted as the most polluted countries today.

Since that time, the offshoring of polluting industries and, crucially, well-implemented air pollution policies have played large roles in attaining cleaner air. For example, in the United States, the Clean Air Act was enacted in 1970. The Act established the National Ambient Air Quality Standards (NAAQS), setting maximum allowable concentrations of particulate matter, among other pollutants. It also created emissions standards for pollution sources, leading industrial facilities to install pollution control technologies and automakers to produce cleaner, more fuel-efficient vehicles. Further, it required each state government to devise its own plan for achieving and sustaining compliance with the standards.

The Act rapidly improved the air Americans breathed[22]. By 1980, albeit aided by the economic slowdown of the 1970s, the United States recorded a 50 percent decrease in particulate pollution compared to 1970 and a 44 percent decrease in ambient concentrations of SO2, a precursor to particulate matter[23]. Today, on average, Americans are exposed to 62 percent less particulate pollution than they would have been in 1970. And, they're living longer lives because of it, with life expectancy increasing by 1.4 years for the average American from 1970 to today[24]. For those living in the former smog capital of Los Angeles, particulate pollution has declined by almost 57 percent since 1970, extending life expectancy for the average Angeleno by 1.4 years. In Philadelphia and Washington, DC, the gain is 2.6 and 3.3 years.

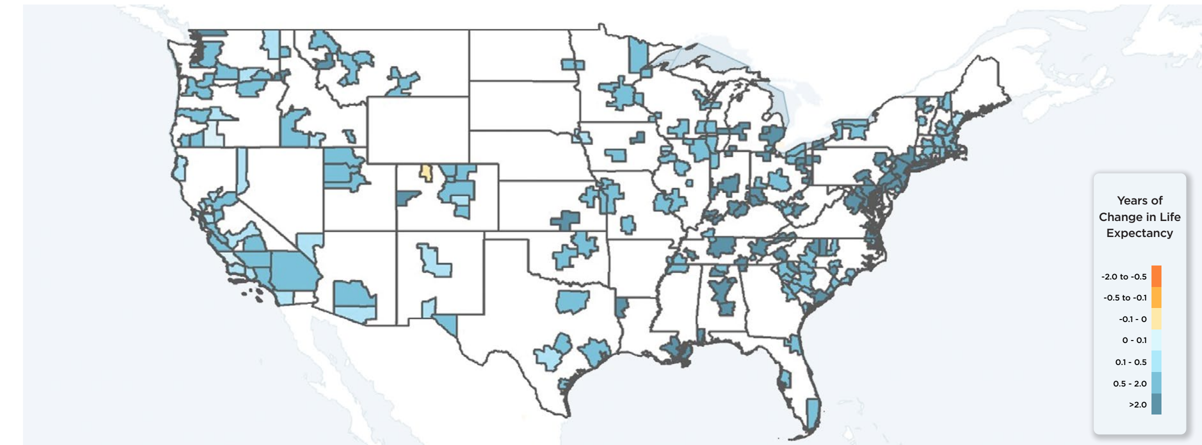
The history of Europe tells a similar story. Among the policy improvements, the European Environment Agency was created in the mid-1990s to provide independent information to policymakers and the public. In subsequent years, the European Union set emissions targets, created a pollution standard, and introduced a comprehensive clean air program with support measures to ensure that targets are met. The European Union's air pollution regulations, such as fuel emissions standards, have formed the basis of standards in many other countries from Argentina to India to Turkey.

22 Several factors that could have affected air pollution have been at play simultaneously since 1970, but research supports an outsize role of the Clean Air Act. For example, Shapiro and Walker (2018) decompose the decline in emissions from manufacturing plants from 1990-2008 into the portions caused by (1) the use of pollution abatement technologies as required by CAA environmental regulations, (2) changes in what Americans produce (i.e. offshoring of pollution-intensive industries), and (3) increases in production efficiency. They find that the total pollution emissions decline is primarily driven by (1).

23 Hunt and Lillis, 1981.

24 These estimates are based on the 236 US counties for which 1970 $PM_{2.5}$ concentrations could be estimated. Details on how 1970 particulate pollution concentrations and life expectancy changes since 1970 were estimated are available at aqli.epic.uchicago.edu/policy-impacts.

Figure 18 · Potential Gain in Years of Life Expectancy Through Permanently Reducing $PM_{2.5}$ from 2019 Concentrations to the WHO Guideline.



Today, on average, Europeans are exposed to 27 percent less particulate pollution than they were two decades ago, gaining 4 months of life expectancy because of it. Areas that were historically more polluted have seen even greater gains.

In the 1990s, Japan tightened its environmental policies, including through the enactment of the Basic Environment Law. An improvement on two earlier rules, the new law included restrictions on industrial emissions and the establishment of environmental pollution control programs, among other changes. Later, in 2001, the country's Environment Agency was promoted to full-fledged Ministry of the Environment. The people of Japan are now living healthier and longer lives thanks to a 34 percent decline in particulate pollution over the last two decades.

Due to the vast improvements in the quality of the air in the United States and Europe, the potential for further progress remains but the potential health benefits are concentrated in specific areas and are limited on average. In the United States, 10 percent of the population lives in areas where particulate pollution exceeds the WHO guideline. Residents of California's Central Valley have consistently been exposed to particulate pollution above both the WHO guideline and the nation's own air quality standard. Those living in this region stand to gain up to 5 months of life expectancy if air quality were kept below the WHO guideline rather than at the 2018 level—a year when California saw intense wildfires that contributed to the pollution.

Figure 19 · Gain in Life Expectancy Due to Change in $PM_{2.5}$ in Europe, 1998-2019

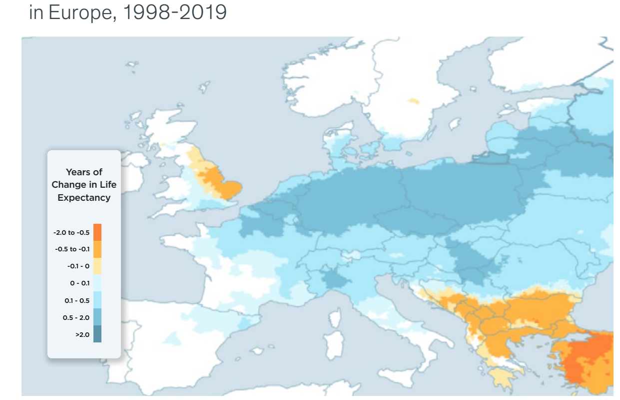
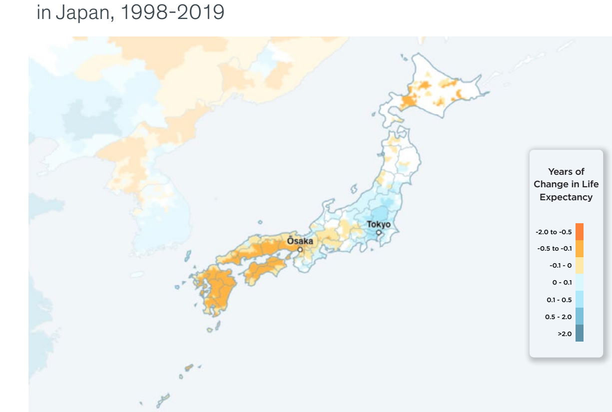


Figure 20 · Gain in Life Expectancy Due to Change in $PM_{2.5}$ in Japan, 1998-2019



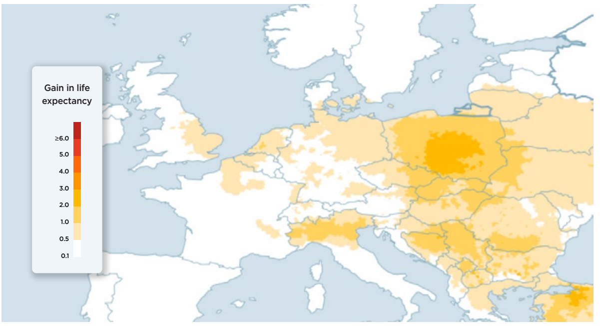


Figure 21 · Potential Gain in Years of Life Expectancy Through Permanently Reducing $PM_{2.5}$ from 2019 Concentrations to the WHO Guideline in Europe

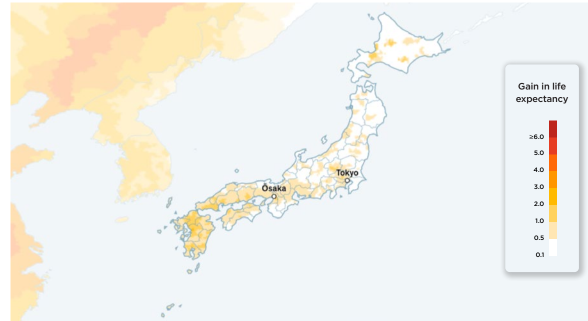


Figure 22 · Potential Gain in Years of Life Expectancy Through Permanently Reducing $PM_{2.5}$ from 2019 Concentrations to the WHO Guideline in Japan

The story is broadly similar in Europe. Nearly three-quarters of the population still lives in areas where particulate pollution exceeds the WHO guideline of 10 µg/m3: the average European was exposed to a particulate pollution concentration of 12.2 µg/m3 in 2019, meeting the European Union's air pollution standard of 25 µg/m3 but falling short of WHO guidance. If particulate pollution were to meet the WHO guideline, average life expectancy across Europe would improve by 4 months.

The most polluted area of Europe is the eastern part of the continent, where the entire populations of Poland, Belarus, Slovakia, Hungary, Lithuania, Armenia, Moldova, Cyprus, as well as Bosnia and Herzegovina do not meet WHO's guideline. Poland is the most polluted country in Europe and areas surrounding Warsaw and Łódź suffer particularly high levels of particulate pollution, mainly due to a heavy dependence on coal for household and commercial heating, and industry and power production[25]. If pollution were improved to meet the WHO guideline, residents in Warsaw would gain 1.2 years of life expectancy. Silesia (Śląskie), the hub of Poland's coal mining industry, is the country's most polluted province. Though air quality has been improving there, the average resident still stands to gain 1.3 year of life expectancy if particulate pollution were to permanently meet the WHO guideline.

Outside of Eastern Europe, high pollution remains in areas such as Italy's Po Valley, including the city of Milan, as well as the industrial center of Bursa in Turkey. In Milan and Bursa, residents would gain 10 months and 1.4 years, respectively, if particulate pollution levels met the WHO guideline.

In Japan, 90 percent of the population lives in a region with pollution levels that exceed the WHO guideline, and about 40 percent lives in a region where the pollution is higher than the national standard. The city of Kumamoto could stand to benefit the most from reducing pollution to meet the WHO guideline, which would add a year onto the lives of the 700,000 people living there.

Conclusion

The Air Quality Life Index demonstrates that particulate pollution is the world's greatest threat to human health. South Asia is consistently the most polluted region, with the people there seeing their lives shortened by an average of 5 years relative to what it would be if the region met the WHO guideline—and even more in the most polluted parts of the region like northern India. While South Asian countries are beginning to pay due attention to the severity of the problem, pollution remains largely unacknowledged in Central and West Africa, where the life expectancy impact is on par with better known threats like malaria and HIV/AIDS. Meanwhile, China has made extraordinarily rapid gains, cutting pollution by 28 percent in about 5 years and extending lives by 1.4 years if these reductions are sustained. China not only joins Europe and the United States in establishing strong policies to confront pollution, but is achieving gains at an even quicker pace. The United States, Europe, Japan and China provide lasting examples to more polluted regions that the threat of air pollution can be tackled through serious and sustained public policies. Such public policies that target the major underlying cause of particulate pollution—fossil fuels—are also critical to confronting the shared challenge of climate change.

25 World Bank, 2019.

Appendix Table

Country	$PM_{2.5}$ Concentration, 2019 (µ g/m³)	National Standard (µ g/m³)	Additional Years of Life Expectancy if $PM_{2.5}$ is Reduced to:	
			WHO Guideline**	National Standard
Afghanistan	31	10	2.1	2.1
Akrotiri and Dhekelia	12	0	0.2	
Albania	12	15	0.2	0.0
Algeria	6	0	0.0	
American Samoa	1	0	0.0	
Andorra	5	25	0.0	0.0
Angola	16	0	0.6	
Anguilla	1	0	0.0	
Antigua and Barbuda	1	0	0.0	
Argentina	7	15	0.0	0.0
Armenia	17	0	0.7	
Aruba	3	0	0.0	
Australia	9	8	0.2	0.3
Austria	13	25	0.3	0.0
Azerbaijan	12	0	0.3	
Bahamas	3	0	0.0	
Bahrain	35	0	2.4	
Bangladesh	65	15	5.4	4.9
Barbados	1	0	0.0	
Belarus	14	15	0.3	0.0
Belgium	12	25	0.2	0.0
Belize	9	0	0.0	
Benin	40	0	3.0	
Bermuda	2	30	0.0	0.0
Bhutan	35	0	2.4	
Bolivia	14	10	0.4	0.4
Bonaire, Sint Eustatius and Saba	2	0	0.0	
Bosnia and Herzegovina	16	25	0.6	0.0
Botswana	8	0	0.0	
Brazil	8	0	0.1	
British Virgin Islands	2	0	0.0	
Brunei	16	0	0.6	
Bulgaria	16	25	0.6	0.0
Burkina Faso	15	0	0.5	
Burundi	20	0	0.9	
Cambodia	17	0	0.7	
Cameroon	34	10	2.4	2.4
Canada	7	10	0.0	0.0
Cape Verde	2	0	0.0	
Caspian Sea	10	0	0.1	
Cayman Islands	6	0	0.0	
Central African Republic	32	0	2.2	
Chad	23	0	1.3	
Chile	11	20	0.2	0.0
China	37	35	2.6	0.6
Christmas Island	4	0	0.0	
Cocos Islands	3	0	0.0	
Colombia	24	25	1.4	0.2
Comoros	2	0	0.0	
Cook Islands	1	0	0.0	
Costa Rica	6	0	0.0	
Croatia	13	25	0.3	0.0
Cuba	5	0	0.0	
Cura√ßao	3	0	0.0	
Cyprus	12	25	0.2	0.0
Czech Republic	15	25	0.5	0.0
Cote d'Ivoire	30	0	2.0	
Democratic Republic of	29	0	1.8	
Denmark	11	25	0.1	0.0
Djibouti	25	0	1.4	
Dominica	2	0	0.0	
Dominican Republic	7	15	0.0	0.0
Ecuador	14	15	0.4	0.1
Egypt	12	0	0.2	
El Salvador	12	15	0.2	0.0
Equatorial Guinea	26	0	1.6	
Eritrea	18	0	0.8	
Estonia	8	25	0.0	0.0
Ethiopia	18	0	0.8	
Falkland Islands	1	0	0.0	
Faroe Islands	2	0	0.0	
Fiji	2	0	0.0	
Finland	7	25	0.0	0.0
France	10	25	0.1	0.0
French Guiana	10	0	0.0	
French Polynesia	1	0	0.0	
French Southern	4	0	0.0	
Gabon	22	0	1.2	
Gambia	9	0	0.0	
Georgia	14	0	0.4	
Germany	11	25	0.2	0.0
Ghana	36	0	2.6	
Gibraltar	7	0	0.0	
Greece	10	25	0.1	0.0
Greenland	1	0	0.0	
Grenada	1	0	0.0	
Guadeloupe	2	25	0.0	0.0

* No national standard specified ** 10 µg/m³

Country	$PM_{2.5}$ Concentration, 2019 (μg/m³)	National Standard (μg/m³)	Additional Years of Life Expectancy if $PM_{2.5}$ is Reduced to:	
			WHO Guideline**	National Standard
Guam	2	12	0.0	0.0
Guatemala	17	10	0.7	0.7
Guernsey	7	0	0.0	
Guinea	17	0	0.7	
Guinea-Bissau	13	0	0.3	
Guyana	7	0	0.0	
Haiti	8	0	0.0	
Honduras	13	0	0.3	
Hungary	15	25	0.5	0.0
Iceland	3	0	0.0	
India	70	40	5.9	3.1
Indonesia	35	0	2.5	
Iran	20	10	1.0	1.0
Iraq	17	0	0.7	
Ireland	5	25	0.0	0.0
Isle of Man	5	0	0.0	
Israel	10	25	0.0	0.0
Italy	11	25	0.3	0.0
Jamaica	10	15	0.0	0.0
Japan	13	15	0.3	0.0
Jersey	7	0	0.0	
Jordan	10	15	0.1	0.0
Kazakhstan	14	0	0.4	
Kenya	8	35	0.1	0.0
Kiribati	14	0	0.6	
Kosovo	17	0	0.6	
Kuwait	26	15	1.6	1.1
Kyrgyzstan	19	0	0.9	
Laos	27	0	1.7	
Latvia	10	25	0.0	0.0
Lebanon	12	0	0.2	
Lesotho	6	0	0.0	
Liberia	26	0	1.6	
Libya	4	0	0.0	
Liechtenstein	10	0	0.0	
Lithuania	13	25	0.3	0.0
Luxembourg	9	25	0.0	0.0
Macedonia	16	0	0.6	
Madagascar	4	0	0.0	
Malawi	9	8	0.0	0.1
Malaysia	29	35	1.8	0.2
Mali	10	0	0.1	
Malta	4	0	0.0	
Marshall Islands	0	0	0.0	

Country	$PM_{2.5}$ Concentration, 2019 (μg/m³)	National Standard (μg/m³)	Additional Years of Life Expectancy if $PM_{2.5}$ is Reduced to:	
			WHO Guideline**	National Standard
Martinique	2	25	0.0	0.0
Mauritania	4	0	0.0	
Mauritius	1	0	0.0	
Mayotte	2	25	0.0	0.0
Mexico	12	15	0.3	0.1
Micronesia	1	0	0.0	
Moldova	12	0	0.2	
Monaco	8	0	0.0	
Mongolia	9	25	0.2	0.0
Montenegro	12	20	0.2	0.0
Montserrat	2	0	0.0	
Morocco	6	0	0.0	
Mozambique	7	0	0.0	
Myanmar	23	0	1.3	
Namibia	7	0	0.0	
Nauru	1	0	0.0	
Nepal	61	0	5.0	
Netherlands	13	25	0.3	0.0
New Caledonia	3	25	0.0	0.0
New Zealand	4	0	0.0	
Nicaragua	8	0	0.0	
Niger	15	0	0.5	
Nigeria	44	0	3.4	
Niue	1	0	0.0	
Norfolk Island	3	0	0.0	
North Korea	21	0	1.1	
Northern Cyprus	12	0	0.2	
Northern Mariana Islands	2	0	0.0	
Norway	6	15	0.0	0.0
Oman	30	0	2.0	
Pakistan	50	15	3.9	3.4
Palau	2	0	0.0	
Palestina	10	0	0.0	
Panama	10	0	0.1	
Papua New Guinea	6	0	0.0	
Paraguay	9	15	0.0	0.0
Peru	30	15	2.1	1.8
Philippines	12	25	0.3	0.0
Poland	20	25	0.9	0.0
Portugal	4	25	0.0	0.0
Puerto Rico	2	15	0.0	0.0
Qatar	37	0	2.6	
Republic of Congo	28	0	1.8	
Reunion	2	0	0.0	

* No national standard specified   ** 10 μg/m³

Country	$PM_{2.5}$ Concentration, 2019 (μg/m³)	National Standard (μg/m³)	Additional Years of Life Expectancy if $PM_{2.5}$ is Reduced to:	
			WHO Guideline**	National Standard
Romania	14	25	0.4	0.0
Russia	13	25	0.3	0.0
Rwanda	23	0	1.3	
Saint Helena	2	0	0.0	
Saint Kitts and Nevis	2	0	0.0	
Saint Lucia	2	0	0.0	
Saint Pierre and Miquelon	2	0	0.0	
Saint Vincent and the Grenadines	2	0	0.0	
Saint-Barthélemy	2	0	0.0	
Saint-Martin	2	0	0.0	
Samoa	1	0	0.0	
San Marino	9	0	0.0	
Saudi Arabia	30	15	1.9	1.4
Senegal	7	0	0.0	
Serbia	17	25	0.7	0.0
Seychelles	1	0	0.0	
Sierra Leone	20	0	1.0	
Singapore	48	12	3.8	3.6
Sint Maarten	2	0	0.0	
Slovakia	17	25	0.7	0.0
Slovenia	11	0	0.2	
Solomon Islands	3	0	0.0	
Somalia	8	0	0.2	
South Africa	9	20	0.1	0.0
South Korea	23	25	1.3	0.1
South Sudan	21	0	1.0	
Spain	6	25	0.0	0.0
Sri Lanka	19	25	0.9	0.0
Sudan	16	0	0.6	
Suriname	10	0	0.0	
Swaziland	10	0	0.0	
Sweden	8	25	0.0	0.0
Switzerland	11	0	0.1	
Syria	13	0	0.3	
São Tomé and Príncipe	13	0	0.3	
Taiwan	17	15	0.6	0.2
Tajikistan	23	0	1.3	
Tanzania	9	0	0.1	
Thailand	22	25	1.2	0.1
Timor-Leste	11	0	0.1	
Togo	39	0	2.8	

Country	$PM_{2.5}$ Concentration, 2019 (μg/m³)	National Standard (μg/m³)	Additional Years of Life Expectancy if $PM_{2.5}$ is Reduced to:	
			WHO Guideline**	National Standard
Tonga	1	0	0.0	
Trinidad and Tobago	2	15	0.0	0.0
Tunisia	4	0	0.0	
Turkey	17	0	0.6	
Turkmenistan	11	0	0.2	
Turks and Caicos Islands	2	25	0.0	0.0
Tuvalu	1	0	0.0	
Uganda	18	0	0.7	
Ukraine	13	0	0.3	
United Arab Emirates	31	0	2.1	
United Kingdom	10	25	0.1	0.0
United States	8	12	0.0	0.0
Uruguay	4	0	0.0	
Uzbekistan	23	0	1.2	
Vanuatu	3	0	0.0	
Vatican City	9	0	0.0	
Venezuela	11	0	0.3	
Vietnam	26	25	1.6	0.5
Virgin Islands, U.S.	2	12	0.0	0.0
Wallis and Futuna	1	0	0.0	
Western Sahara	2	0	0.0	
Yemen	25	0	1.5	
Zambia	11	0	0.2	
Zimbabwe	7	0	0.0	
Aland	6	0	0.0	

* No national standard specified   ** 10 μg/m³

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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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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.

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