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The novel coronavirus whose sequence was released on January 10, 2020 has caused more than two million deaths worldwide within a year, along with untold damage to economies and people’s well-being. While the figures are shocking to western societies no longer used to devastating infectious diseases, they are dwarfed by the impact of another airborne killer: pollution.

According to WHO figures, air pollution causes around seven million premature deaths each year, predominantly in low- and middle-income countries. While cities in wealthier countries improved their air quality over the last five decades, the rapidly growing megacities in developing countries have suffered rising pollution and the predictable consequences for public health.

China’s rapid industrialisation, in part based on outsourcing polluting industries from Europe and North America, has led to severe pollution problems, but measures are beginning to show effects. By now, India is among the worst affected countries.

**Insights from India**

India’s megacities like Delhi are notorious for their frequent smog, and the Indian authorities have been driving changes designed to reduce pollution. Given the large population and rapid change in the country, however, it is difficult to get a precise representation of the scale of the problem.

Researchers from the Global Observatory on Pollution and Health at Boston College, USA, with the Indian Council of Medical Research and the Public Health Foundation of India, have now presented an estimate of the health burden caused by air pollution in each of India’s states (Lancet Planet. Health (2019) 3, E26–E39). The report finds that 1.67 million premature deaths that occurred in India in 2019 could be attributed to air pollution, and this is 17.8% of all deaths in the country, whose population now exceeds 1.35 billion. The overall economic impact is estimated at $36.8 billion, representing 1.36% of the annual gross domestic product (GDP). All of these figures are significantly higher than in the previous study, partly due to improved methodology covering a wider range of impacts, such as the health consequences of reduced birth weight and shorter pregnancy.

Detailed results show that the sources of the problem are shifting. Indoor pollution from inadequate devices using solid fuels for cooking has been a major cause of health problems in India, but death rates from this cause have decreased by two thirds since 1990. On the other hand, the air outside has deteriorated in the same time frame. Death rates associated with particulate matter and ground-level ozone have more than doubled, mainly due to motor vehicles and coal-fired power stations.

Regionally resolved data show that, at the state level, the death rates can differ by a factor of three. Generally, the poorer states, such as Uttar Pradesh and Bihar in the north of the country, are more severely affected. This also impacts their economic development, suggesting that the health impact of pollution may exacerbate economic differences between states and overall hinder the economic targets that India is aiming to achieve.

The analysis is complicated by interference with other factors. Climate change may exacerbate some of the impacts of pollution, the authors warn. A population weakened by air pollution could also be more susceptible to infectious diseases like COVID-19, although, as of early February 2021, India appears to be escaping the pandemic with a moderate death toll (155,000) considering its population size. India, like other developing countries, has undergone a dramatic process of urbanisation in recent decades, which has often led to less than sustainable ways of meeting energy and transport needs (Curr. Biol. (2016) 26, R1205–R1208). In such cases,
Invisible killer: The air of many western European cities, such as Antwerp, Belgium, may look cleaner than that of Indian cities, but fine particulate matter and NO2 still cause a substantial number of premature deaths. (Photo: Julie Camerlin/Flickr (CC BY 2.0)).

regulations and interventions are necessary to safeguard public health. Indian governments have already been partially successful in tackling indoor pollution by supporting the switch from solid-fuel cooking stoves to liquefied natural gas.

For ambient pollution, more comprehensive measures are needed. Thus, sustainable infrastructure built into new cities from the beginning is an option that may help to guide urbanisation into healthier forms. China has already invested heavily in ecocities, although results have been mixed (Curr. Biol. (2019) 29, R947–R949). The Indian government launched the Smart City Mission in 2015 as a project to develop 100 sustainable cities, with projects across the country competing for funding.

The National Clean Air Programme launched in 2019 includes pollution control measures across sectors as well as public education efforts. It aims to reduce particulate pollution by 20–30% by 2024.

Delhi is going a step further. In October 2020, it was announced that the city will be setting up two gigantic ‘smoke towers’ — devices meant to filter ambient air. Whether this desperate measure can help to clear the notorious Delhi smog remains to be seen. Conceivably, it might be more efficient to expend the effort on avoiding the pollutants being emitted in the first place.

European contrasts

Most western, industrialised countries have already overcome the 1950s-style city smog by abandoning coal burning in households and power stations. The remaining problems, mostly resulting from motor vehicles, are still a serious health concern (Curr. Biol. (2016) 26, R307–R310). The switch from petrol to diesel vehicles especially, encouraged by the EU on the grounds of better fuel efficiency and therefore lower carbon dioxide emissions, along with manufacturers’ attempts to bypass emissions limits, has led to a situation where particulate matter and NO2 levels are still dangerously high in urban areas.

A recent analysis led by the Barcelona Institute for Global Health (ISGlobal), Spain, estimated the mortality burden attributable to air pollution in nearly 1,000 European cities (Lancet Planet. Health. (2021) https://doi.org/10.1016/S2542-5196(20)30272-2). Results for individual cities are available on the ISGlobal website: http://www.isglobalranking.org.

Across the cities studied, the researchers estimate that a total of 51,000 premature deaths per year could be averted if all cities remained below the WHO standard for PM2.5 (fine particulate matter, 2.5 micrometres or smaller). For NO2 (nitrogen dioxide), the corresponding estimate is 900 avoidable deaths. The authors note that the WHO standard is not a safe limit and, even at that level, pollution still costs lives. If, on each parameter, all cities were to push their pollution level as low as that of the best-performing city in the study, 125,000 premature deaths attributed to PM2.5 and another 79,000 attributed to NO2 could be avoided.

The researchers published separate rankings for the best and worst city air based on the mortality assigned to PM2.5 and NO2. The health burden of fine particulate matter pollution is worst in cities in the Po Valley in northern Italy (Brescia, Bergamo, Vicenza, Saronno), the Czech Republic (Karviná, Ostrava, Havířov) and Poland (Upper Silesian metropolitan area, Jastrzębie-Zdrój, Rybnik). The Po Valley is a densely urbanised area often suffering from stagnant meteorological conditions, allowing pollutants to accumulate. The affected areas in southern Poland and the eastern part of the Czech Republic are traditional coal-mining areas where domestic use of coal for heating still contributes to urban pollution.

Brescia, for instance, could avoid an estimated 309 annual deaths from particulate pollution, corresponding to 15% of its preventable mortality, if its air were as clean as that of Reykjavik (Iceland) or Tromso (Norway), the cities that lead the clean-air chart, followed by other northern European cities, such as Umeå (Sweden) and Oulu (Finland).

This study is the first to resolve pollution-linked mortality burdens to individual cities rather than countries or larger regions. While previous analyses on a broader scale had also highlighted eastern European countries like Poland and the Czech Republic, they had not detected the high mortality burden now found in northern Italy.

The distribution looks different for the health burden linked to NO2. Here, the worst offenders are the capital or larger cities of western European countries, with Madrid, Antwerp, Turin and Paris occupying the top of the table. Road traffic is the biggest single contributor to NO2 pollution in cities. The lowest burden is again found in the far north of the continent, with Tromso, Umeå and Oulu occupying the medal ranks. Madrid alone could avoid an estimated 2,380 premature deaths annually.
corresponding to 7% of its total, if its NOx pollution were as low as Tromsø’s.

Pollution permeating the body
While epidemiologists have no doubt that air pollution kills many thousands of people, it can be difficult to prove the connection in specific cases. In December 2020, a UK coroner ruled that illegal levels of air pollution contributed to the death of the nine-year-old girl Ella Kissi-Debrah in 2013. She had been suffering severe asthma attacks and multiple seizures for three years until she died. While the ruling does not have direct legal consequences, campaigners are now hoping that this strengthens their case to call for a lowering of UK pollution limits to match WHO guidelines.

It is obvious that polluted air may damage airways and lungs, and thereby aggravate conditions like asthma, but researchers are increasingly reporting evidence that the pollutants can also affect other organs, including the heart and even the brain.

The group of Deborah Cory-Slechta at the University of Rochester, USA, for instance, has been studying the effect of exposure to real-world air pollution on the mouse brain and found evidence that it can contribute to symptoms of dementia (Part. Fibre Toxicol. (2019) 16, 45). Even the developing brain of a fetus can suffer from pollutants inhaled by the mother, raising the possibility of a link to the heart and even the brain.

The group of Deborah Cory-Slechta and colleagues suggests that excess amounts of ferrous iron (Fe²⁺) could be an important factor mediating such effects (Toxicol. Pathol. (2019) 47, 976–992). Iron can cause inflammation, which is one of the pathways that may be responsible for the heart consequences of exposure to air pollution.

The group of Caleb Finch at the University of Southern California at Los Angeles, USA, has detected excessive amyloid-β plaques in the brains of mice exposed to air pollution levels corresponding to the typical levels in Delhi. Animal studies in combination with exposure assessments and epidemiology data for humans led the researchers to conclude that a substantial proportion of currently diagnosed cases of dementia may be linked to polluted air.

Eye disease is also being linked to pollution, due to the fact that the retina has a high level of blood flow and is thus exposed to pollutant particles absorbed in the blood. Sharon Chua at University College London, UK, and colleagues from the UK Biobank Eye and Vision Consortium showed that glaucoma can be linked to exposure to PM2.5 pollution (Invest. Ophth. Vis. Sci. (2019) 60, 4915–4923).

Recently, Chua and colleagues also used UK Biobank data of 116,000 people to demonstrate an association of pollution and age-related macular degeneration, the most frequent cause of blindness in older people (Br. J. Ophthalmol. (2021) http://dx.doi.org/10.1136/bjophthalmol-2020-316218).

In a recent comprehensive, two-part review of the medical effects of air pollution (Chest (2019) 155, 409–416 and 417–426), Dean Schraufnagel from the University of Illinois at Chicago, USA, and colleagues come to the conclusion: “Air pollution can harm acutely, usually manifested by respiratory or cardiac symptoms, as well as chronically, potentially affecting every organ in the body”. While some effects are better established than others, scientists tend to find effects once they are looking, which led Schraufnagel to suggest that any organs missing from the review are simply in need of more research.

Switching off pollution
One important way of detecting connections between disease and pollution is to monitor carefully what happens when air quality improves rapidly. Schraufnagel and colleagues have reviewed cases like the dramatic emission controls introduced in Beijing ahead of the 2008 Olympics (Ann. Am. Thorac. Soc. (2019) 16, 1478–1487). Measurements of lung function improved within two months, fewer asthma-related physician visits were recorded and cardiovascular mortality fell. Even the birth weight of the city’s babies increased.

Similar observations were made in the USA after a steel mill in Utah had to close for 13 months, and after the city of Atlanta, Georgia, introduced traffic calming measures to accommodate the 1996 Olympics.

With the current pandemic-induced lockdowns around the world, further examples of such accidental health improvements are to be expected, especially in China, where lockdowns were severe and the COVID-19 death toll remained moderate. Although the preferable solution would be for the world to invest in sustainable technologies that don’t poison us with every breath we take.

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