

Impact of air pollution on health may be far worse than thought, study suggests

Results chime with earlier review indicating almost every cell in the body may be affected by dirty air

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The number of health problems linked to air pollution could be far higher than previously thought, according to research suggesting hospital admissions for conditions ranging from heart failure to urinary tract infections increase as air becomes dirtier.

Air pollution has already been associated with a number of conditions, from **strokes** to **brain cancer**, **miscarriage** and **mental health problems**.

However, the research suggests the impact could be far wider, despite looking at only one component of air pollution, chiming with a **global review published earlier this year** that indicated almost every cell in the body may be affected by dirty air.

“The drive behind [the new research] was to do the most comprehensive study ever conducted at looking at all possible causes of hospitalisation that could be [linked] to exposure to fine particulate matter,” said Prof Francesca Dominici, of Harvard University and co-author of the study.

Writing in **the BMJ** (<https://www.bmj.com/content/367/bmj.l6258>), Dominici and colleagues report how they analysed more than 95m insurance claims made between 2000 and 2012 by hospital inpatients in the US aged 65 or older enrolled in the Medicare programme.

They then looked at air pollution, focusing on levels of a type of fine particulate matter, known as PM2.5, which is produced by sources including vehicles and power stations. By harnessing air quality data from a range of sources, they were able to estimate PM2.5 levels for each patient based on their home zip code.

The team then compared air pollution levels for each patient during the two days around their hospital visit with levels from other points in time.

This approach essentially takes into account factors such as age, socioeconomic status and even obesity, since it uses each patient as their own reference. Fluctuations in air temperature and other factors were taken into account separately.

The results back up previous studies showing a link between short-term exposure to dirty air and conditions such as heart failure, pneumonia and heart attack.

Indeed, the analysis suggests even a small average rise in PM2.5 of 1 micrograms per cubic metre over a two-day period is linked to an increase of 68 older people per billion being taken to hospital with heart failure the next day.

Put another way, that increase in air pollution raises the risk of such people being hospitalised with heart failure by 0.14%.

However, the team also found diseases including septicaemia, Parkinson’s disease and urinary tract infections were associated with poorer air quality. For the latter, the team estimate the short-term rise in PM2.5 is linked to a further 39 older people per billion being taken to hospital the next day.

While the increases in risk might look small, the team say a 1 micrograms per cubic metre rise in PM2.5 levels occurred on more than 122 days in each year within each zip code.

The team’s analysis further reveals air pollution is linked to more than just hospital visits: the data shows short-term increases in PM2.5 were linked to an average annual increase of 634 deaths, and about \$100m in costs for inpatients and post-acute care.

Even when the team looked at days when the air quality was within the limits set by the WHO, they found the trends remained.

Yaguang Wei, first author of the study, said the research suggested the health effects of PM2.5 were not restricted within individual organs. “It has a more systemic effect on multiple pathophysiological processes such as inflammation, infection, and water electrolyte balance,” he said, although the details remain unclear.

While the study cannot prove that air pollution causes the diseases, the team say it adds weight to calls for air pollution guidelines to be reviewed.

Dr Ioannis Bakolis, of King’s College London, who was not involved in the study, agreed. He said: “These guidelines needs to be revised, as even the 9% of the population that lives within the WHO limits may be substantially by affected by air pollution concentrations and its associated costs, according to the findings of the study.”

However, the study has limitations, including that it looked only at one component of air pollution and only considered outdoor air pollution near patients’ homes.

What’s more, it does not account for short-term changes in behaviour that might have varied with air pollution levels – such as physical activity levels – while it is not clear if the results would hold in those not enrolled in Medicare, including younger people.

Writing in an **accompanying editorial**, a team of experts from the University of Southampton say the study suggests figures for the number of early deaths down to air pollution – put at **800,000 a year in Europe** – are likely to be considerable underestimates, and stressed action is needed.

“Clearly, there is much still to learn, but we should not mistake knowledge gaps for paucity of evidence,” they write. “The sooner we act, the sooner the world’s population will reap the benefits.”

Revealed: air pollution may be damaging ‘every organ

in the body'

Exclusive: Comprehensive analysis finds harm from head to toe, including dementia, heart and lung disease, fertility problems and reduced intelligence

Damian Carrington
Environment editor
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Air pollution may be damaging every organ and virtually every cell in the human body, according to a comprehensive new global review ([https://journal.chestnet.org/article/S0012-3692\(18\)32723-5/pdf](https://journal.chestnet.org/article/S0012-3692(18)32723-5/pdf)). The research shows head-to-toe harm, from heart and lung disease to diabetes and dementia, and from liver problems and bladder cancer to brittle bones and damaged skin. Fertility, foetuses and children are also affected by toxic air, the review found.

The systemic damage is the result of pollutants causing inflammation that then floods through the body and ultrafine particles being carried around the body by the bloodstream.

Air pollution is a "public health emergency", according to the World Health Organization, with more than 90% of the global population enduring toxic outdoor air. New analysis indicates 8.8m early deaths each year – double earlier estimates – making air pollution a bigger killer than tobacco smoking.

But the impact of different pollutants on many ailments remains to be established, suggesting well-known heart and lung damage is only "the tip of the iceberg".

"Air pollution can harm acutely, as well as chronically, potentially affecting every organ in the body," conclude the scientists from the Forum of International Respiratory Societies in the two review papers, published in the journal *Chest*. "Ultrafine particles pass through the [lungs], are readily picked up by cells, and carried via the bloodstream to expose virtually all cells in the body."

Prof Dean Schraufnagel, at the University of Illinois at Chicago and who led the reviews, said: "I wouldn't be surprised if almost every organ was affected. If something is missing [from the review] it is probably because there was no research yet."

The review represents "very strong science", said Dr Maria Neira, WHO director of public and environmental health: "It adds to the very heavy evidence we have already. There are more than 70,000 scientific papers to demonstrate that air pollution is affecting our health."

She said she expected even more impacts of air pollution to be shown by future research: "Issues like Parkinson's or autism, for which there is some evidence but maybe not the very strong linkages, that evidence is coming now."

How air pollution reaches every part of the body ...

The WHO has called air pollution the "silent killer" because its widespread effects are often not ascribed to toxic air.

Lungs and heart

The harmful effects of dirty air shown in the review begin when the pollution is inhaled.

This results in breathing problems, from asthma to emphysema to lung cancer.

There is now overwhelming evidence that air pollution results in serious harm not only to the lungs, but also to the heart. Here it increases the risk of heart attacks as arteries narrow and muscles weaken.

One reason for the wide-ranging damage from air pollution is that very small particles can penetrate the lungs and be carried around the body. "They land in the organs directly," Schraufnagel said.

"Animal studies have shown they can even travel right up the olfactory nerve into the brain." An emerging area of research also suggests air pollution can affect how genes function, he added.

Brain and mind

Strokes, dementia and reduced intelligence are all conditions affecting the brain

that have been linked to air pollution.

There is also evidence that poor sleep can be a consequence of breathing toxic air. The main reason for the far-reaching damage from air pollution is systemic inflammation, said Schraufnagel.

“Immune cells think a [pollution particle] is a bacteria, go after it and try to kill it by releasing enzymes and acids,” he said.

“Those inflammatory proteins spread into the body, affecting the brain, the kidneys, the pancreas and so forth. In evolutionary terms, the body has evolved to defend itself against infections, not pollution.”

Abdominal organs

Among the many other organs affected is the liver. Schraufnagel said the latter surprised him, until he thought about the liver’s role in removing toxins from the body: “It makes perfect sense, but I would not have thought about it before starting the study.”

Research highlighted in the review also links air pollution to numerous cancers, including in the bladder and the gut, where an increase in irritable bowel syndrome has also been found.

Even skin and bones are affected, with skin ageing, hives and brittle bones associated with toxic air.

Reproduction, babies and children

Perhaps the most disturbing impact of toxic air is the damage to reproduction and children. Fertility is reduced and miscarriages increased by exposure to air pollution.

The unborn are also affected, with a recent study finding pollutants in the placentas that nourish foetuses.

Air pollution is also strongly linked to low birthweights for babies, which has lifelong consequences.

Children are especially vulnerable, the review found, as their bodies are still developing.

Exposure to dirty air leads to stunted lungs, increases in childhood obesity, leukemia and mental health problems.

‘Doctors need to speak up’

Schraufnagel is concerned that many doctors are unaware of this wide-ranging damage associated with air pollution.

“Some have no idea air pollution affects the organs they specialise in. But it affects their organs too and they had better pay attention,” he said. “They need to educate their patients and then they should speak up” in favour of action.

Researchers cannot experiment on people and so by necessity many studies show significant associations between poor air quality and disease, but cannot prove cause and effect.

However, Schraufnagel said particularly compelling evidence comes from three types of study: where air pollution and illness change in tandem over time, where the “dose” of pollution correlates with levels of disease and from animal studies.

For example, government action to slash pollution before the Beijing Olympics in 2008 led to a rise in birth weights in the city.

“Harmful effects occur even at levels below air quality standards previously considered to be safe,” warn the review scientists, who between them represent every continent. But they add: “The good news is that the problem of air pollution can be addressed.”

“The best way to reduce exposure is to control it at its source,” said Schraufnagel. Most air pollution comes from burning fossil fuels to generate electricity, heat homes and power transport.

“We need to work on these factors in a very dramatic way,” said Neira. “We are probably the first generation in history to be exposed to such a high level of pollution. People will say that in London or other places it was worse 100 years ago, but now we are talking about an incredible number of people exposed for a long time.”

“We have megacities where all the citizens are breathing toxic air,” she said. “However, with all the tonnes of

evidence we are collecting now, politicians will not be able to say we didn't know."