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IP Indian Journal of Immunology and Respiratory Medicine

Journal homepage: https://www.ijirm.org/

Editorial

Air pollution: An invisible enemy of lung health

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Received: 09-02-2025; **Accepted:** 31-03-2025; **Available Online**: 17-07-2025

Air pollution is a silent but dangerous global problem that affects the air we breathe and harms our lungs in serious ways. It is caused by harmful substances, known as pollutants, that mix into the air from various sources. These include tiny particles called particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), ozone (O_3), carbon monoxide (CO), and volatile organic compounds (VOCs). These pollutants come from everyday activities like driving cars, running factories, burning coal or oil, construction work, and even household tasks such as cooking or using chemical cleaning products.[1] Indoor air pollution is just as concerning, caused by things like poor ventilation, cigarette smoke, mold growth, and chemicals released from household items in tightly sealed homes. In rural areas, practices like burning waste or using wood and charcoal for cooking add to the pollution problem.[2,3] The World Health Organization (WHO) estimates that air pollution leads to approximately 7 million deaths worldwide each year, with around 2 million of those in India alone, primarily due to lung and heart-related diseases.[2] Fine particles like $PM_{2.5}$ are especially harmful because they can penetrate deep into the lungs and even enter the bloodstream, causing widespread damage. Ozone, a gas formed at ground level, irritates the airways and worsens conditions like allergies, asthma, and chronic lung diseases.[1,4]

In our country, air pollution is a major public health issue. National capital Delhi is often covered in thick smog, a mix of smoke and fog, caused by heavy traffic, industrial emissions, and the burning of crop residue in nearby areas. This creates a serious health crisis, particularly for vulnerable groups like children, the elderly, and people with existing health conditions.[1,5] Around the world, the impact of air pollution varies depending on its sources, local regulations, and economic conditions. Poorer communities, who often live near factories, highways, or other polluted areas, face higher exposure to bad air, which deepens health inequalities. For example, families living near industrial zones breathe in more harmful substances daily, putting them at greater risk of illness. Climate change makes the situation even worse by increasing temperatures, triggering more wildfires, and causing dust storms, all of which add more pollutants to the air we breathe.[1,6]

Air pollution harms the lungs in multiple ways. It causes inflammation, which is the body's response to irritation, and creates stress in cells, known as oxidative stress. It also weakens the immune system, leads to excess mucus production, and damages tiny hair-like structures in the airways called cilia. These cilia normally help clear out harmful substances, but when they are damaged, the lungs become more vulnerable.[3,4] Over time, these effects cause lasting damage to the lungs and worsen respiratory diseases. Children are especially at risk because their lungs are still developing, making them more sensitive to pollutants. Older adults, whose bodies are less able to fight off damage, and people with pre-existing health conditions also suffer greatly from exposure to polluted air.[3] Common respiratory problems like bronchitis, an inflammation of the airways, and pneumonia, a lung infection, are often triggered or made

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http://doi.org/10.18231/j.ijirm.2025.008

worse by breathing polluted air, adding to the overall burden of disease.[3,4,6]

Indoor air pollution is a major concern as well, especially in homes with poor ventilation. Chemicals like VOCs, released from paints, cleaning products, or furniture, and mold growth in damp or poorly ventilated spaces create an environment that triggers allergies.[7] In modern energy-efficient homes, which are often tightly sealed to save energy, pollutants can get trapped indoors, leading to constant exposure. This can cause ongoing symptoms like sneezing, coughing, or skin irritation, which lower people's quality of life. For many, the simple act of breathing safely at home becomes a daily challenge. This highlights the urgent need for better indoor air quality, such as using air purifiers, improving ventilation, or choosing low emission household products.[4,7]

Air pollution is also a known cause of lung cancer, recognized as a major cancer-causing agent by international health experts[8]. Tiny particles like $PM_{2.5}$ and chemicals called polycyclic aromatic hydrocarbons (PAHs), found in car exhausts and factory emissions, damage DNA, cause cell stress, and trigger long-term inflammation. $PM_{2.5}$ particles are small enough to settle deep in the lungs, increasing the risk of adenocarcinoma, a type of lung cancer common in non-smokers. PAHs, which are released from burning fossil fuels, disrupt the body's ability to repair damaged cells, raising the risk of cancer. In India, air pollution is linked to roughly 10% of lung cancer cases, with people in cities and workers exposed to exhaust fumes, like truck drivers, facing higher risks. This shows how constant exposure to polluted air can have deadly long-term effects.[3,5,8,9]

Allergies are another health issue closely linked to air pollution. Conditions like allergic rhinitis, also known as hay fever, and skin conditions like eczema occur when the immune system overreacts to environmental triggers such as pollen, dust mites, or pet dander. Pollutants like $PM_{2.5}$ and NO_2 make these triggers more dangerous by altering their structure, making them more likely to cause allergic reactions.[5,10] In urban areas, pollen grains can mix with pollutants and break into smaller fragments. These smaller pieces can reach deeper into the lungs, leading to symptoms like a stuffy or runny nose, sneezing, itchy eyes, or skin rashes.[5,6] In places like Punjab, Haryana, and Uttar Pradesh in India, the parali burning residue releases large amounts of harmful substances, including $PM_{2.5}$, PM_{10}, carbon monoxide, and nitrogen oxides.[5,11] These pollutants spread to nearby cities, reducing visibility and causing practical problems like more road accidents and disruptions to air and train travel. For example, during crop-burning seasons, cities like Delhi often see a sharp rise in air pollution levels, making it harder for residents to breathe safely.[11]

Asthma, a condition where the airways become narrow and inflamed, is significantly worsened by air pollution. Pollutants like $PM_{2.5}$, NO_2, and ozone irritate the airways, triggering asthma attacks that cause symptoms like wheezing, shortness of breath, and coughing. Ozone, which forms when sunlight reacts with emissions from cars and factories, is a major asthma trigger, especially during warmer months when ozone levels are higher [3]. In cities like Delhi, where NO_2 levels often exceed safe limits set by the WHO, hospitals see a spike in asthma-related visits during high-pollution seasons, such as winter months when smog is common. Indoor pollutants also play a big role in worsening asthma. For example, cigarette smoke, chemicals from cooking or heating, and particles from burning wood or charcoal in poorly ventilated homes can trigger attacks. This is especially common in low-income households that rely on biomass fuels like wood or dung for cooking, as these release high levels of harmful particles.[1,4,5,12]

Chronic Obstructive Pulmonary Disease (COPD) is another serious lung condition heavily influenced by air pollution. COPD includes diseases like emphysema and chronic bronchitis, which make it hard to breathe. Long-term exposure to $PM_{2.5}$ causes inflammation in the lungs, damages tissues, and leads to scarring, which reduces lung function over time.[3,7] In India, where air quality often fails to meet WHO safety standards, COPD is a widespread problem, particularly in urban areas with heavy pollution and rural areas where people burn biomass fuels. Symptoms of COPD, such as a persistent cough, shortness of breath, and frequent lung infections, severely affect quality of life.[5,6] Air pollution is linked to more frequent COPD flare-ups, increased hospital admissions, and higher death rates. The WHO estimates that air pollution contributes to millions of COPD-related deaths each year, making it one of the top environmental risks for this disease.[13]

Interstitial Lung Disease (ILD), a group of disorders that cause scarring in the lungs, is another condition worsened by air pollution. Pollutants like $PM_{2.5}$ and dust from workplaces, such as coal mines, cause ongoing inflammation and stress in the lungs, leading to excessive scar tissue. This scarring makes it harder for the lungs to work properly, causing breathing difficulties.[7] In India's coal-mining regions, ILD cases are increasing, particularly among workers exposed to dust over long periods. Another severe condition, Acute Respiratory Distress Syndrome (ARDS), can also be triggered by high levels of air pollution, especially in people exposed to toxic fumes or heavy particulate matter. These conditions highlight the wide-ranging impact of air pollution on lung health, affecting people in both urban and rural settings.[7,13]

The effects of air pollution on lung health vary across the world, depending on factors like pollution sources, economic development, and government regulations. Wealthier

countries have made progress in reducing outdoor pollution through strict emission controls and cleaner energy sources, but indoor air quality remains a challenge, especially in cities with tightly sealed buildings.[8,9,14] Poorer communities, often located near polluted areas like factories or highways, face worse exposure, which deepens health inequalities[4]. Addressing the severe impact of air pollution on lung health requires urgent and comprehensive action. This global crisis, made worse by climate change and social inequalities, demands a united effort to protect people's health.[9,14,15] Practical steps can make a difference, such as monitoring air quality in real time to warn people of dangerous pollution levels, reducing exposure by staying indoors on high-pollution days, and improving indoor air quality with better ventilation or air purifiers. Protecting vulnerable groups, like children and the elderly, is critical, as they are most at risk. Stronger government policies, such as stricter emission limits and cleaner energy sources, are essential to reduce pollution at its source. Creating more green spaces, like parks and trees in cities, can help clean the air naturally. Individuals can also play a role by cutting personal emissions, such as using public transport or reducing energy use at home. Promoting healthy lifestyles, like avoiding smoking and staying active, can help strengthen the lungs against pollution's effects. Finally, research into new treatments for pollution-related lung diseases can offer hope for those already affected.[13-11,15]

LiFE (Lifestyle for Environment) program was launched by Prime Minister Narendra Modi on June 5, 2022, encouraging everyone in India to adopt habits that help protect the environment and reduce pollution. The author is involved with many NGOs to combat air pollution with his personal suggestions like, gifting plant saplings instead of flower bouquets, including plant ceremonies in events like birthdays, marriage anniversaries, and engagements, promoting use of public transport, no smoking, advocating for anti-smoking initiatives, and utilizing the Ujjwala Yojana. Addressing air pollution requires collective action, it's not just up to the government everyone needs to join the effort for cleaner air.[16]

Clean air is not just an environmental goal—it's a basic human right. Everyone deserves to breathe air that doesn't harm their health. By combining individual actions, community efforts, and strong policy changes, we can reduce the burden of air pollution on lung health. Together, we can work toward a future where every breath is a healthy one, ensuring a better quality of life for people everywhere.[1,4,5,13,15,16]

Conflict of Interest

None.

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Cite this article: Kant S. Air pollution: An invisible enemy of lung health. *IP Indian J Immunol Respir Med*. 2025;10(2):41-43.