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Bad Air Day: Checking the Effect of Air Pollution on Health

Air pollution is a broad term applied to any visible or invisible chemical, physical (particulate matter), or biological agent that is not a part of the natural composition of air which modifies the natural characteristics of the atmosphere. It is a pervasive mixture of chemicals containing carcinogenic compounds and endocrine disrupting properties.

Sources of Air Pollution

Outdoor Air Pollution involves exposures that take place outside of the built environment viz.

- Fine particles produced by the burning of fossil fuels (i.e. the coal and petroleum used in energy production)
- Noxious gases (sulfur dioxide, nitrogen oxides, carbon monoxide, chemical vapors, etc.)
- Ground-level ozone (a reactive form of oxygen and a primary component of urban smog)
- Tobacco Smoke

Indoor Air Pollution involves exposures to particulates, carbon oxides, and other pollutants carried by indoor air or dust viz.

- Gases (carbon monoxide, radon, etc.)
- Household products and chemicals
- Building materials (asbestos, formaldehyde, lead, etc.)
- Outdoor indoor allergens (cockroach and mouse dropping, etc.)
- Smoke from cooking, candles, fireplaces or tobacco
- Mold and pollen

Significance of Major Pollutants

Ozone O3, which is the major component of smog, is a strong lung and airway irritant. Short-term exposures can cause breathing difficulties, chest pain, and airway hyperreactivity. Children who participate in outdoor activities on days on which ozone pollution is high are more likely to develop asthma and chronic obstructive pulmonary disease (COPD) symptoms, and there is a greater risk of illnesses like pneumonia and bronchitis. Long-term exposure to ozone causes permanent decrease in lung function.

Ground-level ozone is formed when volatile organic compounds (VOCs) and oxides of nitrogen (NOx) react with the sun's ultraviolet rays. The primary source of VOCs and NOx is mobile sources, including cars, trucks, buses, construction equipment and agricultural equipment. It is a strong irritant that can cause constriction of the airways, forcing the respiratory system to work harder in order to provide oxygen. It can also cause aggravated respiratory disease such as emphysema, bronchitis and asthma, lung damage, even after symptoms such as coughing or a sore throat disappear, wheezing, chest pain, dry throat, headache or nausea, reduced resistance to infections, increased fatigue and weakened athletic performance.

Particulate Matter (PM) is a complex mixture that may contain soot, smoke, metals, nitrates, sulfates, dust, water and tire rubber. It can be directly emitted, as in smoke from a fire, fossil fuel combustion or it can form from reactions of gases such as nitrogen oxides. The size of particles is directly linked to their potential for causing health problems. Small particles (known as PM2.5 or fine particulate matter) pose the greatest problems because they bypass the body's natural defences and can get deep into the lungs and potentially the bloodstream. Exposure to such particles can affect both lungs (COPD, asthma, bronchitis) and heart (heart attacks, strokes). These particles can carry toxic chemicals which are linked to cancer. Long-term exposure to particulate matter can also contribute to the development of lung cancer.

Nitrogen dioxide (NO2) is a major component of urban air pollution episodes and comes from man-made sources viz. vehicles, power stations and heating. High levels of NO2 can irritate and inflame the lining of airways, causing respiratory infections, allergies, flare-up of asthma or COPD and symptoms such as coughing and difficulty breathing.

Sulphur dioxide (SO2) come from electric industries due to combustion of fossil fuels, petrol refineries and cement manufacturing and are easily deposited in the upper airway making them inflamed and constricted, causing symptoms such as breathing difficulty, increase in the risk of chronic bronchitis, respiratory infections and aggravates asthma and COPD.

Effects of Air Pollution on Health

World Health Organization estimates that nine out of ten people breathe polluted air, which kills 7 million people every year. The health effects of air pollution are serious – one third of deaths from stroke, lung cancer and heart disease are due to air pollution. This is having an equivalent effect to that of smoking tobacco, and much higher than the effects of eating too much salt. The global burden of diseases study estimated that exposure to ambient particulate matter (PM) 2.5 led to about 3 million deaths and 84 million disability adjusted life years lost due to ischemic heart disease, acute low respiratory infections, etc.

According to Global Burden of Disease (Lancet, Nov 2017), non-communicable diseases like COPD and asthma are on the rise and contribute to 10.9% of all deaths in India and that is 1/4th of deaths caused worldwide by these two most chronic respiratory diseases. India is home to 16 of the world's 30 most polluted cities, according to a 2016 World Health Organization (WHO) report. According to one of the few nationwide studies sponsored by the Indian Council of Medical Research (ICMR), in 2009, an estimated 14.84 million (3.49%) Indians suffer from chronic bronchitis alone.

Exposure to indoor and outdoor air pollutants may increase an individual's risk for morbidity and mortality from a variety of different conditions in multiple organ systems. In 2013, the World Health Organization concluded that outdoor air pollution is carcinogen to humans. High levels of air pollution can adversely affect lung function and trigger asthma, bronchitis, emphysema and COPD exacerbations and increase risk of lung cancer. Most air pollutants cause the muscles in airways to contract, narrowing the airway (airway hyperreactivity). Even among members of the general healthy population, especially children, long-term exposure to air pollution may increase respiratory infections and symptoms of respiratory disorders (such as cough and difficulty breathing) and decrease lung function.

Air pollution also increases risk of acute cardiovascular events (e.g. myocardial infarction) and development of coronary artery disease. Apart from increased cardio-respiratory morbidity and mortality, air pollution exposures are also known to elevate the risk of stroke, Alzheimer's-like pathology, mood disorders, gastrointestinal disorders, sensory irritation, loss of visibility, adverse pregnancy outcomes (such as preterm birth) and even death.

A higher risk of breast cancer has been associated with nitrogen dioxide (NO_2) and nitrogen oxides (NO_x) levels, both of which are proxies for traffic exposure. Hazardous air toxic levels and sources of indoor air pollution may also contribute to breast cancer risk. A review of previous research confirmed that BRCA1 and BRCA2 genes which try to stop tumours growing can be "silenced" by exposures to dioxins and polycyclic aromatic hydrocarbons - both found in exhaust fumes.

Diagnostic Testing for Air Pollution

Diagnosis is based on a person's history of exposure to high concentrations of known pollutants in the air at work and at home, symptoms, and lung function tests. Patients with lung disorders such as asthma and chronic obstructive lung disease are checked for whether their symptoms worsen when exposed to air pollution.

Personal and Medical History This includes any current physical problems like shortness of breath, wheezing, coughing, and tightness in chest. This also includes all previous medical conditions. A history of allergies or eczema increases the chance of asthma. A family history of asthma, allergies or eczema increases the chance of having asthma, too. Home or work exposure to environmental factors that can worsen asthma such as pet dander, pollen, dust mites and tobacco smoke should also be enumerated.

Physical Exam This exam may include a pulmonary/ lung function test to detect how well one exhales air from the lungs. Spirometer is a common lung function test used to diagnose asthma. An X-ray of lungs or sinuses may also be needed.

Spirometry

Traditionally, lung has been a relatively neglected organ for maintenance checks. One of the reasons being, unlike in case of some other organs like kidney or the liver or the heart, the lung does not have established biomarkers which can accurately measure its function.

The presence of symptoms is not a reliable indicator of disease and diagnosis is often delayed until more severe airflow obstruction is present. Early diagnosis is worthwhile, as it allows risk factors for COPD such as smoking to be addressed promptly and treatment optimised. Spirometry is accepted as the gold standard diagnostic test to assess airflow obstruction and classify severity of lung disease. Spirometers can be hand held or computer interfaced. The criterion for diagnosis defined in guidelines is based on the FEV1/FVC ratio. It represents the proportion of a person's vital capacity that they are able to expire in the first second of forced expiration (FEV1) to the full, forced vital capacity (FVC). The result of this ratio is expressed as FEV1%. A portable spirometer potentially allows wide application of testing to improve recognition and diagnosis of COPD, such as for case finding during preventive health checks even during home visit by phlebotomists.

People including children exposed to higher levels of air pollution show reduced lung growth and function that may affect them decades later. The early lung deficits may increase the risk of developing COPD later in life, as well as cardiovascular morbidity and general mortality. According to a study published in the New England Journal of Medicine, current levels of air pollution have chronic, adverse effects on lung development in children from the age of 10 to 18 years, leading to clinically significant deficits in attained FEV1 as children reach adulthood.

An early diagnosis can help check further damage to the lungs and enable one to lead a normal life, with medication and certain lifestyle changes.

Fractional Exhaled Nitric Oxide (FENO) tests are challenge tests used to measure how much nitric oxide is in the air that one exhales. For this test, one will breathe out into a tube that is connected to the portable device. The test measures nitric oxide, which is a marker for inflammation in the lungs, recommended in monitoring of asthma patients.

Other Diagnostic Tests

Glucose Testing: Historically, ambient air pollutants (AAP) and traffic-related air pollution (TRAP) have been associated with cardiorespiratory disease, yet it is only recently that studies have begun to link elevated air pollution exposure with metabolic dysfunction in humans. Increased exposure to air pollution is associated with higher insulin resistance and secretion, which is observed in conjunction with higher glycaemia. AAP and TRAP appear to act as environmental factors that contribute to risk factors for type 2 diabetes independent of adiposity (7).

Testing for Altered Heart Parameters: Long-term ambient air pollution is associated with both altered lipid profiles and dyslipidemias, especially among overweight or obese patients (8, 11).

Hematological and Blood Pressure: *Testing* A Taiwanese study on the effect of long-term air pollution concluded that changes in blood pressure, blood lipids, blood glucose and hematological markers of inflammation are associated with long-term exposure to ambient air pollutants (9). Exposure to particulate matters, O_3, and nitrogen dioxide (NO_2) contributes to increased susceptibility to respiratory infection as well.

Allergy Testing: Air pollution leads to increased rates of occurrence of allergic symptoms and asthma exacerbations with elevated production of **total** and **antigen-specific IgE** and histamine (10).

Vitamin D – ASSOCHAM Healthcare Committee reported that about 8 out of 10 people in Delhi suffers from Vitamin D deficiency with the highest concentration among those in the age group of 21-35 years. Another research by CSIR-National Physical Laboratory (NPL) published in Atmospheric Environment 2018 found that increasing air pollution levels in Delhi over the last 15 years is depriving its citizens of Vitamin D. An increase in aerosol optical depth (AOD), which indicates the amount of direct sunlight that is prevented from reaching the earth's surface by aerosols particles, has reduced solar ultraviolet (UV) radiation over the city. Using monthly data retrieved from Clouds and Earth Radiant Energy System (CERES) developed for NASA's Earth Observing Satellite, between March 2000 and February 2016, the team found an average 10% decrease in UVA and 20% decrease in UVB with an increase in AOD. UVB –most of which is absorbed by the earth's atmosphere – is a major source of vitamin D in humans. Air pollution decreases vitamin D by following mechanisms:

- Pollution reduces the amount of time that people are outdoors
- Pollution attenuates the amount of UVB getting to the skin
- Irritation/Inflammation of lungs may consume vitamin D

High Sensitivity C - reactive protein (hs-CRP) – Growing body of literature shows association between long-term exposure to PM and markers of inflammation (hs-CRP). Exposure to PM air pollution has been linked to chronic diseases related to the mechanism of chronic inflammation, such as atherosclerosis, diabetes mellitus and mild cognitive impairment (13, 14).

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