Effects of Air Pollution on Respiratory Diseases in India

Authors

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Abstract

Air pollution is the undesirable change in quality of air. In a developing country like India where majority of population lives in rural area, but both rural and urban areas are equally affected by pollution. Air pollution is largest environmental health risk that approximately kills 1 in 8 people globally, due to heart disease, stroke, respiratory disease and cancer. According to WHO air quality model (2016) about 92% of world’s population lives in places where air quality level exceed WHO limits. Particulate matter present in polluted air such as dust, smoke, pollen and volatile organic compounds trigger can cause serious damage to respiratory tract. When we breathe in dirty air, we bring air pollutants deep into our lungs; can trigger new cases of asthma. It can not only worsen a pre-existing respiratory illness, but also provoke the development of other diseases such as chronic illness, including chronic obstructive pulmonary disease, asthma and respiratory allergies, pulmonary hypertension, lung cancer etc., which can be fatal. By eating balanced and nutritious diet, not exposing to polluted area and wearing masks at a place where AQI is above the limit. Creating awareness about harmful effects of air pollution among people may be helpful to downscale its fatal effects.

Keywords- Pollution, indoor, outdoor, AQI, biomass, particulate matter.

Introduction

Air pollution is responsible for many health problems majorly in urban but also in some rural cities in India. According to WHO (World Health Organization) pollution is contamination of environment by any chemical, physical or biological agents that modifies the natural characteristics of atmosphere. Air pollution can be categorized into two categories, indoor and outdoor pollution which are presence of pollutants in air inside and outside the house respectively. Indoor cooking and heating with biomass fuels (agricultural residues, dung, straw and wood) or coal produces high levels of smoke that contains a various health-damaging pollutants. According to WHO Indoor air pollution is responsible for 2 million deaths annually. Outdoor air pollution is the result of inefficient combustion of fuels for transport, power generation and other activities. The World Health Organization (WHO) estimated 84000 deaths directly attributable to outdoor air pollution in Indian cities. Urban outdoor air pollution is estimated to cause 1.3 million deaths worldwide per year (WHO report on air pollution). Global urbanization which requires
large energy consumption has resulted in increased emissions into the atmosphere and a decrease in urban air quality \[1\]. Pollutants can be classified as primary or secondary. Primary pollutants are released directly into the atmosphere, whereas secondary pollutants result from chemical reactions among primary pollutants \[2\]. The air pollutants of most concern include nitrogen dioxide (NO\(_2\)), ozone and particulate matter (PM) \[1\]. PM is a general term that refers to a complex mixture of solids or liquids that vary in number, size, shape, surface area, chemical composition, solubility depending upon its place of production and mode of emission \[3\]. Particulate matter include inorganic compounds such as sulphates, nitrates, organic compounds such as polycyclic aromatic compounds and biological materials, such as pollen, bacteria, spores, and animal remains. On the basis of total suspended particle size, PM is classified as follows: constituent particles of up to 30 µm in diameter; constituent particles of less than 10 µm in diameter (PM\(_{10}\) or inhalable fraction); constituent particles of less than 2.5 µm in diameter (PM\(_{2.5}\) or fine PM); and constituent particles of less than 10 nm in diameter (PM\(_{0.1}\) or ultrafine PM) \[4,5\]. Current studies revealed a potential association between urban air pollutants and adverse health effects, particularly those that affect the respiratory and cardio-vascular systems \[6,7\].

**Mechanism: How Air Pollution Affect the Respiratory System**

Several mechanisms have been suggested to explain the adverse effects of air pollutants. Most widely accepted explanation is that, once in contact with the respiratory epithelium, high concentrations of oxidants and pro-oxidants in environmental pollutants such as PM of various sizes and compositions and in gases such as O\(_3\) and nitrogen oxides cause the formation of oxygen and nitrogen free radicals. These pollutants in turn induce oxidative stress in the airways. These free radicals are neutralized by antioxidants such as vitamin C. In other words, an increase in free radicals that are not neutralized by antioxidant defenses initiates an inflammatory response with release of inflammatory cells and mediators (cytokines, chemokines, and adhesion molecules) that reach the systemic circulation, leading to inflammation, which not only has a negative effect on the respiratory system but also causes systemic effects \[4,5\]. Air pollutants also negatively and significantly harm lung development, creating an additional risk factor for developing lung diseases later in life.

**a. Latent Period**

The effects of pollutants on health can be acute or chronic. Acute effects are manifest shortly after exposure (hours or days). Chronic effects are usually assessed in longitudinal studies over years or decades \[8\].

**b. Effects of Air Pollution on Children**

Children are highly susceptible group to air pollutants. Children are more susceptible than adults because children have higher basal metabolic rates and engage in more physical activity than do adults, as well as because children spend more time outdoors than do adults. Also the volume of air passing through the airways of a child at rest is twice that of an adult under similar conditions. Pollutant-induced irritation producing a weak response in adults can result in significant obstruction in children. In addition, the fact that their immune system is not fully developed increases the possibility of respiratory infections \[4,5,8-10\].

**c. Effects of Air Pollution during Pregnancy**

During pregnancy exposure to air pollutants can impair foetal development and cause intrauterine growth retardation, premature birth, low birth weight, congenital anomalies, and, in cases that are more severe, intrauterine or prenatal death \[11\]. Maternal inhalation of pollutants can cause accelerated cell proliferation, prematurity and change in metabolism of foetus \[12,13\]. Another study revealed that a 1-µg/m\(^3\) increase in PM10 concentration and a 1-ppm increase in CO concentration were associated with a 0.6g and a 12g reduction in birth weight, respectively \[14,15\].
Diseases of Respiratory System

Asthma

Asthma, a chronic disease of the lungs characterized by inflammation and narrowing of the airways, causes a sensation of tightness in the chest, shortness of breath, wheezing, and coughing. If untreated, asthma episodes can be near fatal or even fatal \[16\]. For the past 40 years, the prevalence of asthma has increased in all countries in parallel with that of allergy. Asthma is still increasing worldwide as communities adopt modern lifestyles and become urbanized \[13,53,54\]. According to the WHO data published in may 2014 Asthma Deaths in India reached 151, 877 or 1.71% of total deaths. The age adjusted Death Rate is 17.16 per 100,000 of population ranks India #14 in the world. In a study among children between 6-18 years of age revealed that there is a significant association between traffic-related pollution and the development of asthma exacerbations and respiratory infections in children born to atopic parents and in those suffering from recurrent wheezing or asthma. These findings suggest that environmental control may be crucial for respiratory health in children with underlying respiratory disease \[17\]. The recent data base on asthma and traffic is less robust in adults \[18\].

A recent advance in assessing the effects of air pollution on asthma is the use of biomarkers of airway inflammation and oxidative stress as outcome measures in epidemiological studies \[19-21\]. With a projected increase in the proportion of the world’s population living in urban areas, there is likely to be a marked increase in the number of people with asthma worldwide over the next two decades. Asthma affects approximately 300 million people worldwide. The costs of asthma are high in severe or uncontrolled asthma \[22\].

Chronic Obstructive Pulmonary Disease (COPD)

COPD is a progressive disease that makes it hard to breathe. Its symptoms include coughing that produce large amount of mucus, wheezing, shortness of breath and chest tightness. Among various causes of COPD, cigarette smoking is the leading one \[23,24\]. Chronic exposure to particulate pollutants may cause impaired lung growth in children. In a study of elderly people (≥65 years), it was found that short-term increases in O3 and PM10 concentrations were related to increased hospital admissions for COPD and pneumonia, especially during the warm season \[25\]. And it may be possible that the magnitude of effect increases with the days of exposure. In a multi-centric study in India, prevalence of COPD (chronic obstructive pulmonary disease) was 4.1%, with a male to female ratio of 1.56:1 and a smoker to non-smoker ratio of 2.65:1 in urban and the rural populations at Bangalore, Chandigarh, Delhi and Kanpur \[26,27\]. Particulate matter from fossil fuel combustion is air pollutants which can cause inflammation in the lung and further impaired the reduced pulmonary function in COPD patients \[28\]. Infection is one of the major factors which worsen COPD. In India, a study collecting data without spirometry assessment suggested that 12 million people were affected by COPD \[29\].

Lung Cancer

Lung cancer causes more deaths worldwide than any other cancer, with 1.8 million new cases and 1.5 million deaths in 2012. It is the most diagnosed cancer in men and third most common in women after breast and colorectal cancers \[30\]. Partial combustion of solid fuel produces large amount of particulate matter and carcinogenic gases. Epidemiologic studies have revealed that general air pollution, mainly due to the by-products of the incomplete combustion of fossil fuels, is associated with small relative increases in lung cancer. According to the WHO data published in Geneva in may 2014 Lung Disease Deaths in India reached 1,061,863 or 11.97% of total deaths. The age adjusted Death Rate is 126.99 per 100,000 of population ranks India #1 in the world. Lung cancer is often and accurately related to smoking. Smoking itself is one of the sources of air pollution in a closed space such as a room, besides its pathogenic role in the pathogenesis of COPD \[31\]. In smokers with asthma, lung function can be improved by
smoking cessation. Inhalation exposure to airborne particulate matter in fine ranges (PM$_{2.5}$) is related to pulmonary dysfunction. In another study it was observed that each 10 μg/m$^3$ elevation in fine particulate air pollution was associated with approximately 4%, 6%, and 8% increased risk of cardiopulmonary and lung cancer mortality respectively.

**Low Vitamin D Status**

Air pollution may have an indirect negative impact on vitamin D status. Vitamin D is majorly synthesized in the skin through the action of sunlight since vitamin D is found naturally only in a few food items. Therefore, vitamin D status in humans is mainly determined by exposure to ultraviolet B (UVB) radiation, which initiates the conversion of 7-dehydrocholesterol to vitamin D$_3$. Air pollution decreases the amount of sunlight that reaches the earth surface. According to a study, to reach an optimal vitamin D status in urban residents, the index of sun exposure was double that for rural residents. This suggests that, in an urban environment, the amount of UVB reaching the earth is significantly decreased due to air pollution, which is the major factor in high prevalence of vitamin D deficiency. Deficiency of Vitamin D can promote multiple diseases, particularly osteoporosis but also cardiovascular disease, diabetes and cancer.

**Measures to Reduce Negative Impact of Air Pollution**

**a. Nutritional solutions**

Air pollution has been found to be associated with many fatal diseases both in urban and rural areas. In urban areas pollution is mainly due to industries, factories and TRAP (Traffic Related Air Pollution). Whereas, in rural areas it is due to household air pollution (HAP), burning of biomass and solid fuels. Diets characterized by a low intake of fruit, vegetables, wholegrain and fish, and an increased intake of processed foods, resulting in a nutrient intake that is low in beneficial nutrients such as antioxidants (e.g., carotenoids, vitamin D, E, falvinoids) and omega-3 PUFA. This reduces immunity against harmful effects of air pollution. It has been hypothesized that the intake of antioxidant and anti-inflammatory nutrients may improve various respiratory effects of air pollution through reductions in oxidative stress and inflammation. Pollutants in air increase the production of reactive oxygen species (ROS) which in turn react with organic molecules and destroy them. Omega-3 PUFA intake from fish oil increases the activity of endogenous antioxidants which destroy excess of free radicals and reduce oxidative stress.

**b. Preventive Measures**

In a developing country like India, one of the major sources of rural pollution is household air pollution from cooking and heating practices. Clean LPG and electricity can be used as alternative to reduce pollution. People can reduce the time spent on outdoor activity when level of Air Quality Index (AQI) is beyond specified level. Wearing personal protective equipment might be a useful for avoiding detrimental effect of ambient air pollutants. Masks have been proved to be useful in reducing respiratory virus transmission. Using of nose mask during haze environment can help people to prevent adverse effects from vehicular pollution.

**Conclusion**

India is a developing country which is progressing towards being developed. With the great progression one negative thing that is increasing along with is air pollution. Air pollution can create various diseases like asthma, COPD, lung cancer etc. one should try to reduce or compensate this by a positive thing like growing trees, by being less exposed to highly polluted places. A prudent diet is a key determinant to health throughout the whole life and could reduce the deleterious impact of air pollution on health. WHO launched The Global Alliance against Chronic Respiratory Diseases (GARD) is a voluntary alliance of national and international organizations, institutions and agencies committed to the vision of “a world where all people breathe freely”. Incorporating the ‘universal
access to clean fuel’ agenda within the broader framework of rural development and raising the standard of living will go a long way in reducing disease burden.

Abbreviations
COPD: Chronic Obstructive Pulmonary Disease
TRAP: Traffic Related Air Pollution
PM: Particulate Matter
AQI: Air Quality Index
ROS: Reactive Oxygen Species

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