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EDITORIAL

Indoor air pollution and human health

Indoor air pollution (IAP) arising from chemical, biological and physical contaminants in air is one of the leading health risks very relevant to India. Concern over the negative health impacts of poor indoor air quality is growing. According to WHO, in 2020, household air pollution caused roughly 3.2 million deaths. Although the vast majority of houses and buildings appear to have no issues, non-industrial IAP accounts for a variety of symptoms and illnesses (Redlich, C. A. *et al*., *Lancet*, 1997, **349**, 1013–1016). Pollutants in indoor air emanate from a variety of sources like aero-biologicals and irritants. Biological contaminants include dust mites, pet dander and saliva, mould, pollen, infectious agents due to stagnant water, mattresses, carpets and humidifiers (Paramesh, H., *Indian J. Pediatr.*, 2002, **69**, 309–312). The incomplete combustion by-products of biomass fuels include formaldehyde, carbon monoxide, polyaromatic hydrocarbons, suspended particulate matter and oxides of sulphur, arsenic and fluorine, which are produced when coal is burnt and are harmful to human health. Resins, waxes, polishing agents, cosmetics and binders contribute to the production of pollutants such as aldehydes, volatile and semi-volatile organic compounds, which significantly contaminate indoor air (Kankaria, A. *et al*., *Indian J. Commun. Med.*, 2014, **39**(4), 203–207). Concern over harmful chemical compounds discharged into interior spaces by home furnishings and building materials has grown in recent years (Suzuki, N. *et al*., *Int. J. Environ. Res. Public Health*, 2019, **16**, 4142). Also, strong, short-lived climate pollutants (SLCPs) include black carbon (sooty particles), methane released by inefficient stove combustion and off-gases released by building materials. India tops the list of nations with the largest population lacking access to clean fuel for cooking, since nearly 80% of households in villages still depend on biomass fuel. About 1.3 million deaths occur in India due to poor indoor air quality (Kanti, A., *Business World*, 9 September 2017).

Airborne suspended particulate matter (SPM) consists of a complex mixture of solids and aerosols, including dry solid particles, liquid-coated solid cores and minute inhalable liquid droplets, all of which can harm health. Short-term exposures to SPM 2.5 μm (up to 24 h) exacerbate existing health issues like chronic bronchitis, respiratory symptoms, asthma, ER visits and days with limited activity. These unfavourable health impacts are observed in individuals of all ages (Paramesh, H., *Indian J. Pediatr.*, 2018, **85**, 284–294). According to the Global Burden of Disease Project of WHO, PM 2.5 μm is the common air particle that is most strongly linked to ill-health caused by air pollution. Particles with diameter of 10 μm (PM10) are predominantly known to impact the upper respiratory tract causing allergic rhinitis and related comorbidities, which are a cause of major concern in India (Paramesh, H. *et al*., *J. Pediatr. Assoc. India*, 2020, **9**, 4).

IAP has multi-system health impacts that are visible from early pregnancy through old age. It has been demonstrated that exposure to IAP, depending upon the severity of the exposure to pollutants during pregnancy, has both short-term and long-term health consequences. The pollutants are absorbed into the blood stream through the lung parenchyma, causing multiple coagulopathy syndrome and depositing in the placenta, interfering with foetal nutrition, causing stillbirth, pre-mature birth, small for gestation babies, who are born with fixed airway obstruction leading to chronic lifelong lung problems along with other non-pulmonary diseases, including memory and behavioural problems. IAP causes 400,000–550,000 premature deaths in India from acute lower respiratory infections and chronic pulmonary obstruction disease (Bhave, P. and Kulkarni, N., *Series A*, 2015, **96**(3), 259–265). Exposures during pregnancy also affect the epigenome and cause congenital abnormalities (Paramesh, H., *J. Pediatr. Assoc. India*, 2020, **9**, 4). The cardiovascular system, endocrine system and brain system are affected as well. Many types of cancer have also been linked to IAP (Apte, K. and Salvi, S., *F1000 Research*, 2016, 5). WHO has released guidelines for safeguarding public health against the threats posed by selected indoor pollutants, which mentions that annual average PM2.5 concentrations should not be more than 5 g/m^3, and 24-h average exposures must not be higher than 15 g/m^3 on more than 3–4 days per year.

Households employ a variety of domestic fuels and technologies for heating cooking and lighting like firewood, LPG, cow-dung cakes, coal and kerosene, all of which contain compounds like formaldehyde, poly-organic materials and hydrocarbons (*ICMR Bull.*, 2001). Out of the 0.2 billion people in India who use fuel for cooking, 49% use firewood, 28.6% LPG, 8.9% cow-dung cake, 2.9% kerosene, 1.5% coal, lignite or charcoal, 0.4% biogas, 0.1% electricity and

0.5% other alternatives. Also, over 750 million families are unable to access electricity, which forces them to use hazardous lighting sources like kerosene lamps, exposing them to extremely high levels of fine particulate matter (WHO, 2022). At the household level, women and children disproportionately experience the highest health burden in terms of IAP, as they spend more time exposed to toxic smoke from polluting stoves and fuels while cooking.

Indoor air quality (IAQ) in workplaces impacts productivity and well-being. Outside the homes, considerable time is spent by people in indoor spaces in their workplaces, schools, and other commercial and industrial buildings. Rapid urbanization and contemporary architecture as well as changes in life style have all increased the consumption of consumer products and construction materials, emissions from which result in poor IAQ. The building structure and materials, surface coatings and activities of residents have been identified as major causes of enhanced volatile organic compound (VOC) concentrations in commercial buildings. Combustion by-products, radon and organic chemicals that are volatile or semi-volatile are among the pollutant types with significant indoor sources. Particulate matter and ozone are the two outdoor contaminants that warrant particular attention. Additionally, outdoor particulate matter levels from nearby construction sites, tobacco smoke, carpets and anthropogenic activities have all been linked to an increase in indoor PM levels. Concrete additives are known to cause higher indoor ammonia concentrations (Mannan, M. and Al-Ghamdi, S. G., *Int. J. Environ. Res. Public Health*, 2021, **18**, 3276). Indoor radon is the dominant source of health-relevant radiation exposure to public health. Exposure to high levels of indoor radon has a significant lung cancer risk factor. Krewski, D. *et al.* (*J. Toxicol. Environ. Health, Part A*, 2005, 69533–69597) have described the direct evidence of an association between household radon exposure and lung cancer risk. Another health impact from IAP is the sick building syndrome (SBS), which is associated with a set of nonspecific symptoms experienced by occupants due to time spent in a building with poor IAQ. It is considered that SBS is caused by a variety of chemical contaminants from indoor sources. One of the most frequently mentioned causes is inadequate ventilation.

Hospitals, the most essential component of public infrastructure, contribute to nearly 4.4% of carbon footprint, including IAP. Each department of a hospital sources pollutants, e.g. anaesthesia (nitrous oxide and waste anaesthetic gases – halogenated anaesthetic agents), laboratory fumes (hazardous air pollutants, HAPs), refrigerators (hydrofluorocarbons), sterilization units (VOCs, especially ethylene oxide), nebulization in the ER and ICU, and the cleaning agents used. Large, enclosed, air-conditioned public gathering places like hospitals represent a health concern owing to dangers from IAP and the transmission of airborne diseases. According to the Pollution Control Board, the primary Indian Air Law did not mandate IAQ. The Indian National Green Tribunal took note of the issue and determined it to be a significant legal issue, urging regulation of IAQ in public areas (Singh, R. and Dewan, A., *Int. J. Tuberc. Lung Dis.*, 2022, **26**, 801–802). Poor hospital IAQ may induce sick hospital syndrome (SHS), which can cause headaches, exhaustion, eye and skin irritations, and other symptoms. More gravely, poor hospital IAQ management may result in nosocomial infections and occupational disorders (Leung, M. and Chan, A. H., *Int. Med. J. Exp. Clin. Res.*, 2006, **12**, 17–23). Also, ill-ventilated hospitals contribute to four times more infection rates.

In developing and underdeveloped countries, there is still a dearth of IAQ-focused research and a shortage of the literature that examines the implications of climate change on IAQ that might affect public health. Research is needed on indoor environmental quality monitoring to combat the health risks caused by various indoor air pollutants. Additional research is necessary to assess the exposure levels of indoor pollutants and to strengthen the evidence for their association with health outcomes (Kankaria, A. *et al.*, *Indian J. Commun. Med*., 2014, **39**(4), 203–207). Rural populations are aware of the dangers of breathing in smoke from conventional cooking methods. However, the affordability and availability of an alternate cooking energy source is a disadvantage for these populations. In India, to prevent, control and reduce air pollution, the government has implemented a variety of legislative measures like the National Clean Air Programme (NCAP) and a Comprehensive Action Plan (Kumari, S., National Clean Air Programme. Critical Analysis, 2019). Persistent and collaborative efforts from several industries like housing, energy, environment, health and rural development are needed to mitigate IAP. While formulating policies, India should follow reasonable and logical principles that consider the ground conditions. Concurrently, effective interventions, beginning with education, a shift in fuel usage and suitable urban architectural methods are required. To improve IAQ in commercial buildings, architects and designers should seriously consider circulation, filtration, sunlight, ventilation and greenery (indoor plants). This will help reduce pollution at its source, while enhancing ventilation and purifying the air. Green buildings and sustainable architecture are known to improve IAQ compared to conventional buildings. It is imperative to take quick action to improve IAQ, as most people spend a maximum amount of time indoors.

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