Commentary

Is the impact of air pollution on lung function moderated by body mass index?

There is a general consensus that air pollution impacts lung functions and respiratory health. An appraisal of studies however, does not find uniform results. While some studies observe the varying degree of adverse effects, others do not. While China and India are highly polluted countries and adverse respiratory effects are expected, countries such as the Netherlands and Sweden which are below 50% of the European Union air quality limits still observe adverse health effects in their population.[1] In Australian children, a reduced forced vital capacity (FVC) of 1.19% per interquartile increase in NO2 was observed. Even a fourfold lower level of the WHO recommended levels of NO2 of 40 μg/m^3 was associated with a 7% lower forced expiratory volume in 1 s (FEV1) *z*-scores.[2] In the prevention and incidence of asthma and mite allergy (PIAMA) birth cohort study, FEV1 was reduced by 2.36% per interquartile increase in PM2.5.[3] Lower pollution levels seem to cause higher adverse effects in some populations while others exposed to higher pollution levels are less affected. This raises the possibility of modifying factors that may mitigate or worsen the effects of air pollution on lung functions and recent evidence confirm that body mass index (BMI) is of critical importance.

Earlier studies have shown that obesity has an important synergistic effect along with air pollution on adverse lung health outcomes. Per interquartile increase in PM2.5 in Chinese children observed a decrease in FVC of 25 ml when BMI was normal, compared to decrease of 120 ml in the obese group.[4]

A German birth cohort study observed that not only overweight and obesity was associated with a 3.37% reduction in FEV1 per quartile increase in NO2 (4.95 mg/m^3), a good marker for traffic-related air pollution but also a 2.89% reduction in FEV1 was observed in children who were underweight.[1] This has major implications for low- and middle-income country's (LMIC's) such as India where due to economic disparities both overweight-obese and underweight are common.

The pathways involved in the synergistic effect of obesity and air pollution on lung functions are not fully clear. It is likely that obesity leads to increased adipokines and pro-inflammatory cytokines such as tumor necrosis factor-alpha and interleukin-6 leading to low-grade systemic inflammation.[5] Adipose tissue can lead to increased activated macrophages in the lungs causing further pulmonary inflammation. Obese individuals have a higher respiratory rate leading to a greater concentration of air pollutants reaching the lungs.[1] Air pollutant exposure leads to oxidative damage to airway epithelium and smooth muscle and can cause varying degrees of pulmonary inflammation.

Although there is strong evidence regarding the synergistic deleterious effects of obesity and air pollution on the lungs, there is less strong but compelling evidence on synergistic deleterious effects of air pollution on the lungs in those who are underweight. A large study evaluating the effect of air pollution on lung functions in children in nearly 8000 children from Delhi and West Bengal observed that underweight children are equally susceptible as obese children. While in a low pollution area (West Bengal), 30% of underweight and 33.3% of obese children had abnormal lung functions, in Delhi, 50.1% of underweight and 55.6% of obese children had low lung functions.[6] The pathways involved are even less clear than the effects of obesity and air pollution on the lungs. Underweight participants have lower concentrations of antioxidants in their blood. They also have higher oxidative stress due to different reasons; their malnutrition in LMIC countries and improper diet and eating disorders in high-income countries.[7]

An important question is whether BMI or air pollution has a greater effect on lung function development. Many studies have not carefully analyzed this important issue, but it is likely that BMI may be more relevant.

Underweight children had the lowest lung functions of all children and thus likely to make them more susceptible to the effects of air pollution. The FEV1 and FVC of underweight children were 3.1 L and 3.5 L, children with normal weight 3.5 L and 4.0 L, and overweight-obese were 3.7 L and 4.4 L in a German birth cohort at 15 years of age.[1] The study by Sundeep *et al*.[8] in the current issue, observed a greater percentage of underweight children in Mysore-Kottayam (45.2%) in comparison to Delhi (23.1%), while overweight children were more common in Delhi (25.1%) in comparison to Mysore-Kottayam (11.9%). Although Delhi has much greater air pollution than Mysore-Kottayam, lower lung functions were observed in children from Mysore-Kottayam. A larger proportion of participants with lower (<80%) FVC and FEV1 were also observed in Mysore-Kottayam (22.0% and 28.3%) versus Delhi (12% and 13.7%).

Future studies are needed to carefully tease out the effects of obesity, being underweight and dose response between different pollutants and its effects on lung growth and development. Studies have evaluated the effects on lung functions for a unit difference in pollutants such as particulate matter or NO2, but not for changes in BMI. What happens when both abnormal BMI (obesity or underweight) is associated with different levels of air pollutants? Is there a strong dose response? Is there additive or synergistic effects? Is there a ceiling effect, which means that after a threshold of obesity or underweight for a given threshold of air pollution, there is no further risk, or does it continue to be linear? If the BMI is improved (weight reduction in obese and weight gain in underweight) what is the mitigation of risk? Advanced statistical methods are needed and these effects are unclear and not evaluated even in studies when sufficient data is collected.

Acknowledgment

DBT-Wellcome Trust India Alliance Team Science Grant IA/TSG/19/1/600026 for Dr. Mahesh PA.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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Submitted: 03-May-2021 **Accepted:** 03-May-2021
Published: 30-Aug-2021

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Access this article online

Quick Response Code:

Website:
www.lungindia.com

DOI:
10.4103/lungindia.lungindia_188_21

How to cite this article: Mahesh PA. Is the impact of air pollution on lung function moderated by body mass index? Lung India 2021;38:489-90.