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Effects of air pollution on the health of children in India

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Abstract
Air pollution contributes substantially to premature mortality and disease burden globally, with a greater impact in low-income and middle-income countries than in high-income countries. India has one of the highest exposure levels to air pollution globally. The major components of air pollution are ambient particulate matter pollution, household air pollution, and to a smaller extent ozone in the troposphere, the lowest layer of atmosphere. In India, the major sources of ambient particulate matter pollution are coal burning for thermal power production, industry emissions, construction activity and brick kilns, transport vehicles, road dust, residential and commercial biomass burning, waste burning, agricultural stubble burning, and diesel generators. Household air pollution is caused mainly by the residential burning of solid fuels for cooking and to some extent heating, the major types of which are wood, dung, agricultural residues, coal, and charcoal. Ground level ambient ozone is produced when nitrogen oxides and volatile organic compounds emitted from transport vehicles, power plants, factories, and other sources react in the presence of sunlight. Rapidly developing countries such as India face the dual challenge of exposures from both ambient and household air pollution. Evidence also suggests that air pollution is a major risk factor for disease burden. We found several previous studies that have estimated subnational variations in ambient particulate matter and household air pollution exposure in India and their contribution to deaths from various causes.

Keywords: Air pollution, disease, burden, household, mortality and globally

Introduction
Children are known to be more vulnerable to the adverse health effects of air pollution due to their higher minute ventilation, immature immune system, involvement in vigorous activities, the longer periods of time they spend outdoors and the continuing development of their lungs during the early postneonatal period. A large number of epidemiological studies have reported an association between exposure to criteria air pollutants and several morbidity and mortality outcomes in children. Criteria air pollutants consist of six air pollutants that are regulated on the basis of their potential to cause adverse health and/or environmental effects: ozone (O_3), particulate matter (PM), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide and lead. In the present commentary, we highlight the adverse health outcomes associated with exposure to criteria air pollutants in children. The purpose of the present article is to inform paediatricians about the current epidemiological evidence on the associations between ambient air pollution and adverse health outcomes in children.

Air pollution contributes substantially to premature mortality and disease burden globally, with a greater impact in low-income and middle-income countries than in high-income countries. India has one of the highest exposure levels to air pollution globally. The major components of air pollution are ambient particulate matter pollution, household air pollution, and to a smaller extent ozone in the troposphere, the lowest layer of atmosphere. In India, the major sources of ambient particulate matter pollution are coal burning for thermal power production, industry emissions, construction activity and brick kilns, transport vehicles, road dust, residential and commercial biomass burning, waste burning, agricultural stubble burning, and diesel generators.

Household air pollution is caused mainly by the residential burning of solid fuels for cooking and to some extent heating, the major types of which are wood, dung, agricultural residues, coal, and charcoal. Ground level ambient ozone is produced when nitrogen oxides and volatile organic compounds emitted from transport vehicles, power plants, factories, and other sources react in the presence of sunlight.

Rapidly developing countries such as India face the dual challenge of exposures from both ambient and household air pollution. Existing evidence suggests that India, with a population of 1·38 billion people living across states at different levels of economic, social, and health development, has one of the highest air pollution levels in the world. Evidence also suggests that air pollution is a major risk factor for disease burden. We found several previous studies that have estimated subnational variations in ambient particulate matter and household air pollution exposure in India and their contribution to deaths from various causes. However, a comprehensive understanding of the variations between the states of India in the exposure to the major components of air pollution, the associated deaths and disease burden, and the impact on life expectancy is not available in a single standardised framework to inform relevant policy interventions commensurate with the situation in each state.

This study provides a comprehensive assessment of the exposure to air pollution and its impact on deaths, disease burden, and life expectancy in every state of India in 2017 using the unified Global Burden of Diseases, Injuries, and Risk Factors Study framework, which includes 359 diseases or injuries and 84 risk factors. Using improved GBD 2017 methods for air pollution. Our findings highlight that 77% of India's population was exposed to an annual population-weighted mean $PM_{2·5}$ greater than 40 μg/m^3 in 2017, which is the level recommended by the National Ambient Air Quality Standards in India, and none of the Indian states met the WHO-recommended criteria of ambient particulate matter air quality of less than 10 μg/m^3. Even with substantial increasing provision of clean cooking fuels in India, more than half of India's population was exposed to household air pollution from solid cooking fuels in 2017. We report that one out of every eight deaths in India in 2017 could be attributed to air pollution. This study shows that India has a higher proportion of global health loss due to air pollution than its proportion of the global population. The findings of this study suggest that the impact of air pollution on deaths and life expectancy in India might be lower than previously estimated, but this impact is still quite substantial.

The high level of air pollution in India is a major public health and development issue that has significant implications for planetary health. There are large variations between the states of India in exposure to ambient particulate matter pollution and household air pollution and the consequent health loss and deaths. Although control of air pollution is needed all over India, the heterogeneity between the states should be taken into account in designing policies and interventions consistent with the magnitude and sources of air pollution in each state. In addition to the existing interventions, concerted multisectoral efforts are needed related to power production, industry, transport, fuel use, urban planning, construction, and agriculture for controlling air pollution in India to mitigate its impact. Public and policy focus on the control of air pollution in India is increasing, which should be sustained to translate this positive trend into effective interventions.

India had a population of 1·38 billion in 2017 spread across 29 states and seven union territories, many of which are as large as some countries and are at varying levels of development, leading to a heterogeneous distribution of health risks and their impact.

The India State-Level Disease Burden Initiative has reported the overall trends of diseases, injuries, and risk factors from 1990 to 2016 for every state of India as part of the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2016, and also detailed trends of some major non-communicable diseases and suicide.

According to these findings, air pollution was the second largest risk factor contributing to disease burden in India after malnutrition in 2016, with an increasing trend in exposure to ambient particulate matter pollution and a decreasing trend in household air pollution.

Review of literature

Review of related literature makes the investigator fully aware with the previous work that has been done. It also provides an opportunity of gaining insight into the method, measures, subject and approaches employed by the other.

Dutta *et al*., (2012) [3] In addition, a limited number of population studies carried out in India corroborate the broader global evidence for the higher incidence of chronic non-communicable respiratory and cardiovascular diseases in India.

Pant *et al*., (2016) [4] This makes the task of understanding the nature and distribution of nationwide population exposures much more difficult. Another important aspect relates to the spectrum of exposures. In India, exposure to locally strong sources such as biomass cooking, trash burning, street food carts, and small industries contribute to large spatial gradients in exposures that are poorly captured by outdoor ambient levels measured at central sites.

Garaga *et al*., (2018) The risk of exposure to air pollution occurs in both rural and urban populations, however, the routine monitoring of air quality, in India and many countries across the globe, is nearly exclusively confined to urban centers.

Methodology

The method used in this paper is descriptive-evaluative method. The study is mainly review based. It is purely supported by secondary source of data, i.e. books, journals, papers and articles and internet.

Result and discussion

Mortality outcomes

Ambient air pollution has been linked to increased mortality in children and adults. Sudden infant death syndrome, a leading cause of postneonatal mortality in India and other developed countries, has been associated with exposure to criteria air pollutants. In a systematic review of the literature on the association between ambient air pollution and infant mortality, Glinianaia *et al*. observed a consistent and significant association between PM and postneonatal mortality due to respiratory causes, as well as sudden infant death syndrome. Other studies have reported a significant relationship between ambient air levels of criteria air pollutants and mortality in children younger than five years of age.

Adverse pregnancy outcomes

Ambient levels of criteria air pollutants have been associated with adverse pregnancy outcomes, including premature birth, low birth weight, intrauterine growth retardation, abnormal birth length, abnormal head circumference and small size for gestational age. However,

no specific trimester has been identified as the most vulnerable period of gestation during which air pollution might be most harmful to the fetus.

Currently, only one study has investigated the effects of ambient air pollution on birth defects. Ritz *et al* observed a significant association between prenatal exposure to carbon monoxide and cardiac ventricular septal defects, while O_3 was associated with an increased risk of aortic artery and valve defects, as well as pulmonary artery and valve defects.

Adverse respiratory health outcomes

Exposure to ambient levels of criteria air pollutants has been associated with several acute and chronic adverse respiratory health effects in both asthmatic and nonasthmatic children, although asthmatic children have been shown to be more susceptible to the adverse health effects of ambient air pollution. Several studies have linked ambient air pollution to an increased prevalence of asthma symptoms, as well as an increased incidence and prevalence of childhood asthma, particularly among children who regularly engage in sporting activities and those with increased asthma medication use, increased asthma emergency department visits and increased hospitalization due to asthma. Other studies have documented an inverse relationship between exposure to criteria air pollutants and lung function in both asthmatic and nonasthmatic children. There is evidence suggesting that current levels of ambient air pollutants may cause deficits in lung function growth in children. Ambient air pollution has been associated with increased reporting of respiratory symptoms among nonasthmatic children, as well as increased respiratory hospital admissions and emergency department visits for children.

School absenteeism

Although the results from epidemiological studies suggest that both short-term and long-term exposure to ambient air pollution may contribute to illness-related school absenteeism, these data are not consistent. Day-to-day changes in the levels of criteria air pollutants (PM_{10}, SO_2, NO_2 and O_3) have been associated with illness-related absenteeism, while short-term changes in O_3 and SO_2 have been linked to respiratory illness-related elementary school absenteeism.

Altered immunity

Exposure to ambient levels of criteria air pollutants has been shown to cause alteration in the immune system in children. Leonardi *et al* studied the impact of ambient air pollution on the immune system of school children between nine and 11 years of age in 17 cities in Europe and found that ambient air pollution may alter both cellular and humoral immunity in children. However, a study conducted in Chile by Ruiz *et al* found no association between ambient air pollution and the humoral immune system in children. Emerging evidence from animal toxicological studies suggest that ambient air pollution may cause suppression of host immunity.

Increased risk of vitamin D-deficiency rickets

In the tropics, children who live in regions with higher levels of ambient air pollution have been shown to be at increased risk of developing vitamin D-deficiency rickets compared with those residing in less polluted areas. The amount of solar radiation in the ultraviolet B range reaching ground level has been found to be inversely related to the level of ambient air pollution (haze). Ultraviolet B radiation emitted by the sun is required for the conversion of 7-dehydrocholesterol to cholecalciferol (vitamin D_3).

Other air pollutants

Although the present article is restricted to the health effects of criteria air pollutants, there are many other toxic air pollutants regularly released into the air that have the potential to harm children. Studies are appearing in the literature identifying potential exposures and health effects. The effects of air pollutants on genetic material are being investigated. Further studies may lead to a better understanding of not only childhood disorders, but possibly adult ones too.

Conclusions

Significant morbidity and mortality in children is attributed to ambient air pollution at great economic cost to society. As our cities grow and our population increases, we need to be aware of air pollution and its effects on children. Further studies are needed in India to improve our understanding of air pollution on the health of children to aide policy-makers in decisions that relate to the sustainability of development. Consideration needs to be given to emerging science on non-regulated pollutants that may be affecting the health of children today and may also be endangering future generations by affecting genetic material.

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