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Air Pollution and Respiratory Health of Children: Focus on India

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ABSTRACT

Ambient air pollution (AAP) and household air pollution (HAP), including second-hand smoke, have been associated with various health problems in humans, globally. The pollution has been estimated to result in 4.2 million deaths annually with corresponding economic losses. Among children, exposure to pollutants increases the risk for respiratory health problems, both acute, such as community-acquired pneumonia (CAP), as well as chronic, such as asthma. CAP results in almost 14% of deaths in children under 5 years of age and HAP increases the odds of acquiring it two-folds. The odds of exacerbation and hospitalization for asthma increase with exposure to AAP in children. With some pollutants, a non-linear increase of morbidity due to asthma with exposure has been deducted. There is a dearth of studies on health effects of AAP/HAP on children from India. The air quality index of most of the Indian cities and rural areas is higher than the recommended safe level of 50. Therefore, strict enforcement of policies to reduce AAP and HAP are needed urgently to achieve the Sustainable Development Goal, more so as pollution causes climate change and climate change and pollutants synergistically have adverse health effects.

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INTRODUCTION

Air pollution, both ambient and indoor/household, have been associated with multiple adverse effects on the health and wellbeing of children as well as adults. Ambient air pollution (AAP) is caused primarily by suspended particulate matter (PM), such as $PM_{2.5}$ and PM_{10}, and gases, like ground-level ozone (O_3), carbon monoxide (CO), sulfur dioxide (SO_2), and nitrogen dioxide (NO_2).[1] Indoor/household air pollution (HAP) is caused by use of biofuels for cooking and heating, building materials, microbes and other biological pollutants such as dust mites and pet dander, etc, household cleaners, CO from air conditioning, indoor PM from second hand smoke and aerosols, pesticides, radon and other volatile organic compounds.[2]

It has been reported in 2020 that the annual global economic burden of pollution is $4.6 trillion, which is about 6.2% of global economic output.[3] About 4.2 million deaths occur each year as a result of exposure to AAP, as estimated in 2018.[4] Of these 68% are due to ischaemic heart disease and stroke, 14% due to chronic obstructive pulmonary disease, and 14 and 4% due to acute lower respiratory infections (ALRI) and lung cancers, respectively. In addition, by the trans-epidermal route, pollutants permeate the skin and also are absorbed through hair follicles and sweat ducts. As a result, there is an increased risk of photoaging, lentigines, melasma, atopic dermatitis/eczema, psoriasis, inflammatory acne and skin cancer.[5] Yet as of 2019, almost all of the population (99%) lives in areas where the air quality is sub-optimal, according to the WHO standards.[1]

Children are at greater risk of adverse respiratory effects of air pollution as compared to adults. As a result of air pollution, they are at a higher risk of acute respiratory infections, asthma and a decrease in lung function. The risk is variable across regions, depending upon climatic conditions, source of pollution and its contents, exposure duration and the age of the child. Prenatal exposure can result in adverse respiratory health in later life due to altered development of the lungs. However, this article will focus on impact of air pollution on certain aspects of the respiratory health of children. Hence this scoping review was done to assess the reported effects of AAP/HAP on community-acquired pneumonia (CAP) and asthma in children in India.

METHODS

For this scoping review Pubmed, Scopus and Google Scholar databases were searched for articles published between the years 2019 and December 2024. The following search strings were used:

a. ((air pollution) AND (asthma)) or (Pneumonia) AND (India) NOT (covid)
b. (ambient air pollution) AND (child) AND (asthma) AND (India)

Relevant articles were identified, read independently and interpreted by two authors (SA and RA).

RESULTS AND INTERPRETATIONS

The results of literature search are given in Table 1

Table 1: Articles on effect of pollution on respiratory health of children published from 2019 to 2024.

String	Number of articles found	Number of articles relevant
((air pollution) AND (asthma)) or (Pneumonia) AND (India) NOT (covid)	2492	5
(ambient air pollution) AND (child) AND (asthma) AND (India)	12	2

Pneumonia

Community-acquired pneumonia (CAP), an acute lower respiratory tract infection (LRTI), contributes to 14% of mortality in children < 5 years of age and 22% in ages 1 to 5 years in 2019.[6] Exposure to AAP and HAP increases the risk of acquiring CAP and contributes to almost half of the morality due to it.[6,7] HAP is due to the incomplete combustion of biomass fuels used for cooking and heating, especially with poor ventilation. Small children have spent large time at home which increases their exposure time.

Asthma

Asthma is the most common chronic disease among children. In a metanalysis which included 33 studies with a sample of 167,626 children, the estimated prevalence of asthma was 7.9%, ranging from 6.3 to 9.6%.[8] Clinical features of asthma are the history of recurrent cough and breathlessness, often aggravated by exercise, exposure to allergen or change of seasons and on auscultation of the chest there could be wheezing. These features are due to the narrowing of airways due to inflammation, reversible constriction of bronchial muscles and mucus production and are recurrent. Incidence as well as exacerbation of asthma increase due to exposure to AAP,[8,9] and there is a corresponding increase in hospitalization for its management.[10,11] There is consequently higher rates of use of reliever and controller medications in asthmatics on exposure to AAP.[11]

In a retrospective observational study, India's National Family Health Survey (NFHS-5, 2019–2021) data was combined with NASA's Global Annual PM2·5 Grids database.[12] Among 224,214 children <5 years of age, associations between key social-environmental factors and respiratory illness were analysed. Data came from 165,561 families living in 29,757 geographic clusters. Throughout India, extremely high annual $PM_{2·5}$ levels were found (median 63·4·g/m^3, IQR 41·9–81·6). There was higher exposure to $PM_{2.5}$ in rural and lower socioeconomic status families. On analysis, increased $PM_{2·5}$ levels were statistically significantly associated with the occurrence of respiratory illness. In generalized additive models, a statistically significant increasing but non-linear relationship was observed between $PM_{2·5}$ and respiratory illness, even at values of 40 μg/m^3. This is below India's National Ambient Air Quality Standards, controlling for social and environmental factors. Hence, the authors interpreted that improving air quality and reducing AAP will result in mortality reduction in children less than 5 years of age due to respiratory illnesses.

Another study from Delhi, India, using geographic information system approach[13] explored the relationship between exposure to $PM_{2.5}$ concentration and air quality index (AQI) with visits of cases with acute respiratory symptoms to the emergency room (ER). Data of ER visits of cases with respiratory symptoms of < 2 weeks was collected from four hospitals from March 2018 to February 2019. Exposure data were obtained from the Delhi Pollution Control Committee. AQI was poor in winter, moderate in summer and satisfactory in monsoon season. Yet there was no day with good AQI (<50). Poor AQI and higher $PM_{2.5}$ of winter months was associated with more cases of acute respiratory ER visits in northwest

Table 2: Health advisory based on air quality index.[16]

Quality	Air Quality Index	Health Advisory
Good	0 to 50	None
Moderate	51 to 100	Sensitive persons to limit prolonged outdoor activities
Unhealthy for Sensitive Groups	101 to 150	Children and people with respiratory disease, such as asthma, to limit prolonged outdoor activities.
Unhealthy	151 to 200	Children and people with respiratory disease, such as asthma, should avoid outdoor exertion; everyone else to limit prolonged outdoor activities.
Very Unhealthy	201 to 300	Children and people with respiratory disease, such as asthma, to avoid outdoor exertion; everyone else should limit outdoor activities.
Hazardous	301 to 500	Everyone to avoid all outdoor physical activity.

regions of Delhi which are highly polluted. Relatively lower $PM_{2.5}$ concentrations were seen in south-west Delhi, which also had fewer ER visits for acute respiratory symptoms. The study demonstrated that regional variations in ER visits could be attributed to variations in PM2.5 concentrations and AQI after taking into consideration the seasonality.

In another research conducted in Mysore, India, a five-year time-series analysis was done to assess the role of AAP in the daily hospitalization of children for asthma.[14] Daily admissions for asthma and wheezing were modelled to assess the effect, both non-linear and additive, of AAP on these admissions, adjusting for confounders. In the study duration 362 cases, half boys, were hospitalised. Their average age was 5.34 years (± 4.66). AAP such as NO_2, $PM_{2.5}$, and NH_3, showed a non-linear association with hospitalization for asthma. Admissions for asthma were increased by 2.42 for a 10% increase in NO_2, more so in boys. For the increase in PM_{10}, a statistically significant linear increase in hospitalizations was seen (Relative risk 1.028; 95% CI: 1.013- 1.043).

Almost 40% of global population, including children, are exposed to HAP.[15] In lower- and middle-income countries (LMIC) like India, almost all children are exposed to $PM_{2.5}$, and in half the cases the levels are above the safe cutoff recommendations of the WHO. AAP and HAP jointly contribute to 1 in 10 deaths out of 600,000 deaths in children <15 years of age.[15]

AQI is a summary measure of eight major pollutants – O_3, causing smog, PM_{10} and $PM_{2.5}$, CO, SO_2, NO_2, ammonia (NH_3) and lead (Pb). The health advisory at various levels of AQI, according to the American Lung association[16] is given in Table 2.

Children exposed to HAP have double the risk of developing LRTI as compared to those who are not[17] AAP exposure also increases risk of developing ALRI.[12-14] Upper as well as lower respiratory infections have been associated with increased ambient PM.[10,18] Increased hospitalizations for pneumonia in children were also observed with short-term exposures to AAP consistently.[19]

It is postulated that air pollutants act on a child's immune system and compromise its ability to counteract pathogens found in the respiratory tract. Healthy alveolar epithelial cell lining releases cytokines and free radicals in response to pathogens.[20,21] As a result inflammatory cells, such as macrophages and phagocytes, are recruited to the site and there are phagocytosis and digestion of pollutants and/or pathogens. Exposure to air pollutants compromises this normal inflammatory mechanism resulting in increased susceptibility to ALRI and asthma.[21]

As reported from India, a study conducted in 10 European cities reported that AAP due to road traffic was found to be associated with 14% of all new cases of childhood asthma and 15% of exacerbations.[15] Children living or attending schools in areas with high AAP suffer from greater incidence and severity of asthma.[13,22]

Use of biomass fuels is responsible for about one-third of air pollution in India and other LMIC. The prospective urban and rural epidemiology study (PURE) in 11 countries, which included India, reports mean level of pollutants in the kitchen to be 450 microgm/m^3. The average pollutant in the living area was 113 microgram/m^3 (95% CI: 102-127). The use of LPG lowers the overall probability of ARI by 5 and 10% in rural areas. It has also been documented that exposure to $PM_{2.5}$ increased the odd's to pulmonary tuberculosis by 4.3 to 5.49.[23]

CONCLUSION

CAP results in 14% of under-five mortality in India and half of this can be attributed to AAP/HAP. To achieve the Sustainable

Development Goal target of under 5 mortalities of 25 per 1000 live births by 2030, reducing the level of pollution and exposure to them will be urgently needed. There will be an overall reduction in incidence and hospitalizations as well as he use of medications for asthma in children. There will be immediate and long-term health benefits, not only to children but to the entire population. For this, awareness campaigns for all stakeholders are needed and formulating, modifying and strict implementation of policies against pollution are required. HAP is also harmful[11,16] and increasing parental awareness about it through education is needed. Within the country, there is a regional divide and within the city's geographic variation in pollution levels. Effective environmental management lessons learned from less polluted areas and countries have to be adapted and implemented in polluted areas. Needless to say, measures giving quick yield are needed for the day. In India, the **Air (Prevention and Control of Pollution) Act of 1981** came into existence aiming to prevent, control, and reduce air pollution. As a part of this act, to ensure implementation, boards at the central and state levels were established. These boards are currently just monitoring pollution levels. To implement the antipollution policies, intersectoral coordination will be needed at the governmental level. Also, further research is needed from India to assess the impact of AAP and HAP on the respiratory health of children focussing on the interaction with climate change.

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