Protecting Child Health From Air Pollution in India

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ABSTRACT

Recent research has underscored the diverse ways in which air pollution detrimentally affects child health in India. Notably, India shoulders one of the highest burdens of mortality of children under five years of age globally due to exposure to air pollution. Distinct mitigation strategies are vital to reduce air pollution exposure and its resultant health burdens among children in India when compared to strategies applicable in the global West. This necessity arises due to the substantial influence of residential combustion of solid fuels, and considerable disparities prevalent among India's population. Addressing these unique challenges requires widespread awareness, community engagement, and sustainable policies. As India embarked on a mission to reduce air pollution, showcasing health benefits linked to interventions is crucial. Augmenting access to health data is equally essential to bolster evidence-based policymaking aimed at reducing the child health burden stemming from air pollution in India.

Keywords: *Ambient and household exposure,Child mortality, Environment, $PM_{2.5}$, Health burden*

INTRODUCTION

Exposure to criteria pollutants such as fine particulate matter less than 2.5 µm in diameter ($PM_{2.5}$), nitrogen dioxide (NO_2), and ozone (O_3) results in various health issues, encompassing morbidity and mortality related to cardiovascular diseases, respiratory diseases, and many other ailments [1,2]. Children under five years of age (U5) are among the most vulnerable groups being impacted by exposure to air pollution due to their developing bodies and immature immune systems [3,4]. In India, the longstanding challenge of poor air quality has had alarming impacts on the health of children [3,5,6]. Despite the implementation of multiple policies intended to mitigate air pollutant emissions, the country grapples with persistently high levels of air pollution. Over the past two decades, i.e., between 2000 and 2018, the population-weighted exposure to ambient $PM_{2.5}$ in India has risen significantly, after which it seems to show a sign of stabilization [7]. This pattern sharply contrasts with the global pattern of improving air quality [8]. Concurrently, NO_2 exposure within India surged by 17% during this timeframe, in contrast to the 10% global decrease. These decreasing global trends are largely attributed to successful policy implementations in the global West and East Asia, contributing to improvements in global air quality [9].

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Where does India stand globally in terms of child health burden attributable to air pollution?

The Global Burden of Disease (GBD) study [2,10], examining the impact of diseases, injuries, and risk factors worldwide, indicates a significant decline in deaths among U5 children due to exposure to $PM_{2.5}$ in India. This rate reduced notably from 418 deaths per 100,000 population in 1990 to 127 deaths per 100,000 population in 2019, primarily driven by a decrease in household air pollution. A recent study revealed that over 11% of worldwide deaths resulting from ambient $PM_{2.5}$ occur among children U5 in India [11]. **Fig. 1*a*** depicts the deaths among children from exposure to ambient $PM_{2.5}$ with data from Chowdhury et al [11]. Comparatively, in the global West and East Asia, this percentage is less than 1%. In African nations like Nigeria and the Democratic Republic of Congo, this percentage rises to over 40% (**Fig. 1*b***). In addition to high ambient $PM_{2.5}$ exposure, due to its sizable population of U5 children (17% of the global total), India contributes to 34% of all deaths in this age group caused by exposure to ambient $PM_{2.5}$.

Though exposure to NO_2 is not included in the current GBD assessments, studies have associated NO_2 exposure with incidences of asthma among children and adolescents [12]. In 2015, exposure to NO_2 was associated with 0.3 million (95% confidence interval 0.17-0.52) cases of asthma among children and adolescents in India. This accounts for 20% of all asthma cases within this age group in the country. Compared to the numbers estimated in

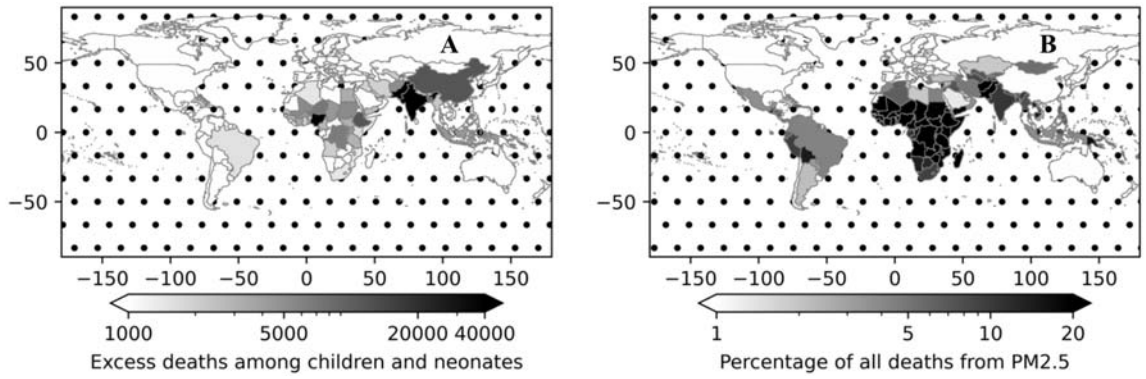

Fig. 1. (*a*) Excess deaths from exposure to ambient $PM_{2.5}$ among U5 children (including neonates). (*b*) Excess deaths among U5 children are expressed as a percentage of all deaths from exposure to ambient $PM_{2.5}$.

India, the incidence of asthma related to NO_2 exposure in Western Europe and the United States was nearly 3 times and 1.5 times lower, respectively.

While the GBD study provides a comprehensive framework for understanding the impact of air pollution on human health, studies in developing countries like India are quite limited. Earlier research lacked robust geospatial data for epidemiological analysis and instead used spatiotemporally coarse pollution measures relying on a handful of ground monitors. These exposure estimates are plagued by the disadvantages of errors and exposure misclassification. As satellite-derived $PM_{2.5}$ prediction models [e.g., 7] have evolved, there has been a gradual shift towards utilizing spatiotemporally resolved ambient exposures. Recently, numerous studies (**Fig. 2**) have established associations between satellite-derived ambient $PM_{2.5}$ data and geo-coded child health data from the National Family Health Survey (NFHS). Simultaneously, studies also explored the association of child health outcomes with household air pollution, thereby producing evidence on child health outcomes such as anemia [5,13,14], stunting [13,15], low birth weight [5,16,17], acute respiratory infection [3,5,18], and even mortality [19-21].

Addressing child health burden attributable to air pollution in India - How is it different?

Children's health in India requires unique attention compared to other regions due to several distinctive factors.

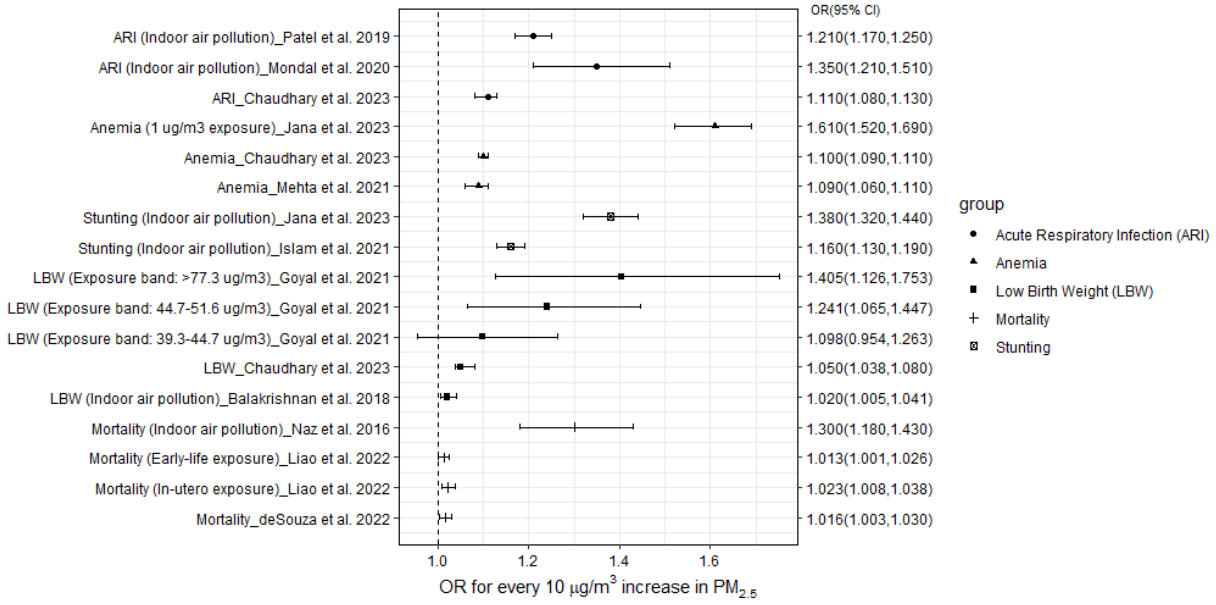

Fig. 2 Forest plot showing the studies that assessed the association between $PM_{2.5}$ exposure and a range of health outcomes among U5 children

Household air pollution is a big problem

All the studies attempted to understand the sectoral contributions to ambient air pollution in India unanimously point towards indoor combustion of solid fuels for cooking, heating, and various household activities as the leading cause of excess deaths associated with ambient $PM_{2.5}$ among U5 children in India [22,23]. These studies indicate a variable range of contributions, from 20 to 50% of total deaths in this age group. Furthermore, this indoor exposure to air pollution adds to the toll, accounting for an estimated 68 (45-96) thousand deaths [2,10]. These figures starkly outweigh the contributions from more common urban sources like transportation, industries, and power generation, which play a dominant role in causing excess deaths related to ambient $PM_{2.5}$ in the global West and East Asia [11]. Likewise, concerning exposure to NO_2, while transportation is the largest contributor to NO_2-related asthma incidences globally, contributing to up to 70% of asthma incidences in North America and Western Europe; the leading source in India is the use of solid fuels within households [12]. These findings underscore the increased significance of social programs such as the Pradhan Mantri Ujjwala Yojana (PMUY) in India.

Social inequality is a major concern

Economic inequalities notably impact children's vulnerability to air pollution and its health effects, particularly in India. Recent studies highlight that families in rural areas and those facing poverty in India have elevated exposure to $PM_{2.5}$, raising the risk of respiratory illnesses in U5 children from disadvantaged socioeconomic backgrounds [24]. Moreover, households with limited resources rely on cheap and easily accessible polluting fuels for cooking and other household activities leading to enhanced indoor air pollution exposure. Children in economically disadvantaged communities encounter difficulties in accessing quality education, which could otherwise raise their awareness about air pollution. In India, over 60% of the child population resides in rural areas, yet the National Clean Air Program (NCAP) primarily focuses on reducing air pollution in selected cities, thus overlooking the significant rural population. An airshed-based approach to encountering major sources of air pollution by region is of utmost importance. Bridging these gaps requires comprehensive approaches that prioritize access to clean energy, healthcare, and education, aiming for equal opportunities for all children regardless of their location or socioeconomic status. Additionally, there is an urgent need for increased data availability to drive comparative research addressing environmental justice concerns.

Lack of India-specific studies on air pollution and health impacts

Health impact assessments are based on exposure-response curves that are developed using data from developed countries, and most importantly, they assume uniform toxicity for all $PM_{2.5}$ species. The counterfactual exposure levels are too low and most likely unattainable for India, given the high background dust [11]. Developing India-specific exposure-response functions and under-standing their sensitivity to sectoral $PM_{2.5}$ is important. For many health outcomes, $PM_{2.5}$ has been considered as the exposure metric. Moreover, health outcomes are the manifestation of exposure to multiple air pollutants (not just $PM_{2.5}$) and their toxicity levels. Chaudhary et al. [5] conducted the sole Indian study assessing the differential effects of $PM_{2.5}$ species on children's health.

There is a need for additional studies of a similar nature, particularly in a cohort setting, which will help in tracing the target emission sector contributing to exposure. Given the increased susceptibility of children to air pollution compared to adults, there is an urgent need to align environmental policies with the national health mission. To advance research on air pollution epidemiology in India, access to health data is crucial.

What are the consequences?

The health hazards among U5 children posed due to in-utero and early-life exposure to air pollution were earlier summarized by Dey [25]. Studies have established that $PM_{2.5}$ can permeate the placental barrier during in-utero exposure, leading to oxidative stress and subsequent changes in the placenta [26]. Oxidative stress and placental inflammation may disrupt the transplacental exchange of nutrients and oxygen, thereby affecting fetal growth. Low birth weight increases the risk of malnutrition [27]. The early life exposure to $PM_{2.5}$ results in compro-mised immunity via oxidative stress and inflammation. Delays in physical development in early childhood can have serious negative long-term consequences for adult life [28]. Air pollution exposure can adversely affect the child's learning outcomes [29], thereby impacting the child's future.

India's National Health Policy (NHP) 2017 has set a target of reducing U5 mortality below 23 deaths per 1000 live births and neonatal mortality below 16 deaths per 1000 live births by 2025. Malnutrition and air pollution are the first and third most important risk factors for child mortality in India [30]. Mitigating air pollution will, therefore, directly and indirectly (by reducing the prevalence of malnutritional outcomes) accelerate India's

progress towards meeting the NHP target.

What should be done?

Despite significant strides made in India's endeavors to decrease U5 child mortality rates through focused interventions and healthcare programs emphasizing maternal and child healthcare services nationwide, the considerable threat stemming from exposure to air pollution tends to be overlooked. These impacts on children are expected to be compounded by global climate change, highlighting the urgent need for policymakers to promptly prioritize and address the mitigation of primary and secondary sources of air pollution.

Minimize exposure in children's primary micro-environments

Efforts aimed at reducing emissions should concentrate on microenvironments where children primarily spend their time, such as homes and schools. Air pollution levels within school premises are notably affected by their proximity to roads and nearby industrial or power plants and are influenced by the presence of green spaces in the vicinity. Research indicates that implementing measures like traffic restrictions, establishing 'school streets' (with traffic bans during school entry and exit times in the immediate school vicinity), or relocating drop-off/pick-up points away from school entrances have the potential to decrease exposure to air pollution in and around schools [31].

Access to clean energy can significantly reduce household $PM_{2.5}$ exposure [32]. The PMUY has effectively disbursed over 90 million Liquefied Petroleum Gas (LPG) connections nationwide, yet ensuring the continued adoption of clean fuels through a sustainable financial model poses an ongoing challenge [33]. However, for accelerated progress, stricter implementation of clean air action plans and technological innovations are the way forward.

Include evidence on children's health in air quality policies

Policy makers and regulatory bodies traditionally do not take impacts on children fully into account while developing guidelines and thresholds for air pollution exposure. Implementing stricter air quality standards aimed specifically at safeguarding children's health in India is crucial in ensuring a healthier environment for their growth and reducing the prevalence of acute and chronic diseases linked to air pollution exposure.

Effective communication and awareness

There is a lack of widespread awareness regarding air pollution that persists in regions beyond major cities in India, particularly in the entire Indo-Gangetic plain, encompassing rural areas. Despite $PM_{2.5}$ levels surpassing national standards, there is a lack of awareness among citizens regarding the adverse effects of air pollution, particularly on children. Physicians could serve as advocates for promoting clean air practices, but many of them lack awareness of the diverse health risks associated with air pollution extending beyond respiratory issues. More effective communication is required to drive behavioral changes at individual and community levels that can accelerate the implementation of policy and technological interventions initiated by the central and state governments.

Access to air pollution and health data

For the rapid progression of air pollution epidemiology research in India, focused capacity-building programs promoting interdisciplinary skills is imperative. In recent years, CAPHER-India (*capherindia.org*) and GeoHealth India (*https://www.ceh.org.in/activities/geohealth/*) networks were created to cater to the skill development needs in air pollution epidemiology. The accessibility to health data also plays a pivotal role in conducting comprehensive studies focusing on air pollution health effects and aids evidence-based policymaking. Health needs to be made an integral part of the NCAP with a broader and enhanced scope to address ambient and household air pollution seamlessly, cutting across the urban-rural transact to protect children from the peril of air pollution.

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