

Impact of Air Pollution on the Respiratory Health of Children with Disabilities: A Study in Delhi NCR

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ABSTRACT: Air pollution continues to pose a critical environmental hazard to urban populations worldwide, with Delhi NCR consistently ranked among the most polluted regions. Among the most adversely affected are street children with special needs, who face compounded vulnerabilities due to physical, mental, or developmental challenges. This study investigates the impact of air pollution on the respiratory health of such children living in the slum areas of Delhi NCR, where exposure to environmental pollutants is exceptionally high. Utilizing a mixed-methods approach, including structured interviews with healthcare providers, direct observations, and secondary data from NGOs and air quality monitoring agencies, the research highlights a strong correlation between chronic exposure to air pollution and increased incidence of respiratory conditions such as asthma, chronic bronchitis, and wheezing. The findings also reveal a critical gap in healthcare access and environmental awareness within these marginalized communities. This paper contributes to the sparse literature at the intersection of disability, poverty, and environmental health, advocating for inclusive public health interventions, targeted policy reforms, and enhanced support mechanisms for this vulnerable demographic.

Keywords: Air pollution, respiratory health, special street children

I. INTRODUCTION:

Air pollution represents one of the most urgent environmental health threats facing the global population today, with profound short- and long-term implications for public health. The World Health Organization (WHO) reports that over 90% of the world's population inhales air that surpasses the organization's recommended pollution thresholds. In developing urban centers, particularly across South Asia, pollution levels have escalated due to rapid industrialization, uncontrolled vehicular emissions, construction dust, biomass burning, and inadequate

regulatory oversight (Chatterjee, 2019). While the adverse effects of air pollution are widespread, certain vulnerable populations are disproportionately impacted.

Children with special needs—those with physical, intellectual, sensory, or developmental disabilities—constitute one such highly vulnerable group. Their susceptibility is magnified when situated in urban slum environments, where access to clean air, potable water, healthcare, and sanitation is alarmingly limited. These children often experience compounded health risks due to both their physiological sensitivities (including weakened immunity and pre-existing respiratory conditions such as asthma and bronchitis) and the hazardous conditions of their living environments. Indoor air pollutants, overcrowding, and poor ventilation further exacerbate their exposure (National Family Health Survey [NFHS-5], 2021).

India's Delhi National Capital Region (NCR) ranks among the most polluted areas globally, with air quality indices consistently breaching safe thresholds. Concentrations of particulate matter (PM_{2.5} and PM₁₀), nitrogen dioxide, sulfur dioxide, and carbon monoxide often remain far above permissible limits throughout the year. Within this region, densely populated urban slums such as Kalyan Puri present particularly alarming conditions. Here, "street special children"—those with disabilities who are homeless or live in temporary shelters—face continuous exposure to toxic air, primarily due to their proximity to vehicular traffic, construction zones, open waste burning, and industrial emissions.

This persistent exposure has been linked to a marked increase in respiratory ailments such as chronic coughing, wheezing, asthma, and other pulmonary disorders. Further complicating their condition is the limited access to medical care, inadequate diagnosis, delayed treatment, and a near absence of rehabilitative support. Contributing socio-environmental factors such as malnutrition,

low caregiver education levels, and entrenched social stigmas result in systemic exclusion of these children from mainstream health and welfare initiatives.

The present study aims to assess the impact of air pollution on the respiratory health of street special children residing in slum areas of Delhi NCR, with a concentrated focus on zones like Kalyan Puri. Employing a mixed-methods approach, the research will examine the correlation between pollution exposure and respiratory morbidity, while also evaluating key social and environmental determinants—such as housing quality, exposure proximity, and healthcare access barriers.

This investigation addresses a critical void in current academic discourse, where the intersection of disability, poverty, and environmental health remains severely underexplored. By shedding light on the compounded vulnerabilities faced by this marginalized group, the study seeks to inform inclusive health policies, catalyze targeted social interventions, and advocate for equitable environmental reforms to protect at-risk children in polluted urban ecosystems.

Overview of air pollution in Delhi NCR: Delhi National Capital Region (NCR) has emerged as one of the most critically polluted metropolitan areas in the world, consistently ranking at the top of global air quality indices for hazardous levels of air pollution (Chatterjee, 2019). The region faces persistent atmospheric degradation driven by a complex interplay of anthropogenic and environmental factors, including rapid urbanization, exponential vehicular growth, industrial emissions, construction dust, and seasonal crop residue burning in neighboring states such as Punjab and Haryana (Dey et al., 2018).

The primary pollutants affecting air quality in Delhi NCR include particulate matter (PM_{2.5} and PM₁₀), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), ozone (O₃), and carbon monoxide (CO), with concentrations often far exceeding the permissible limits set by the Central Pollution Control Board (CPCB) and the World Health Organization (WHO) (Singh & Ghosh, 2020). Seasonal variation plays a crucial role, with winter months experiencing severe pollution episodes due to temperature inversion, stagnant wind patterns, and increased biomass burning.

The region's geographic location, combined with poor urban planning, inadequate public transportation infrastructure, and insufficient

regulatory enforcement, exacerbates the severity of pollution exposure, particularly in vulnerable areas such as urban slums. Additionally, transboundary pollution from surrounding states and long-range transport of dust from arid regions further deteriorate Delhi's air quality on a recurrent basis (Singh & Ghosh, 2020).

Despite various policy interventions such as the National Clean Air Programme (NCAP), the odd-even traffic policy, and short-term bans on construction and firecrackers, the long-term impact of these measures has remained limited.

There remains an urgent need for systemic, multi-scalar strategies that integrate public health, urban planning, and environmental governance to combat the crisis of air pollution in Delhi NCR effectively.

Impact on Children's Respiratory Health:

Children are uniquely susceptible to the adverse effects of air pollution due to their physiological and behavioral characteristics. Their lungs are still developing, they breathe more air per unit body weight than adults, and they spend more time engaging in physical activity outdoors, especially in polluted environments like Delhi NCR. These factors amplify their exposure to harmful airborne pollutants such as PM_{2.5}, PM₁₀, NO₂, SO₂, and ozone (Awasthi et al., 2018).

Studies have consistently demonstrated that exposure to elevated levels of ambient air pollution significantly impairs lung function in children. Verma and Gupta (2019) observed a measurable decline in pulmonary parameters such as Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV₁), and Forced Expiratory Flow (FEF_{25–75}) among school-aged children in Delhi. Their findings revealed a dose-response relationship between pollutant concentration and lung function deterioration, independent of nutrition or socioeconomic status.

Anand (2015) further highlights that children living in urban slums face compounded risks due to poor housing conditions, proximity to vehicular traffic, and limited access to healthcare. These children frequently suffer from chronic bronchitis, asthma, wheezing, and persistent respiratory infections. Undernutrition and pre-existing health disparities exacerbate these effects, leading to more severe and recurrent respiratory episodes.

Awasthi et al. (2018) found that winter months are particularly hazardous, as atmospheric inversions trap pollutants close to the ground, increasing the concentration of harmful particles. This seasonal variation contributes to acute

exacerbations of asthma, bronchial obstruction, and upper respiratory tract infections. Moreover, their study identified that boys and younger children (aged 5–10) are especially vulnerable to air pollution-induced respiratory issues.

The cumulative evidence underscores that prolonged exposure to poor air quality during critical developmental years can result in long-term pulmonary damage, reduced lung growth, and a higher lifetime risk of chronic respiratory diseases. These outcomes are not merely clinical concerns but are indicative of systemic environmental injustice and public health neglect in urban India.

Thus, the impact of air pollution on children's respiratory health is profound, multifaceted, and necessitates immediate, targeted interventions at the policy, community, and healthcare levels to safeguard the health and development of the next generation.

Vulnerability of Street and Special Children: In the vast urban tapestry of India's metropolitan slums, street and special children stand as the most vulnerable cohorts, bearing disproportionate burdens from environmental, social, and economic adversities. Their vulnerability to respiratory health challenges is compounded by a confluence of factors, demanding a multidimensional understanding to formulate effective interventions.

Street children, often homeless and residing in open, unsheltered environments, endure relentless exposure to hazardous air pollutants. The absence of protective indoor spaces exposes them to particulate matter (PM_{2.5}, PM₁₀), nitrogen oxides, and polycyclic aromatic hydrocarbons (PAHs) originating from vehicular emissions, industrial activity, and biomass burning. This persistent exposure, coupled with inadequate nutrition and chronic psychosocial stress, critically undermines their respiratory health, manifesting in elevated incidences of asthma, bronchitis, and diminished lung function. Moreover, their lack of access to healthcare facilities exacerbates untreated respiratory conditions, perpetuating a cycle of morbidity.

Special children—those with developmental disabilities or pre-existing respiratory vulnerabilities—face an augmented risk. Indoor air pollution, frequently intensified by the use of biomass fuels in poorly ventilated homes, disproportionately affects these children by aggravating conditions such as asthma and

bronchopulmonary dysplasia. Their compromised immune systems and physiological immaturity render them less capable of coping with environmental insults. Socioeconomic constraints further limit their access to timely diagnosis, treatment, and preventive care.

The intersectionality of poverty, environmental injustice, and social neglect forms the crux of this vulnerability. Street and special children often reside in neighborhoods where urban planning is deficient, sanitation is poor, and awareness of pollution's health impacts is minimal. These factors converge to deepen respiratory health disparities, calling for innovative policy measures that integrate environmental improvements with robust social support systems.

Strategic interventions must prioritize the provision of clean cooking technologies, enhanced ventilation, mobile healthcare units, and community-based education to empower caregivers and children alike. Recognizing the unique challenges faced by these populations is imperative for achieving equitable respiratory health outcomes, thus transforming vulnerability into resilience through targeted, sustainable action.

Healthcare Access Issues: Healthcare access remains a critical challenge that exacerbates the respiratory health problems faced by street and special children living in urban slums. Despite their heightened vulnerability to pollution-related illnesses, these children often encounter systemic barriers that delay or prevent timely medical care.

Economic hardship significantly restricts the ability of families to afford treatment. Many rely on out-of-pocket payments, lack health insurance, and find public healthcare facilities overcrowded and inadequately resourced to meet their complex needs. Slum healthcare centers frequently suffer from shortages of trained personnel and essential medical supplies, limiting their capacity to address chronic respiratory conditions such as asthma and bronchitis.

Low awareness and limited health literacy within these communities hinder early recognition of symptoms and reduce care-seeking behavior. Caregivers may not fully understand the risks posed by polluted environments or recognize the importance of early intervention, leading to delayed diagnosis and worsening health outcomes. Social stigma and mistrust towards formal healthcare providers also discourage regular visits.

Geographic isolation and poor transportation infrastructure further restrict access to

healthcare. Many slum settlements are located far from well-equipped medical facilities, making it difficult for families to obtain care promptly. For children with disabilities or special health needs, these barriers are even more pronounced due to the scarcity of specialized services.

The healthcare system's lack of integration between environmental health concerns and clinical care limits effective management of pollution-induced respiratory diseases. Screening programs and preventive care targeted at at-risk children are often absent, resulting in underdiagnosis and insufficient follow-up. Preventive measures such as vaccination and regular lung function monitoring remain underutilized.

These challenges reflect deeper socio-political neglect, as public health policies frequently fail to address the specific needs of street and special children. Without targeted, inclusive strategies, health disparities continue to widen.

Effective intervention requires strengthening healthcare infrastructure at the community level, including mobile clinics and deployment of trained community health workers specializing in respiratory health. Public health education campaigns focused on pollution risks and early disease symptoms can empower families to seek timely care. Financial protection mechanisms such as subsidized healthcare and health insurance for vulnerable populations are essential to reduce economic barriers.

II. METHODOLOGY:

The methodology underpinning this research is meticulously structured to address the complex interaction between environmental pollutants and respiratory health outcomes among street special children residing in Delhi NCR slum areas. Recognizing the multifactorial nature of the issue, the study integrates both quantitative measurements and qualitative insights, thereby ensuring a multidimensional examination that captures not only empirical data but also the lived experiences and socio-environmental contexts influencing health vulnerability. The following sections detail the systematic approach undertaken to collect, analyze, and ethically manage data essential for deriving evidence-based conclusions and actionable policy recommendations.

Research Design: The research employs a robust mixed-methods framework that intricately combines quantitative analytical techniques with qualitative exploratory methods to

comprehensively investigate the multifaceted impact of air pollution on the respiratory health of street special children in Delhi NCR slum environments.

The descriptive-analytical design facilitates an in-depth exploration of both environmental exposure metrics and health outcome variables, allowing for a precise correlation analysis between pollutant concentrations and respiratory morbidity among this vulnerable demographic. Emphasis is placed on contextualizing environmental data within socio-economic and infrastructural determinants, thus capturing the layered complexities that shape health risks in these marginalized urban settings. This integrated design also supports triangulation of data, thereby enhancing the validity and reliability of the findings while addressing gaps left by singular methodological approaches.

Study Area and Population: The focus of the study encompasses the slum settlements of Kalyan Puri and surrounding sectors within the Delhi National Capital Region, regions characterized by dense populations, inadequate sanitation infrastructure, and persistently high air pollution indices. These areas were strategically selected due to their documented environmental degradation and a concentrated presence of street special children—defined here as children with developmental disabilities including but not limited to autism spectrum disorder, cerebral palsy, and Down syndrome. These children are disproportionately vulnerable owing to physiological susceptibilities, compromised immune responses, and the cumulative effects of environmental stressors prevalent in slum settings. Detailed demographic profiling, including age distribution, disability type, and socio-economic status, was conducted to ensure accurate characterization of the study population, providing an essential foundation for targeted public health interventions.

Sampling Technique: To ensure statistical representativeness and capture exposure variability, a stratified random sampling protocol was implemented. The stratification criterion was defined by proximity to major sources of ambient pollution such as industrial zones, vehicular highways, and large-scale construction sites, which contribute significantly to particulate and gaseous pollutant loads. Within each stratum, a randomized selection of street special children was undertaken, resulting in a total sample size of 40 participants—from Kalyan Puri, Trilokpuri and from adjacent slum

settlements. This sampling strategy mitigates selection bias and enables comparative analyses across differing environmental gradients, providing nuanced insights into the interplay between pollutant exposure intensity and respiratory health outcomes. Additionally, the sample size was calculated to achieve sufficient statistical power, accommodating potential attrition and ensuring generalizability of results within similar urban contexts.

Data Collection Tools: Data acquisition was multi-pronged, integrating both primary and secondary sources to holistically assess environmental and health parameters.

Interviews: Semi-structured interviews were conducted with a purposive sample of healthcare professionals, including pediatricians, pulmonologists, and community health workers actively engaged in the care of special children within the study locales. These dialogues elicited expert clinical observations, challenges in diagnosis and treatment, and insights into the socio-environmental factors exacerbating respiratory morbidity. The qualitative narratives gathered provided rich, contextualized understanding beyond quantitative indicators.

Observation and Air Quality Monitoring: Direct field observations complemented the health data, focusing on housing conditions, cooking practices, ventilation, and sanitation infrastructure. Air quality was rigorously monitored through portable sensor devices measuring PM_{2.5} and PM₁₀ levels within homes and immediate environments of the participating children. These real-time measurements were cross-validated against official data from the Central Pollution Control Board (CPCB) and regional environmental agencies to ensure accuracy and representativeness of exposure assessment.

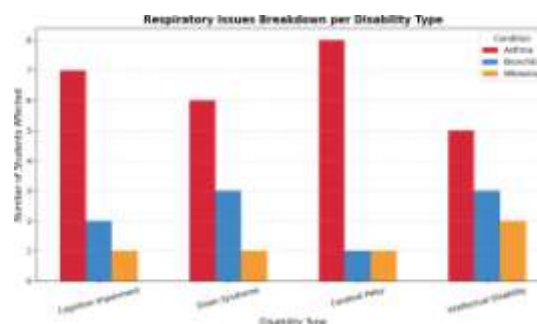
Secondary Data Collection: Extensive review and extraction of medical records from local clinics, hospitals, and NGOs provided longitudinal data on the prevalence and severity of respiratory conditions among the cohort. This was augmented by environmental pollution data encompassing historical and current air quality indices. Integration of these datasets enabled a comprehensive temporal and spatial analysis of health-pollution dynamics.

Ethical Considerations : Adherence to stringent

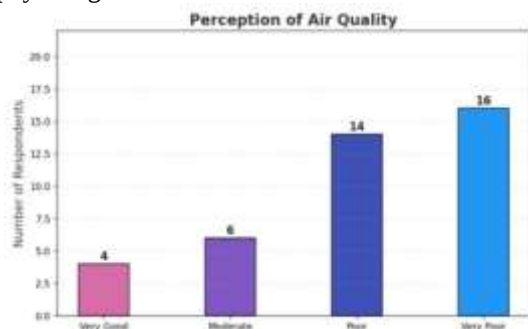
ethical standards was paramount throughout the research process, especially given the involvement of a vulnerable child population. Informed consent protocols were rigorously observed, with detailed explanations provided in the local language to parents or legal guardians, ensuring clarity regarding the study's objectives, procedures, risks, and voluntary nature. Confidentiality was safeguarded through anonymization techniques and secure data storage, protecting participant identities and sensitive health information. The right to withdraw from the study at any time was explicitly communicated without repercussions. All interactions with children were conducted with profound sensitivity, minimizing any psychological or physical distress. Ethical clearance was sought and obtained from an institutional review board, reinforcing the commitment to uphold the highest standards of research integrity and participant welfare.

III. RESULTS:

This study highlights the complex respiratory health landscape faced by children with disabilities residing in urban slums. Respiratory issues such as asthma, bronchitis, and wheezing are prevalent, with a distribution influenced by both the type of disability and the environmental conditions surrounding these vulnerable children. The data reveals that environmental pollution, proximity to hazardous waste sites, and limited access to healthcare significantly exacerbate respiratory morbidity in this population. The frequency of respiratory symptoms varies widely, indicating that while some children experience acute distress regularly, others suffer less frequent but still significant episodes. These findings collectively emphasize the pressing need for targeted healthcare strategies and environmental interventions to address the compounded health risks faced by children with disabilities in resource-poor urban settings. The following graph presents a detailed breakdown of respiratory issues by disability type.



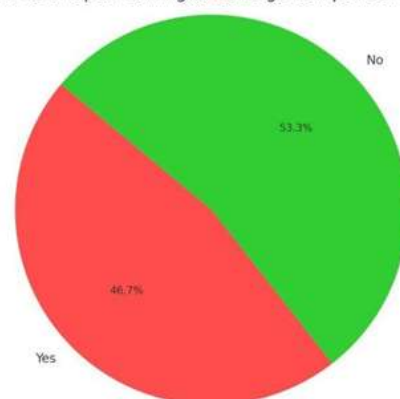
Asthma emerges as the most prevalent respiratory condition across all disability groups, with the highest burden observed among children with cerebral palsy. The intellectual disability group, however, presents a notably diverse pattern—showing not only significant asthma prevalence but also a considerable incidence of bronchitis and wheezing. This suggests multifactorial vulnerabilities, including recurrent infections, limited health literacy, and environmental exposure. The prominence of bronchitis in both Down Syndrome and intellectual disability groups may reflect challenges in airway clearance and susceptibility to inflammation. Wheezing, though less frequently reported, indicates underlying respiratory muscle weakness or delayed symptom recognition. These findings emphasize the necessity for disability-specific respiratory health strategies, encompassing improved diagnostic sensitivity, caregiver training, and adaptive treatment approaches responsive to each group's distinct physiological and communicative needs.



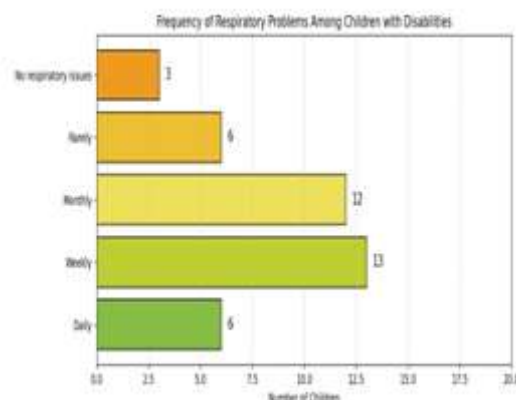
Survey responses regarding air quality perception highlight a divided yet concerning community outlook. While 10% of respondents rated the air quality as very good and 15% as moderate, a significant 75% classified it as poor (35%) or very poor (40%). This skew toward negative perception reflects widespread exposure to substandard environmental conditions and potentially limited health awareness among caregivers. The overwhelming concern about poor air quality underscores the heightened environmental risks faced by children with disabilities. Given their increased physiological vulnerability, even moderate pollutant exposure can exacerbate respiratory complications. These findings stress the urgent need for targeted environmental health interventions and robust community sensitization programs to reduce

exposure and promote protective practices.

Presence of Open Burning or Garbage Dumps Near House



Exposure to pollutants from open burning of waste and garbage dumps is a well-documented contributor to respiratory diseases. In this study, nearly half (46.7%) of the surveyed families live in close proximity to such sources of pollution, significantly increasing the respiratory health risks for children with disabilities. The toxic emissions from these burning sites include particulate matter (PM_{2.5}), carbon monoxide, and other hazardous chemicals known to exacerbate asthma, bronchitis, and wheezing. For children with disabilities, who may have diminished immune defenses and developmental limitations, this environmental hazard represents a critical public health concern. This finding stresses the necessity for policy-level interventions to regulate waste management and reduce environmental health hazards in urban slum areas.



The frequency of respiratory problems among children shows a concerning trend. While only 6.7% reported no issues and 13.3% experienced them rarely, a substantial 80% face recurring symptoms—monthly (26.7%), weekly (28.9%), or daily (13.3%). These frequent

episodes highlight the persistent respiratory burden many children endure, likely driven by prolonged exposure to pollutants and gaps in healthcare accessibility. Recurrent respiratory distress can contribute to long-term health decline, hinder academic participation, and compromise overall well-being. This data emphasizes the pressing need for continuous health surveillance, timely intervention, and disability-sensitive treatment strategies to support vulnerable children in environmentally challenged communities.

IV. CONCLUSION:

This study reveals a compelling portrait of the respiratory health challenges faced by children with disabilities residing in the slum areas of Delhi NCR, where environmental pollution compounds

existing vulnerabilities. The key findings underscore that a significant proportion of these children endure frequent respiratory problems—daily, weekly, or monthly—that are strongly associated with poor air quality, proximity to open burning and garbage dumps, and limited healthcare access. Despite the high prevalence of symptoms, healthcare seeking behavior remains low, and only a minority of children receive appropriate medical treatment. Seasonal variations further exacerbate respiratory distress, particularly during winter and smog episodes, manifesting in increased coughing, fatigue, and breathing difficulties. These insights highlight an urgent need to address both environmental and systemic barriers to improve health outcomes for this marginalized population.

To mitigate these challenges, a multi-pronged policy approach is essential. Policymakers must enforce stricter air pollution control regulations, targeting vehicular emissions, industrial discharges, and open waste burning in urban slums. The introduction of real-time air quality monitoring and public dissemination of data will empower communities to take precautionary measures. Healthcare infrastructures should be strengthened with a disability-sensitive framework—establishing mobile clinics, accessible primary health centers, and specialized training for medical professionals on managing respiratory illnesses in children with disabilities. Social support programs must be expanded to assist families in overcoming financial and logistic barriers to healthcare, ensuring continuity of care and medication adherence. Urban planning must

incorporate inclusive design to create safer living environments with reduced exposure to environmental hazards.

Future research should explore longitudinal health outcomes of children with disabilities exposed to varying levels of pollution, integrating biomarkers and clinical assessments to quantify disease progression. Investigations into the psychosocial impacts of respiratory morbidity, caregiver awareness, and health literacy will provide deeper understanding of barriers to care. Evaluative studies of intervention

programs—including environmental reforms and healthcare delivery models—will be vital to identify best practices and scalable solutions. Collaborative efforts across public health, environmental science, social policy, and community stakeholders are imperative to foster resilient, health-promoting ecosystems for these vulnerable children. Effectively addressing the respiratory health challenges of children with disabilities in Delhi NCR requires a comprehensive approach that integrates environmental improvements, accessible healthcare, and targeted social support, ensuring their well-being and future development are protected.

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