Impact of Environmental Pollution on Children's Lung Health

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ABSTRACT

Environmental pollution poses a significant threat to children's health globally. Children, especially those under five years of age, are highly susceptible to various environmental pollutants—air, water, soil, plastics, and microplastics. Numerous meta-analyses have demonstrated a negative correlation between pollution exposure and child health outcomes. Even low-level exposure impacts fetal development, neurodevelopment (e.g., cognitive deficits, attention disorders, autism), and increases risks of prematurity, low birth weight, respiratory illnesses (e.g., asthma, bronchitis), immune dysfunction, and endocrine disorders.

Nearly 50% of deaths from lower respiratory infections in children under five are linked to particulate matter from indoor air pollution. According to the WHO (2018), 90% of the world's children breathe toxic air, and air pollution accounts for 600,000 deaths annually in those under 15 years. Furthermore, WHO (2022) reported that 17% of pneumonia-related deaths in children were due to ambient air pollution.

This review highlights both the short- and long-term impacts of environmental pollution on children's respiratory health, particularly in children under five, supported by global evidence.

INTRODUCTION

Respiratory illnesses remain a leading cause of mortality among children, particularly those under five. Environmental pollutants are a major contributing factor, accounting for 60% of the more than one million annual pediatric respiratory deaths globally [1]. Key environmental risks include air pollution, contaminated ecosystems, and climate change [1]. While respiratory infections dominate in low-income countries, asthma and allergic diseases are more common in high-income nations.

Pollution and Its Impact

Pollution refers to the excessive presence of harmful substances in the environment that negatively impact human and ecological health [2]. Children are exposed to pollutants via air, water, food, and soil.

Major types include:

- Air pollution
- Water contamination
- Industrial waste
- Soil pollution
- Plastic and microplastic pollution
- Noise pollution

Why Are Children More Vulnerable?

Children's unique physiology and metabolic characteristics increase their vulnerability to pollutants, starting

from the prenatal period. Prolonged lung development—from fetal life through adolescence—makes them especially susceptible to environmental insults.

Key reasons:

- Higher respiratory rate relative to body mass

- Immature immune and detoxification systems

- Incomplete nasal filtration

- More time spent outdoors and closer proximity to ground-level pollutants [3a]

According to WHO, more than 90% of children breathe toxic air daily. In 2016 alone, 600,000 children died from acute lower respiratory infections linked to air pollution [3b].

Lung Development and Pollution Exposure

Lung development occurs in five stages:

1. Embryonic (3–6 weeks) – Formation of primary airways and lobes [4]

2. Pseudoglandular (5–17 weeks) – Development of bronchial tree, cartilage, and vasculature

3. Canalicular (16–25 weeks) – Formation of respiratory bronchioles, early surfactant production

4. Saccular (24 weeks to birth) – Alveolar sac formation; surfactant increases by 32 weeks

5. Alveolar (36 weeks to 8 years) – Postnatal alveolar multiplication and lung maturation

Because lung growth continues until age 8, exposure to pollutants during this period can lead to structural and functional impairment, predisposing children to lifelong respiratory disorders [5].

Air Pollution and Its Respiratory Impact

Air pollution is categorized into:

- Indoor or household air pollution (HAP)

- Outdoor or ambient air pollution (AAP)

Common Pollutants:

- PM2.5, PM10

- Sulfur dioxide (SO_2), Nitrogen dioxide (NO_2)

- Ground-level ozone (O_3)

- Tobacco smoke, dust mites, mold, cooking fumes

Respiratory Conditions Linked to Air Pollution:

- Acute lower respiratory infections (e.g., pneumonia)

- Asthma and allergic rhinitis

- Bronchitis and bronchiolitis

Pneumonia, caused by pathogens like Streptococcus pneumoniae, Haemophilus influenzae, and RSV, is the leading cause of death in children under five. Studies show 44% of these deaths are attributed to HAP [8].

In 2020, of the 3.2 million deaths due to HAP, 237,000 were children under five [8]. AAP exposure led to 286,000 deaths in this group in 2016 alone.

Systematic reviews have linked AAP to increased risks of asthma, pneumonia, hypertension, and impaired lung function in children [9–11]. Oxidative stress from pollution is a major driver of asthma in children [12].

Antenatal Pollution Exposure

The fetal period is a critical window for lung organogenesis. Exposure to pollutants in early pregnancy can disrupt morphogenesis, while late-pregnancy exposure can impair lung function and structure [13,14].

Tobacco Smoke and Pediatric Lung Health

Environmental tobacco smoke (ETS) contains over 4,000 harmful chemicals including heavy metals, cyanide, and known carcinogens. Both prenatal and postnatal ETS exposure are associated with:

- Prematurity and low birth weight

- Impaired lung function

- Increased risk of wheezing, asthma, and ear infections

- Cognitive and behavioral disorders [15–22]

Children may be exposed to ETS at home, in schools, public places, or childcare facilities.

Climate Change and Respiratory Health

Children are highly vulnerable to climate-induced health hazards. Climate change leads to:

- Extreme temperatures, triggering infections and asthma flares

- Increased outdoor air pollutants (O_3, PM2.5) from wildfires, droughts

- Extended pollen seasons exacerbating allergies [23–26]

Plastic Pollution and Lung Impact

Microplastics (<5mm) and nanoplastics (<100nm) are emerging pollutants found in air, water, and soil. These particles can carry adsorbed toxins, which are later released into lung tissue.

Children under five are particularly at risk due to ongoing lung development. Microplastics:

- Deposit in small and large airways depending on size

- Induce oxidative stress, inflammation, and DNA damage

- Contribute to asthma, bronchitis, endocrine disruption, and early puberty [29,30]

CONCLUSION

Children’s developing lungs are especially susceptible to environmental pollutants. Intrauterine and early-life exposure to air pollutants, tobacco smoke, climate-related triggers, and microplastics can have lifelong effects on respiratory health.

Early recognition and intervention are key. Indoor pollution is a significant concern, particularly in children under five who spend more time indoors. The preschool years are the most vulnerable period for acquiring respiratory infections and sustaining permanent lung damage.

Preventive strategies include:

- Public and parental awareness

- Policy-level interventions

- Cleaner technologies

- School and community-based educational programs

Combating environmental pollution requires collective action from families, communities, governments, and NGOs to ensure the respiratory health of future generations.

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