ISSN 2282-0930 • Epidemiology Biostatistics and Public Health - 2025, Volume 20, Issue 1

Air Pollution and the Development of Respiratory Diseases in the Pediatric Age: a Scoping Review

Juan Miguel Pérez Flórez[1], Erwin Hernando Hernández Rincón[2], Paula Andrea García Quinto[1], Diana Marcela Díaz Quijano[3], María del Mar Moreno[2], Samuel David Barbosa Ardila[4]

(1) Universidad de La Sabana, Colombia
(2) Family Medicine and Public Health Department, Universidad de La Sabana, Colombia
(3) Family Medicine and Public Health Department and Epidemiology Department, Universidad de La Sabana, Colombia
(4) Colombian Pediatric Society

CORRESPONDING AUTHOR: *Erwin Hernando Hernández Rincón, Family Medicine and Public Health Department, Universidad de La Sabana, Campus Universitario Puente del Común, Km 7 Autopista Norte de Chía, Colombia. e-mail: erwin.hr@unisabana.edu.co*

SUMMARY

Introduction: Pollution presents a significant danger, especially for children's health since they are more vulnerable to respiratory infections. In low-income countries many diseases result from limited access to health services and poor sanitary conditions, and this associated with exposure to pollutants makes it a relevant issue for public health. This article synthesizes the evidence on the effects of air pollution on respiratory diseases in early childhood.
Materials and Methods: A scoping review was conducted consulting PUBMED and LILACS databases, with studies from 2013 to 2024. A total of 19 articles were used for the present review.
Results: The relevance of $PM_{2.5}$ and other pollutants such as PM_{10}, NO_3 and CO was highlighted, being associated with acute (cough [OR = 1.44 95%CI 1.18-1.77], wheezing [OR = 1.31 95%CI = 1.4-1.65] and pneumonia) and chronic respiratory symptoms (rhinitis, asthma [RR 95% 95%CI 21.3%-73.7%]), affecting lung function during lifetime. In addition, the association between pollution, social determinants, genetics, and prenatal development on child health outcomes was depicted.
Discussion: The review highlights that $PM_{2.5}$ exposure is significantly linked to adverse respiratory outcomes in children and recognizes limitations such as language and database restrictions that might introduce bias. Additional socioeconomic factors like financial stability and literacy also play a role in respiratory health outcomes.
Conclusion: It is imperative to formulate public health policies to address this problem from an interdisciplinary point of view, giving an adequate approach to the different factors that influence the development of respiratory infections in early childhood, especially pollution.

Keywords: Air Pollution, Respiratory Diseases, Asthma, Wheezing, Children

INTRODUCTION

In recent years, the understanding of the real impact of pollution on health and especially on respiratory infections in children has increased. According to data provided by the World Health Organization (WHO), approximately 2.4 billion people worldwide are exposed to levels of pollution that are harmful to health in the domestic context, from the smoke produced by large forest fires during certain times of the year, to the particles released by the combustion of biomass such as firewood, coal, fossil fuels, construction, among others [1].

Air pollution refers to the presence of matter of chemical or biological origin in the air. Among

DOI: 10.54103/2282-0930/28585
Accepted: 24th April 2025

the main substances that make up this group are particulate matter with aerodynamic properties (PM) of 2.5μm ($PM_{2.5}$) and 10μm (PM_{10}), Ozone (O_3), Nitrogen Oxides (NO and NO_2), Sulfur Oxides (SO and SO_3) and Carbon Monoxide (CO) [2] . PM can be as well divided into three different groups according to the size of its particles: $PM_{2.5}$, PM_{10} and Ultra Fine particles (UF) [3]. Many of these pollutants may come from the gases produced by vehicles, power and other sources in combination with sunlight and heat. There is consistent evidence that establishes a relationship between these compounds and the development of respiratory diseases [4].

Children are more susceptible to respiratory infections than adults, their immune system is immature and more exposed to pollution because they have a higher rate of ventilation and oral respiration [5]. The infections that cause the greatest involvement of the respiratory tract in children are viral in 80% of cases, although atypical microorganisms are also relevant [6]. In consequence, during the first 3 years of life, the development of the bacterial microbiota plays a fundamental role in modulating the host's immune response and appears to be affected by exposure to different air pollutants [7].

It has been demonstrated that substances such as $PM_{2.5}$, PM_{10}, sulfides, or nitrites increase respiratory morbidity and contribute to the exacerbation of diseases such as asthma [8]. In addition, air pollutants contribute to the compromise of the respiratory system by promoting a prolonged inflammatory state that predisposes to immunosuppression [9]. Other compounds, such as gasoline can be associated with the development of pneumonia in children, even above the inhalation of $PM_{2.5}$ and PM_{10} [10].

On the other hand, according to information compiled by the United Nations Children's Fund (UNICEF), more than 30% of pneumonia and diarrhea cases occur in low-income countries, populations that share similar characteristics in terms of limited access to health services, nutrition, and poor sanitary conditions [11]. Uncontrolled exposure to air pollutants from biomass combustion is a relevant aspect in the communities of people experiencing poverty, where children living in these households are more likely to inhale substances from biomass combustion smoke and other compounds such as kerosene or butane [12].

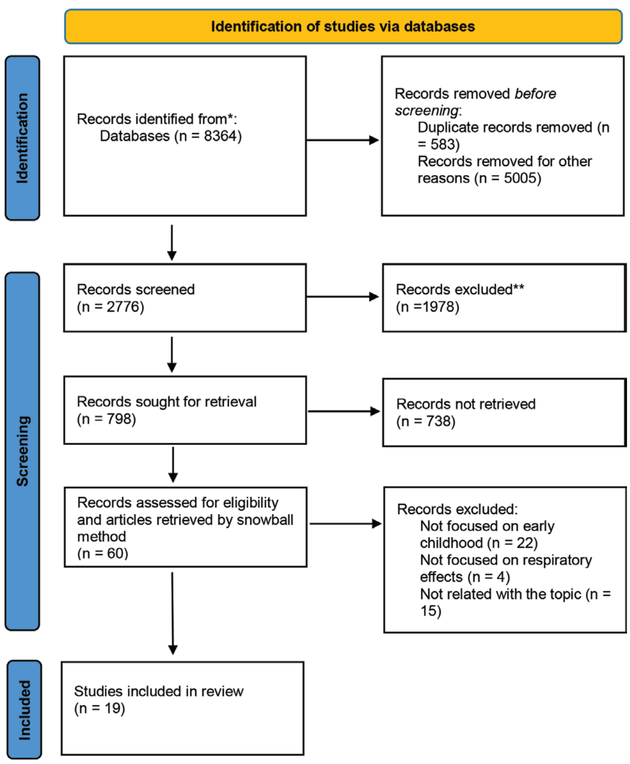
Therefore, the aim of this article is to summarize the available evidence on the effects of air pollution on the development of respiratory diseases in the pediatric age, with special consideration of early childhood (0 to 5 years) [13].

METHODS

A scoping review was carried out on November 2024, for which the PubMed and LILACS databases were consulted. Descriptors and keywords were used to filter the information as follows: MeSH terms: ((("Air Pollution"[Mesh])) AND "Respiratory Diseases" [Mesh]) AND "Children "[Mesh])). In combination with DeCS Terms: (Air Pollution AND Respiratory Diseases AND Children). The result was 8364 articles in total.

As inclusion criteria, articles were considered that included environmental risk factors, especially pollution, in the development of respiratory infections in children, the articles that exposed the effects on children under 5 years of age were preferred due to the reported effect on the development of the respiratory system observed in the first years of life [14]. Studies in English and Spanish were included, with a time limit from 2013 to 2024 to gather the most up-to-date evidence possible. Articles that were not relevant or related to the topic were excluded, also those who exposed consequences of pollution in other body systems (i.e. skin, cardiovascular, nervous), duplicates were eliminated, and the remaining articles were selected according to population and relationship to the defined topic. The evidence was strengthened by including the most relevant articles on this topic using the snowball search method. The choice of articles was made at first by two authors separately and discrepancies were resolved by a third investigator. The quality of the evidenced was assessed according to the criteria of the Joanna Briggs Institute [15] in a prior individual handwritten assessment and were classified according to their methodological rigor and relevance to the research to consider heterogeneity, risk of bias and effects on the findings reported in this study. The selection of articles is presented in Figure 1.

Figure 1. PRISMA diagram of the articles included in the present review. Source: own elaboration for the present study



The PRISMA statement [16] was implemented to synthesize the results found in exploratory systematic reviews (PRISMA-ScR), PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis), and subsequently the steps proposed by Arksey and O'Malley [17] and reviewed by Levac [18] for Scoping reviews were followed, which are based on a) identification of the research question; b) identification of relevant studies; c) selection of studies; d) data extraction; e) synthesis and reporting of results. The research question was answered: What are the main effects of air pollution on the development of respiratory diseases in early childhood?

RESULTS

Once the inclusion and exclusion criteria had been applied, the information was filtered three times by reviewing the title and abstract of the articles. Most of the articles were not focused solely on early childhood and included populations up to 18 years of age, so they were not included. Also, articles in other languages, such as Portuguese, were excluded. On the other hand, an analysis was made of articles that emphasized acute or chronic respiratory outcomes and their correlation with pollution.

Nineteen articles were selected that met the inclusion and exclusion criteria. Of these, 2 were systematic reviews, 4 were cross-sectional observational studies, 4 were cohort studies, 2 were randomized clinical trials and 8 were narrative reviews. Of the included studies, 8 were conducted in America, 9 in Asia, 3 in Europe, 1 in Oceania and 1 in Africa. The characteristics of each of the studies are summarized in Table 1.

Table 1. Characteristics of the articles included in the review. Source: Own elaboration based on research results

Authors	**Year**	**Design**	**Summary**	**Ref**
Kuo Pin Yu, et al	2019	Cohort study	It was found that levels exceeding the permitted levels of $PM_{2.5}$ [HR 93.74%] and PM_{10} [HR 23.34%] in the air are ingested to a greater extent in children under 5 years of age due to their respiratory frequency and increase the risk of presenting respiratory pathologies	[18]
Lulú Zhang, et al	2019	Descriptive Study	It evidenced the settlement of PM along the airways and its proinflammatory and cytotoxic effect on the pulmonary tree of children	[19]
Nathan Lothrop, et al	2017	Observational study	It evidenced the relationship of socioeconomic and housing characteristics with air pollution levels influencing emergency room admissions and hospitalization for lower respiratory diseases and asthma in children under 5 years of age ($p<0.001$).	[20]
Elena Webb, et al	2014	Narrative review	It associated UOG, O3, OM, silica dust, Benzene, and Formaldehyde and the prevalence and incidence of asthma and acute respiratory symptoms [RR 95% 95%CI 21.3%-73.7%]	[21]
Miao-Miao Liu, et al	2013	Cohort study	It evidenced that exposure to highly trafficked roads, factories, or smoking adults increases wheezing [OR = 1.31 95%CI = 1.4-1.65], persistent cough [OR = 1.44 95%CI 1.18-1.77] and persistent phlegm [OR = 1.36 95%CI 1.02-1.81]	[22]
Elizabeth Tam, et al	2016	Cross-sectional study	Demonstrated association between increased respiratory disease in children not diagnosed with asthma and exposure to acidic areas or frequent exposure	[23]

(*continued*)

Table 1. Characteristics of the articles included in the review. Source: Own elaboration based on research results (continued)

Authors	Year	Design	Summary	Ref
Torie L Grant, Robert Wood	2022	Narrative review	It was found that children residing in areas with high concentrations of allergens from pests, tobacco smoke, PM, and NO_2 had higher respiratory morbidity.	[24]
Rhonda Spencer-Hwang, et al	2016	Cross-sectional study	It showed that children from schools near the railroad have more adverse respiratory symptoms [PR = 1.59 95%CI 1.19-2.21].	[25]
Chua Poh Choo y Juliana Jalaluddin	2014	Narrative review	Prolonged exposure to indoor pollution increases the onset of respiratory increases the occurrence of respiratory diseases due to an increase in PM_{10} ($p<0.05$).	[26]
Ethan Walker, et al	2022	Randomized trial	No difference was observed between the use [OR = 11.7% higher 95%CI 16.57-49.72] or not of air filters [OR = 6.96 lower 95%CI 30.50-24.55] and the decrease in respiratory pathology.	[27]
Chinatsu Nishida and Kazuhiro Yatera	2022	Narrative review	It demonstrated the negative relationship between exposure to air pollutants such as $PM_{2.5}$, PM_{10}, SO_2, NO_2, O_3, CO, reactive aromatic hydrocarbons, and VOC and their impact on the incidence and prevalence of lung diseases.	[28]
Tun Z Maung, et al	2022	Systematic review	It was shown that children exposed to higher concentrations of air pollutants have more respiratory symptoms than their rural counterparts	[29]
Lifang Liu, Jingxuan Ma, Shan Shan Peng, Linshen Xie	2023	Narrative review	A relationship is described between prenatal and early childhood exposure to urban traffic pollution and the risk of developing allergic rhinitis in early life	[30]
Wei Liu, et al	2016	Retrospective cohort and multicenter cross-sectional study	It proved the relationship between exposure from gestational age and early childhood to air pollutants such as SO_2, NO_2, and PM with the occurrence of childhood asthma [OR = 1-77 95%CI 1-29-2.43] and allergic rhinitis [OR = 1.67 95%CI 1-067-2.61]	[31]
Patrick L Kinney, et al	2021	Randomized trial	It showed that an increase of 1 ppm CO in the environment increases by 6% [RR 1.06 95%CI 0.99-1.13] the risk of pneumonia and 10% of severe pneumonia in children under 1 year of age [RR 1.10 95%CI 1.04-1.16]	[32]

(*continued*)

Table 1. Characteristics of the articles included in the review. Source: Own elaboration based on research results (continued)

Authors	Year	Design	Summary	Ref
Helena Teresinha Mocelin, Gilberto Bueno Fischer y Andrés Bush	2021	Narrative review	Evidence of the susceptibility of lung tissue from gestational age and in early life to environmental pollutants and their consequences on long-term respiratory health	[33]
Francesca Mastorci, Nunzia Linzalone, Lamia Ait Ali, Alessandro Pingitore	2021	Narrative review	Demonstrated the effects of endocrine disrupting chemicals found in water, air, or by direct contact chemicals from the prenatal period and early childhood, which alters the development of multiple pathologies including respiratory	[34]
Michela Deolmi, et al	2023	Systematic review	There is evidence that pollutants may predispose to lung diseases during development and in adulthood such as asthma and COPD	[35]
Jelte Kelchtermans y Hakon Hakonarson	2022	Narrative review	Genetic variants were found to influence defenses against oxidative stress and increase sensitivity to AAP and the development of asthma in children	[36]

The studies focused mainly on the health effects that could be generated by exposure to different pollutants found in the environment in early childhood. In this sense, some studies mention the most frequently studied substances such as $PM_{2.5}$, PM_{10}, NO_2, and SO_2 [19–21], although other pollutants with special relevance in generating damage to the pulmonary parenchyma such as benzene, formaldehyde [22], carbon monoxide, volatile compounds [23] and even acid vapors released by volcanic activity [24] were also studied. One study depicted the effects of outdoor pollutants such as pollen from grass, weed and trees or seasonal fungi spores [25]. The main effects of exposure to these pollutants are shown in Table 2. In general, the studies agreed in concluding that, of all these, the compound that has the most deleterious effects on the respiratory system is $PM_{2.5}$ [19–21,26].

Although $PM_{2.5}$ is not the most toxic of the pollutants studied, its presence was documented in most of the emissions related to human activity, and it was found that exposure over a longer period can lead to worse health outcomes in children than exposure to much more hazardous compounds [20].

Among the effects, most studies evaluated short and medium-term outcomes with the development of respiratory diseases in their acute phase such as allergic rhinitis or wheezing [19,23,27,28], although impacts on predisposition to respiratory diseases that usually affect the adult population were also described [29–31]. It is noteworthy to mention that studies documented a substantial alteration in respiratory capacity through pulmonary function tests or self-administered surveys [19,24,27,32].

Air pollution and its impact on epigenetics

Pollutants are an irritant to the airways, $PM_{2.5}$ and PM_{10} have been shown to generate a decrease in forced expiratory volume in one second (FEV1) due to the production of lung injury by oxidative stress and local inflammation [22]. Air pollutants, especially $PM_{2.5}$ are associated with increased oxidative stress and impact on the epigenetic control of lung cells [32,33]. These changes have even led to the description of more than 14 genetic variations that produce sensitivity to pollution by producing the respiratory inflammatory-irritative programming effect and therefore could contribute to the development of asthma [34]. The summary of the effects concerning its contaminant are shown in Table 2.

Tracking the influence of pollution to prenatal era

Pregnancy constitutes a risk group when addressing the air pollution exposure, a study evaluated the kinetic behavior of chemical compounds released into the environment because of industrial activities, finding that naphthalene has a higher rate of bioaccumulation in the placenta of pregnant women [35]. Other studies described the effects of exposure to contaminants from intrauterine life, finding a direct influence on the alteration of pulmonary function by increasing the risk of prematurity, low birth weight, or Intrauterine Growth Restriction (IUGR) [31]. One cross-sectional study performed in China, observed the effects of the exposition to SO_2, NO_2 and PM_{10} during pregnancy, encountering an influence form NO_2 in the development of allergic diseases such as eczema, rhinitis and asthma during the early childhood [OR = 1.20 95%CI = 1.02-1.41] [28].

Table 2. Air pollutants and their effects on the development of respiratory diseases in early childhood. Source: own elaboration based on references [21,22,24,25,27–31]

Pollutant compund	Effect
$PM_{2.5}$	• Increases the risk of asthma [21] • Decreases forced expiratory volume in the first second (FEV1) [21] • Increases cough [22] • Contributes to the development of lower respiratory tract infections [24] • Increases asthma exacerbation [27] • Decreases overall lung function [25,29] • Increases the risk of allergic rhinitis [30]
PM_{10}	• Produces persistent cough, wheezing, and phlegm [26] • Increases respiratory symptoms such as cough, rhinorrhea, odynophagia, and wheezing [25] • Increases risk of allergic rhinitis (30]
O_3	• Decreases pulmonary function [21] • Produces more severe allergic responses [28]
CO	• Increases odynophagia, cough, or flu and produces exacerbation of asthma symptoms [22] • Increases risk of allergic rhinitis [30] • Increases risk of severe pneumonia in the first year of life [32]
Formaldehyde	• Produces respiratory distress and decreases lung function [21]
Benzene	• Increases coughing, wheezing, bronchitis and asthma [21]
NO_2	• Increases risk of allergic rhinitis [26,30] • Produces more severe allergic reactions [28] • Increases the risk of developing asthma, allergic rhinitis, and pneumonia [31]
$NO_2 + PM_{10}$	• Increases risk of pneumonia in the first 3 years of life [31]
SO_2	• Produces more severe allergic reactions [28] • Increases risk of developing asthma, allergic rhinitis, and pneumonia [31]
$SO_2 + NO_2$	• Increases the risk of pneumonia [31]

Air pollution and respiratory tract symptoms

A direct impact on exposure to pollutants derived from human action (gasoline combustion, factory emissions, painting, cooking with wood or other biomass) has been described with the development of upper respiratory symptoms such as allergic rhinitis [29], cough [20], odynophagia [27] or influenza [23]. A systematic review conducted in China found that exposure to high levels of traffic-related pollution ($PM_{2.5}$, PM_{10}, NO_2, and CO) in the first year of life is associated with the development of allergic rhinitis [36].

On the other hand, contact with these substances is associated with increased morbidity from respiratory tract infections in children ($PM_{2.5}$ [HR 93.74%] and PM_{10} [HR 23.34%]). Moreover, a cross-sectional study conducted in this same country during two different seasons (winter and summer) showed that PM_{10} contributed to coughing and wheezing cases by 33% (without heating) and 67% (without) [*ER coughing and wheezing: 0.186 95%CI = 0.092-0.277], whereas O_3 was associated with cough and wheeze cases by 13% (with heating) and 87% (without heating) [ER cough: 0.02 95%CI -0.019-0.222 and wheeze: 0.016 95%CI = -0.043-0.081] [20].

[*ER stands for: *exposure response coefficient* (unit: cases/(year-person-μg/m^3)]

In addition, the relationship between exposure to material released from pollution effects such as $PM_{2.5}$, PM_{10}, NO_2, and SO_2, among others, and the development of lower respiratory tract diseases has been widely demonstrated. An observational study conducted in Hawaii evaluated the impact of pollution and volcanic emissions on lung health, finding that 20% of the patients studied had a diagnosis of asthma [24]. Substances such as benzene and formaldehyde have shown a strong association with the development of asthma [OR = 2.03, 95%CI 0.80-5.11] and bronchitis [OR = 10 95%CI 1.045-161.7] [18].

Exposure to SO_2, NO_2, and PM was associated with an increased risk of developing asthma, allergic rhinitis, and pneumonia; a cohort study in China showed that exposure to NO_2 during the first year of life increased the risk of developing asthma [37]. In addition, a systematic review found that high levels of volatile compounds and carbon monoxide (CO) were related to a worsening of asthma symptoms, especially in those children who reside near factories [23].

Another important relationship described is between the inhalation of environmental pollutants and the development of pneumonia, a factor that will be fundamental depending on the time the child has been exposed to the substances. In a study conducted with preschool children in Shanghai, the development of pneumonia was associated with exposure to the mixture between SO_2 and NO_2 during gestation and the mixture between NO_2 and PM_{10} during the first 3 years of life [37].

In addition, a randomized clinical trial in Ghana demonstrated that the estimated risk of pneumonia and severe pneumonia in the first year of life increased by 10% [RR 1.10; 95%CI, 1.04-1.16] and 15% {RR 1.15; 95%CI, 1.03-1. 28], respectively, for each one part per million (ppm) increase in average prenatal carbon monoxide (CO) exposure, and by 6% [RR 1.06; 95%CI, 0.99-1.13] for each 1 ppm increase in average postnatal CO exposure [38]. A narrative review described the effect of $PM_{2.5}$ on respiratory health in children, arguing that an exposure of 25 μg/m3 per day over 6 days is sufficient to contribute to the development of lower tract respiratory infections [26].

The long-term effects on lung function have been widely described, with a narrative review finding that 11% of asthmatic children with abnormal lung function had fixed lung obstruction in adulthood, which speaks of the long-term impact of exposure to these substances [30].

Air pollution and Social Determinants of Health

In the reviewed literature, there is a clear trend that suggests the relationship between social determinants of health, the exposure to air pollutants, and consequently the development of respiratory diseases [27,29,39]. An observational study conducted in southern Arizona showed that there is a complex multifactorial relationship between asthma and lower tract infections as they are determined by multiple geographic, socioeconomic, and even housing factors, such as the use of gas heaters [IRR = 0.98 95%CI = 0.95-1.0] and residence in trailer homes [IRR = 1.03 95%CI = 0.99-1.08] [21]. Exposure to pollutants is not the only factor influencing the development of respiratory diseases; other geographical, demographic, or economic aspects are also relevant. A cross-sectional study conducted in California showed that 59% of children living near the railroad had a decrease in lung function compared to those in the control group. As well as chronic cough and wheezing were more frequent in the group studied [27].

The scientific literature supports the association between indoor allergens (allergens from cockroaches, mice, pet hair) and outdoor allergens (PM, NO_2, traffic-related pollution, second-hand tobacco smoke) with social determinants (poverty, poor living conditions, obesity, chronic stress) that lead to an increase in the incidence of asthma and its exacerbations with a consequent decrease in the control of the disease and as a consequence a decrease in lung function [26]. Furthermore, household and outdoor pollutants, including O_3, CO, NO_2, SO_2, PM_{10}, $PM_{2.5}$, dust mites, pollen, pet dander, and smoke, have been shown to contribute to more severe allergic responses [31]. A cross-sectional study conducted in Australia, demonstrated that spores of Alternaria spp., a fungus, was associated with episodes of exacerbation of asthma in boys [OR = 1.02 95%CI 1.00-1.04] [25].

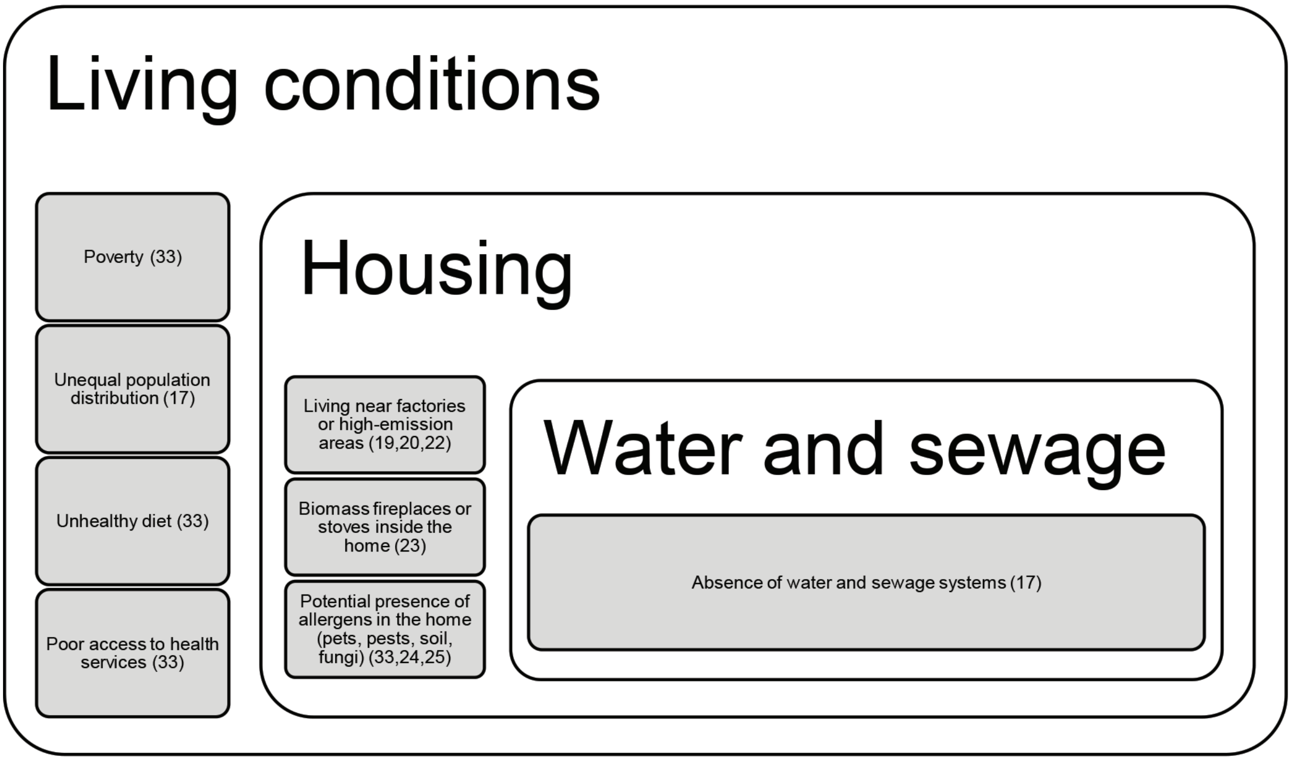
Children born in disadvantaged environments are more likely to be exposed to polycyclic aromatic hydrocarbons such as coal, oil, gasoline, garbage, and organic substances (tobacco, grilled meat), especially in the prenatal period. A 2022 narrative review described that nutritional factors also play a key role. Diet can mitigate or promote the negative effects of exposure to pollutants, as demonstrated by the animal model with lycopene, an antioxidant presents in foods such as tomatoes [39]. Other protective nutrients include iron and zinc. Although more research is needed, it is suggested that psychosocial factors, especially in early childhood, may also play a role. The effects of pollutants can have immediate but also long-term impacts on children's health, even from the prenatal stage, alterations in birth to early childhood outcomes have been described [40]. A general overview of the interaction between different Social Determinants of Health and its potential relation with exposition to air pollutants is presented in Figure 2.

DISCUSSION

The scientific literature gathered in this article demonstrated that, of the most frequently described substances, $PM_{2.5}$ was of relevance in being associated with both acute and chronic adverse pulmonary outcomes. A study conducted in Mexico City from 2006 to 2012 showed that $PM_{2.5}$ exposure is a risk factor for the development of acute respiratory symptoms [43]. Furthermore, a systematic review showed that exposure to this substance increased respiratory mortality by 1.10% for every 10 μg/m3 increase in $PM_{2.5}$ [44]. The effects of this pollutant, as previously mentioned, despite not being the most toxic of the compounds evidenced, produce a much more harmful effect on the health of children since it is a waste produced by most air pollutant emissions. However, other elements should be considered as they are also released in many of the emissions analyzed, including PM_{10} and even O_3. The ESCALA study, a multicenter study to evaluate mortality due to pollution in Latin America in children, found that these substances had an impact on the increased risk of mortality when they were above the standard levels described in the literature [45].

The exposed review also opens the panorama on other factors that are aligned with increased morbidity and mortality in respiratory diseases in preschool children. Disease is a complex interaction between multiple factors and thus we can see that exposure to pollutants is only one of the many determinants that can influence the development of respiratory diseases during childhood and into adulthood. A retrospective study conducted in Nebraska from 2016 to 2019 showed that in addition to exposure to environmental pollutants, financial stability, and

Figure 2. Diagram of the interaction of the Social Determinants of Health that interact with pollution in the development of respiratory diseases. Source: own elaboration based on references [21,23–25,27,29,31,34,39]



literacy played a determining role in the number of cases of children who had asthmatic attacks requiring medical attention [46].

Regarding lung development, it has been described that the most important structural maturation of the lung occurs in embryonic life. However, from birth to the transition to adulthood, the infant lung undergoes a process of constant transformation in alveolar recruitment and microvasculature [41]. This process can be affected by multiple factors, not only exposure to toxic agents from air pollution, but a prospective observational study also conducted in Great Britain showed that children of underweight mothers, infants with low weight for gestational age and higher fat percentage of their total body weight had decreased lung capacity at 4 and 7 years of follow-up [42].

One of the limitations that can be taken into consideration is that the scope for articles was limited to a span of 11 years (from 2013 to 2024), this is due to the interest in proposing associations supported by the most up-to-date literature. However, this situation could have led to leaving literature with relevant information to delve deeper into the effects produced by pollutants and increase the risk of bias. In addition, the fact of only including articles in English and Spanish leaves out valuable information that has been published in different languages. Finally, the use of only three databases to extract the articles used in this review could have generated information bias, since important evidence contained in other databases could not be accessed.

CONCLUSION

Knowing the consequences of inhaling these inert materials should urge decision-makers to take concrete actions to decrease the burden of these compounds on the environment. Disease is a complex multifactorial interaction, respiratory diseases in childhood are impacted by the interaction between different circumstances. Understanding the interaction of the different factors involved in the development of respiratory diseases will also lead to the formulation of comprehensive policies with a person-centered view and the maintenance of their health.

DECLARATION OF GENERATIVE AI

OpenAI's artificial intelligence software ChatGPT 4.0 and Microsoft Copilot were used to review the writing and proofread the style of this article to ensure clarity, coherence, and accuracy in the presentation of the results. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

FUNDING

Project sponsored by code MED-234-2023 by Universidad de La Sabana, Colombia.

AUTHORSHIP CONTRIBUTION

This research holds local relevance and was designed and conducted in consideration of local communities to ensure that it addresses specific regional concerns according to the TRUST Code guidelines [47]. Local ethics review was sought to ensure compliance with regional ethical standards. Special measures were implemented to safeguard participants from discrimination, incrimination, or health risks associated with the elaboration of this review. Cultural sensitivities were proactively explored to avoid any inadvertent offense.

As per the ICMJE Guidelines [48] contributors meeting the authorship requirements have been duly listed as authors. The authors JP, PG, and EH were involved in the collection, filtering, curation, and selection of information, as well as in writing the text. The article was reviewed and corrected by all authors, incorporating perspectives from their respective areas of practice. All research was conducted to the highest possible ethical standards, irrespective of local requirements, emphasizing the commitment to ethical integrity throughout the study. All authors read and approved the final version of the manuscript.

REFERENCES

1. World Health Organization. WHO. 2019 [cited 2024 Oct 20]. Air pollution. Available from: https://www.who.int/health-topics/air-pollution#tab=tab_1
2. Dondi A, Carbone C, Manieri E, Zama D, Del Bono C, Betti L, et al. Outdoor Air Pollution and Childhood Respiratory Disease: The Role of Oxidative Stress. Int J Mol Sci. 2023 Feb 22;24(5):4345.
3. Kurt OK, Zhang J, Pinkerton KE. Pulmonary health effects of air pollution. Curr Opin Pulm Med. 2016 Mar;22(2):138–43.
4. Behinaein P, Hutchings H, Knapp T, Okereke IC. The growing impact of air quality on lung-related illness: a narrative review. J Thorac Dis. 2023 Sep;15(9):5055–63.
5. He M, Zhong Y, Chen Y, Zhong N, Lai K. Association of short-term exposure to air pollution with emergency visits for respiratory diseases in children. iScience. 2022 Sep;25(9):104879.
6. Zhang D, Li Y, Chen Q, Jiang Y, Chu C, Ding Y, et al. The relationship between air quality and respiratory pathogens among children in Suzhou City. Ital J Pediatr. 2019 Dec 23;45(1):123.
7. Wang H, Dai W, Feng X, Zhou Q, Wang H, Yang Y, et al. Microbiota Composition in Upper Respiratory Tracts of Healthy Children in Shenzhen, China, Differed with Respiratory Sites and Ages. Biomed Res Int. 2018 Jun 14;2018:1–8.
8. Kim J. Ambient Air Pollution: Health Hazards to Children. Pediatrics. 2004 Dec 1;114(6):1699–707.
9. Aithal SS, Sachdeva I, Kurmi OP. Air quality and respiratory health in children. Breathe. 2023 Jun 13;19(2):230040.
10. Adaji EE, Ekezie W, Clifford M, Phalkey R. Understanding the effect of indoor air pollution on pneumonia in children under 5 in low- and middle-income countries: a systematic review of evidence. Environmental Science and Pollution Research. 2019 Feb 19;26(4):3208–25.
11. United Nations Children's Fund (UNICEF). One is too many [Internet]. NewYork; 2016 Nov [cited 2024 Oct 20]. Available from: https://data.unicef.org/resources/one-many-ending-child-deaths-pneumonia-diarrhoea/
12. Emmelin A, Wall S. Indoor Air Pollution. Chest. 2007 Nov;132(5):1615–23.
13. United Nations Children's Fund (UNICEF). Early Moments Matter for every child [Internet]. NewYork; 2017 Sep [cited 2024 Oct 20]. Available from: https://www.unicef.org/sites/default/files/press-releases/glo-media-UNICEF_Early_Moments_Matter_for_Every_Child_report.pdf
14. Stocks J, Sonnappa S. Early life influences on the development of chronic obstructive pulmonary disease. Ther Adv Respir Dis. 2013 Jun 25;7(3):161–73.
15. Peters MD, Godfrey C, McInerney P, Munn Z, Tricco AC, Khalil H. Scoping reviews. In: JBI Manual for Evidence Synthesis. JBI; 2024.
16. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med. 2018 Oct 2;169(7):467–73.
17. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol. 2005 Feb;8(1):19–32.
18. Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. Implementation Science. 2010 Dec 20;5(1):69.
19. Yu KP, Lee YC, Chen YC, Gong JY, Tsai MH. Evaluation of PM 1 , PM 2.5 , and PM 10 exposure and the resultant health risk of preschool children and their caregivers. Journal of Environmental Science and Health, Part A. 2019 Aug 24;54(10):961–71.
20. Zhang L, Morisaki H, Wei Y, Li Z, Yang L, Zhou Q, et al. Characteristics of air pollutants inside and outside a primary school classroom in Beijing and respiratory health impact on children. Environmental Pollution. 2019 Dec;255:113147.
21. Lothrop N, Hussaini K, Billheimer D, Beamer P. Community-level characteristics and environmental factors of child respiratory illnesses in Southern Arizona. BMC Public Health. 2017 Dec 25;17(1):516.
22. Webb E, Hays J, Dyrszka L, Rodriguez B, Cox C, Huffling K, et al. Potential hazards of air pollutant emissions from unconventional oil and natural gas operations on the respiratory health of children and infants. Rev Environ Health. 2016 Jun 1;31(2).
23. Liu MM, Wang D, Zhao Y, Liu YQ, Huang MM, Liu Y, et al. Effects of Outdoor and Indoor Air Pollution on Respiratory Health of Chinese Children from 50 Kindergartens. J Epidemiol. 2013;23(4):280–7.
24. Tam E, Miike R, Labrenz S, Sutton AJ, Elias T, Davis J, et al. Volcanic air pollution over the Island of Hawai'i: Emissions, dispersal, and composition. Association with respiratory symptoms and lung function

in Hawai'i Island school children. Environ Int. 2016 Jul;92–93:543–52.
25. Batra M, Vicendese D, Newbigin E, Lambert K a, Tang M, Abramson MJ, et al. The association between outdoor allergens – pollen, fungal spore season and high asthma admission days in children and adolescents. Int J Environ Health Res. 2022 Jun 3;32(6):1393–402.
26. Grant TL, Wood RA. The influence of urban exposures and residence on childhood asthma. Pediatric Allergy and Immunology. 2022 May 24;33(5).
27. Spencer-Hwang R, Soret S, Knutsen S, Shavlik D, Ghamsary M, Beeson WL, et al. Respiratory Health Risks for Children Living Near a Major Railyard. J Community Health. 2015 Oct 19;40(5): 1015–23.
28. Deng Q, Lu C, Li Y, Sundell J, Dan Norbäck. Exposure to outdoor air pollution during trimesters of pregnancy and childhood asthma, allergic rhinitis, and eczema. Environ Res. 2016 Oct 1;150:119–27.
29. Choo CP, Jalaludin J. An overview of indoor air quality and its impact on respiratory health among Malaysian school-aged children. Rev Environ Health. 2015 Mar 1;30(1):9–18.
30. Walker ES, Semmens EO, Belcourt A, Boyer BB, Erdei E, Graham J, et al. Efficacy of Air Filtration and Education Interventions on Indoor Fine Particulate Matter and Child Lower Respiratory Tract Infections among Rural U.S. Homes Heated with Wood Stoves: Results from the KidsAIR Randomized Trial. Environ Health Perspect. 2022 Apr;130(4).
31. Nishida C, Yatera K. The Impact of Ambient Environmental and Occupational Pollution on Respiratory Diseases. Int J Environ Res Public Health. 2022 Feb 27;19(5):2788.
32. Maung TZ, Bishop JE, Holt E, Turner AM, Pfrang C. Indoor Air Pollution and the Health of Vulnerable Groups: A Systematic Review Focused on Particulate Matter (PM), Volatile Organic Compounds (VOCs) and Their Effects on Children and People with Pre-Existing Lung Disease. Int J Environ Res Public Health. 2022 Jul 19;19(14):8752.
33. Deolmi M, Decarolis NM, Motta M, Makrinioti H, Fainardi V, Pisi G, et al. Early Origins of Chronic Obstructive Pulmonary Disease: Prenatal and Early Life Risk Factors. Int J Environ Res Public Health. 2023 Jan 27;20(3):2294.
34. Kelchtermans J, Hakonarson H. The role of gene–ambient air pollution interactions in paediatric asthma. European Respiratory Review. 2022 Dec 31;31(166):220094.
35. Zhang X, Li Z. Assessing chronic gestational exposure to environmental chemicals in pregnant women: Advancing the co-PBK model. Environ Res. 2024 Apr 15;247:118160.
36. Liu L, Ma J, Peng S, Xie L. Prenatal and early-life exposure to traffic-related air pollution and allergic rhinitis in children: A systematic literature review. PLoS One. 2023 Apr 20;18(4):e0284625.
37. Liu W, Huang C, Hu Y, Fu Q, Zou Z, Sun C, et al. Associations of gestational and early life exposures to ambient air pollution with childhood respiratory diseases in Shanghai, China: A retrospective cohort study. Environ Int. 2016 Jul;92–93:284–93.
38. Kinney PL, Asante KP, Lee AG, Ae-Ngibise KA, Burkart K, Boamah-Kaali E, et al. Prenatal and Postnatal Household Air Pollution Exposures and Pneumonia Risk. Chest. 2021 Nov;160(5):1634–44.
39. Mocelin HT, Fischer GB, Bush A. Adverse early-life environmental exposures and their repercussions on adult respiratory health. J Pediatr (Rio J). 2022 Mar;98:S86–95.
40. Mastorci F, Linzalone N, Ait-Ali L, Pingitore A. Environment in Children's Health: A New Challenge for Risk Assessment. Int J Environ Res Public Health. 2021 Oct 4;18(19):10445.
41. Joshi S, Kotecha S. Lung growth and development. Early Hum Dev. 2007 Dec;83(12):789–94.
42. Mahmoud O, Granell R, Peralta GP, Garcia-Aymerich J, Jarvis D, Henderson J, et al. Early-life and health behaviour influences on lung function in early adulthood. European Respiratory Journal. 2023 Mar;61(3):2001316.
43. Téllez-Rojo MM, Rothenberg SJ, Texcalac-Sangrador JL, Just AC, Kloog I, Rojas-Saunero LP, et al. Children's acute respiratory symptoms associated with PM2.5 estimates in two sequential representative surveys from the Mexico City Metropolitan Area. Environ Res. 2020 Jan;180:108868.
44. Achilleos S, Kioumourtzoglou MA, Wu CD, Schwartz JD, Koutrakis P, Papatheodorou SI. Acute effects of fine particulate matter constituents on mortality: A systematic review and meta-regression analysis. Environ Int. 2017 Dec;109:89–100.
45. Romieu I, Gouveia N, Cifuentes LA, de Leon AP, Junger W, Vera J, et al. Multicity study of air pollution and mortality in Latin America (the ESCALA study). Res Rep Health Eff Inst. 2012 Oct;(171):5–86.
46. Puvvula J, Poole JA, Gwon Y, Rogan EG, Bell JE. Role of social determinants of health in differential respiratory exposure and health outcomes among children. BMC Public Health. 2023 Jan 17;23(1):119.
47. TRUST. The TRUST Code – A Global Code of Conduct for Equitable Research Partnerships. 2018.
48. International Comitee of Medical Journal Editors. ICMJE. 2024 [cited 2024 Oct 28]. Defining the Role of Authors and Contributors. Available from: https://www.icmje.org/recommendations/browse/roles-and-responsibilities/defining-the-role-of-authors-and-contributors.html