Publication status: This preprint has been published elsewhere.
DOI of the published preprint: https://doi.org/10.1590/1413-81232026314.12852024

Adverse effects of atmospheric pollution on public health in Brazil: an integrative review

Virgilio Astori, Wdmila Maria Uliana, Bruna Veríssimo Lopes, Letícia Pontes de Oliveira, Fellipe Pesente, Lucas Rocha Dalto, Luciene Lage da Motta

https://doi.org/10.1590/SciELOPreprints.9284

Submitted on: 2024-07-07
Posted on: 2024-07-16 (version 1)
(YYYY-MM-DD)

Adverse effects of atmospheric pollution on public health in Brazil: an integrative review

Virgilio Astori

Escola Superior de Ciências da Santa Casa de Misericórdia de Vitória - EMESCAM, Vitória, Espírito Santo, Brazil. ORCID: https://orcid.org/0009-0004-8913-6437

Wdmila Maria Uliana

Escola Superior de Ciências da Santa Casa de Misericórdia de Vitória - EMESCAM, Vitória, Espírito Santo, Brazil. ORCID: https://orcid.org/0009-0001-4304-018X

Bruna Veríssimo Lopes

Escola Superior de Ciências da Santa Casa de Misericórdia de Vitória - EMESCAM, Vitória, Espírito Santo, Brazil. ORCID: https://orcid.org/0009-0003-6022-5615

Letícia Pontes de Oliveira

Escola Superior de Ciências da Santa Casa de Misericórdia de Vitória - EMESCAM, Vitória, Espírito Santo, Brazil. ORCID: https://orcid.org/0009-0001-4007-6355

Fellipe Pesente

Universidade Federal do Espírito Santo, Vitória, Espírito Santo, Brazil. ORCID: https://orcid.org/0009-0004-8707-4762

Lucas Rocha Dalto

Universidade Federal do Espírito Santo, Vitória, Espírito Santo, Brazil. ORCID: https://orcid.org/0000-0003-3943-8264

Luciene Lage da Motta

Escola Superior de Ciências da Santa Casa de Misericórdia de Vitória - EMESCAM, Vitória, Espírito Santo, Brazil. ORCID: https://orcid.org/0000-0001-9643-4011

ABSTRACT

Introduction: Atmospheric contamination is closely linked to negative impacts on public health. Understanding the unique aspects of the Brazilian context is crucial for the implementation of public policies and health promotion. **Objective:** To assess the negative impacts of air pollution on public health in Brazil. **Method:** This review was developed through a search in the Latin American and Caribbean Health Sciences Information Literature (LILACS), Scientific Electronic Library Online (SciELO), and PubMed/Medline databases, using the keywords "Air Pollution" AND (Health OR "Public Health") AND "Adverse Effects" AND Brazil. Articles written in English and Portuguese, published from 2013 to 2024, were selected. Additionally, two articles were manually included. After applying the inclusion criteria and removing duplicates, 19 references were used for this review. **Results and Discussion:** There is a significant correlation between respiratory diseases and the emission of atmospheric pollutants, particularly the release of fine suspended particles (PM10), highlighting an increase in hospitalizations due to respiratory illnesses. The lack of studies addressing the effects of pollutants on other systems of the human body beyond the respiratory and cardiovascular systems, as well as the scarcity of information on various atmospheric pollutants, underscores the need for further research to fill these gaps. **Conclusion:** Even at levels considered acceptable, atmospheric pollutants still pose risks to public health. Therefore, specific public policies aimed at reducing emissions of these gasses and improving air quality are necessary.

Keywords: Adverse Effects; Air Pollution; Brazil; Public Health.

INTRODUCTION

Air quality is closely linked to both local and global ecosystems, being influenced by factors such as consumption habits, pollution, and the geography of each region. The use of fossil fuels, especially in motor vehicles, and industrial activity are significant sources of atmospheric contamination worldwide, contributing to increased emissions of particulate matter (PM), carbon monoxide (CO), ozone (O_3), nitrogen oxides (NOx), and sulfur oxides (SOx). Additionally, forest fires represent a significant global concern due to the emission of fine particulate matter (PM2.5) and their adverse effects on human health[1].

In addition to the evident climatic impact caused by these changes in air composition, numerous studies have been conducted to assess possible repercussions on human health, revealing an increase in negative outcomes such as premature deaths and high morbidity due to cardiovascular diseases. Chronic exposure to inhaled pollutants is also associated with a higher incidence of asthma, chronic obstructive pulmonary disease (COPD), lung cancer, reduced lung function, and developmental lung anomalies in children, who, along with the elderly, constitute the population most vulnerable to air pollution exposure[2].

In light of this, various initiatives have been employed by the World Health Organization (WHO)[3] to reduce the emission of atmospheric pollutants, such as the implementation of milestones and safe levels for particulate matter. However, these efforts have yielded unsatisfactory results. In Brazil, environmental pollutants are typically quantified by monitoring stations of environmental agencies, but not all states have such control agencies, which sets a precedent for increased pollution[4]. Nonetheless, even when adhering to the air pollutant limits outlined in WHO's Global Air Quality Guidelines[5], respiratory health issues persist at alarming rates.

Assessing the health impacts requires careful consideration of population-specific and location-specific factors, particularly regarding atmospheric pollution. Comprehensive understanding and measurement of these factors are crucial for developing effective public policies.

Therefore, this study aims to evaluate the detrimental effects of atmospheric pollution on public health in Brazil.

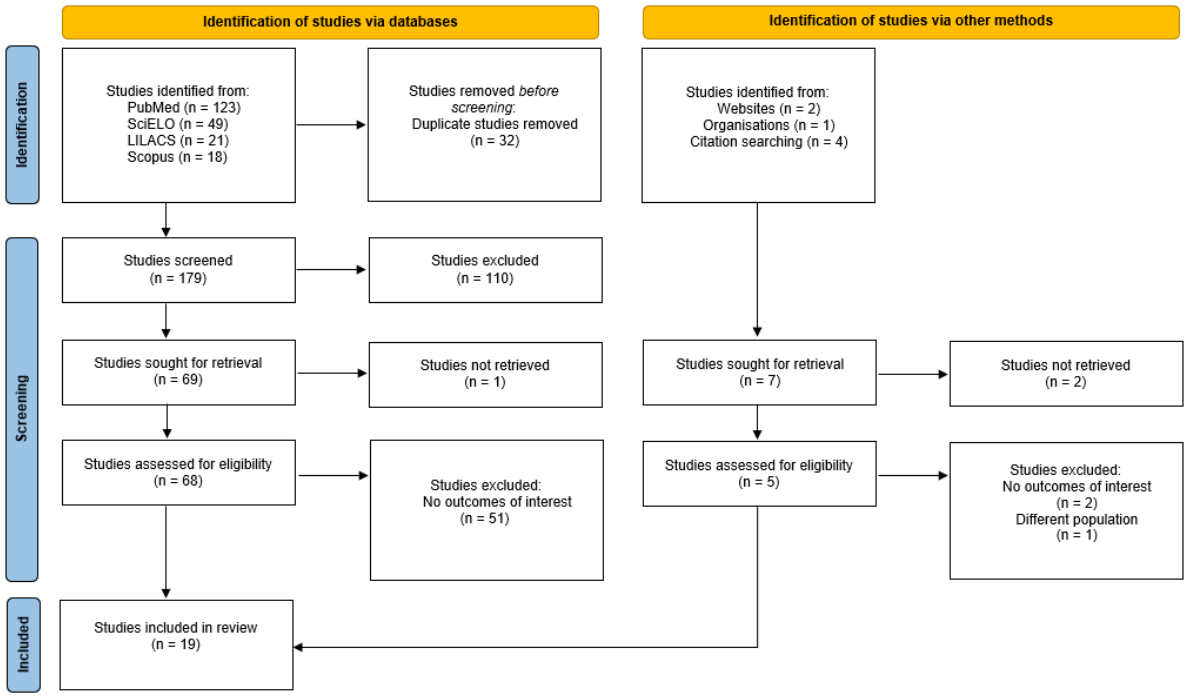
METHODS

Conducted in June 2024, this integrative literature review, which followed a modified six-step framework proposed by de Souza et al.[6], aimed to analyze articles related to the main atmospheric pollutants and their impacts on public health in Brazil. The objective was to address the guiding research question: "What is the impact of atmospheric pollution on the collective health of the Brazilian population?". The inclusion criteria comprised articles that analyzed atmospheric pollution and its health impacts within Brazil, with full texts available in English and/or Portuguese, published between 2013 and 2024, and freely accessible. Conversely, the exclusion criteria consisted of studies that did not analyze Brazilian regions, articles published before 2013, and those in languages other than English or Portuguese.

The databases utilized included the Latin American and Caribbean Health Sciences Literature (LILACS), Scientific Electronic Library Online (SciELO), and PubMed/Medline, aligned with the Biblioteca Virtual em Saúde (BVS). The search strategy employed descriptors and Boolean operators: “Air Pollution” AND (Health OR “Public Health”) AND Brazil AND “Adverse Effects,” as established by the Descritores em Ciências da Saúde (DeCS) and Medical Subject Headings (MeSH). Duplicate removal, data extraction from each included study, and reference management were facilitated using the online software Rayyan[7].

RESULTS AND DISCUSSION

Figure 1. PRISMA 2020 flow diagram for the integrative review which included searches of databases and others (Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71),



This approach identified 193 articles meeting the specified research criteria. After removing duplicates and reviewing titles/abstracts, 63 articles were initially selected for full-text review. Subsequently, 17 publications were identified as relevant for inclusion in the study. Additionally, two articles were manually included to enrich the discussion, bringing the total number of articles reviewed to 19.

Studies have revealed variations in the territorial scope of research due to the extensive geographic magnitude of the Brazilian state and the distinct characteristics of its territories, such as population organization, climatic differences, and the diverse productive activities conducted.. Despite the heterogeneity of climatic conditions, this diversity has, in fact, aided in precisely delineating the impacts that pollutants can have.

The most extensively analyzed region was São Paulo, with more than five studies focusing primarily on this state. The majority of the studies were available in both English and Portuguese, totaling ten studies. Only a few studies were exclusively available in English,

amounting to three, while six studies were available solely in Portuguese. Most of the articles, totaling ten, were published before 2020, while nine were published after this year.

Table 1. Information of included studies (designed by authors).

Study, year	Journal	Type of study	Region analyzed	Main results
Araújo, 2020	Rev. Saúde Pública	Quantitative	São Paulo	No measurable effect of the Vehicle Inspection Program on morbidity and mortality from respiratory and circulatory diseases, and no significant correlation with atmospheric pollutant concentrations (PM2.5 and CO).
Beserra, 2023	Saúde em Debate	Review	NA	Rural women workers experience significant exposure to pesticides, leading to acute and chronic intoxications, which result in skin irritation, respiratory issues, gastrointestinal symptoms, and neurotoxic effects.
de Oliveira, 2023	Cadernos de Saúde Pública	Epidemiologic	NA	Air pollution from forest fires significantly impacts public health in Brazil, especially in the Amazon and Central-West regions. PM2.5 levels often exceed WHO limits, exposing 60% of residents to harmful air quality for about six months each year.
de Freitas, 2016	Rev. Saúde Pública	Epidemiologic	Espirito Santo	Air pollution in Brazil is significantly linked to increased hospital admissions for respiratory and cardiovascular diseases, especially with higher levels of PM10, SO2, and O3.
Gao, 2024	Environmental Pollution	Epidemiologic	NA	Wildfire-related PM2.5 exposure in Brazil increases cardiovascular mortality risk.
Gouveia, 2017	Rev. Saúde Pública	Epidemiologic	São Paulo	Air pollution in São Paulo's metropolitan area increases respiratory hospitalizations by 1.4% and 1.9% for children per 10 μg/m³ rise in PM10. Only São Paulo and São Bernardo do Campo showed significant cardiovascular impacts.
Gouveia, 2019	Ciência & Saúde Coletiva	Epidemiologic	Minas Gerais	Atmospheric pollution in Belo Horizonte, Brazil, significantly increases hospitalizations for respiratory diseases in young children and cardiovascular diseases in adults.
Machin, 2018	Cadernos de Saúde Pública	Ecological Time Series	Mato Grosso	Exposure to fine particulate matter (PM2.5) significantly increases respiratory hospitalizations in children, with a 5μg/m³ rise causing 89 more hospitalizations and costs over 95,000 Brazilian Real (BRL) for Brazil's health system.
Mantovani, 2016	Ciência & Saúde Coletiva	Ecological Time Series	São Paulo	Exposure to PM2.5 in São José do Rio Preto, Brazil, led to a 15% increase in cardiovascular hospital admissions, causing 650 avoidable cases and R$ 1.9 million in excess costs.

Matos, 2019	Cadernos de Saúde Pública	Ecological Space-Time	Espirito Santo	Air pollution in Brazil's Metropolitan Region of Grande Vitória significantly increases emergency visits for respiratory diseases in children, even at pollutant levels within WHO standards.
Miraglia, 2014	Ciência & Saúde Coletiva	Ecological	NA	Atmospheric pollution in Brazil's metropolitan regions results in significant public health impacts, with an estimated 20,050 annual deaths attributable to particulate matter exposure, costing approximately $1.7 billion annually.
Moniz, 2017	Ciência & Saúde Coletiva	Qualitative	Rio de Janeiro	Identifies key socio-environmental and health risks from atmospheric pollution near the Rio de Janeiro Petrochemical Complex, including increased respiratory diseases from air pollution and the spread of communicable diseases due to inadequate sanitation.
Negrisoli, 2013	Revista Paulista de Pediatria	Ecological Time Series	São Paulo	Atmospheric pollution in Brazil, particularly nitrogen dioxide and particulate matter, significantly increases hospital admissions for pneumonia in children.
Ribeiro, 2019	Cadernos de Saúde Pública	Ecological Time Series	São Paulo	Atmospheric pollution in Brazil, particularly from vehicular traffic, significantly increases hospital admissions for respiratory cancers, with higher rates in densely trafficked urban areas like São Paulo.
Rodrigues, 2017	Revista Brasileira de Epidemiologia	Cross-Sectional	Mato Grosso	Key risk factors for cardiovascular disease mortality from traffic-related air pollution in Cuiabá and Várzea Grande are high-income inequality, heavy traffic, and female gender. Mortality risk rises in the dry season.
Santos, 2021	Jornal Brasileiro de Pneumologia	Review	NA	Increased incidence and mortality from respiratory and cardiovascular diseases, asthma, Chronic Obstructive Pulmonary Disease (COPD), lung cancer, and infections, with heightened impacts on children, the elderly, and socioeconomically disadvantaged groups. Additionally, pollutants from biomass burning and fossil fuels contribute significantly to these health issues.
Soares, 2023	Saúde em Debate	Cross-Sectional	Mato Grosso	Significant link between occupational exposure to pesticides and self-reported intoxication among cancer patients in Mato Grosso, Brazil, particularly affecting men and those with lower education levels.
Vassari-Pereira, 2022	Ciência & Saúde Coletiva	Ecological Time Series	São Paulo	Air pollution in Brazil significantly affects public health, particularly in São Paulo's metropolitan areas, with increased hospitalizations for respiratory diseases linked to pollutants like PM10 and O3, and climate change exacerbates these effects, potentially increasing respiratory-related hospitalizations by up to 10% by 2099 in São Caetano do Sul.
Yu, 2024	Journal of Hazardous Materials	Retrospective Cohort	NA	Short-term PM2.5 exposure significantly increases cancer mortality in Brazil, particularly for lung, colon-rectum, stomach, breast, prostate, and leukemia cancers.

Air pollutants and their impact

Air pollution, stemming from substances such as suspended particles (PM10 and PM2.5), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and ozone (O_3), has been linked to various negative health effects in the population. The incidence of respiratory diseases emerged as the most significant indicator for analyzing the effects of air pollution on health. Respiratory diseases have notably emerged as a key indicator of the health impacts of air pollution. Evidence shows a significant correlation, with a 1.4% increase in total hospitalizations and admissions of children under 5 years old for respiratory diseases per 10 μg/m³ increase in PM10 levels[8,9]. Moreover, both short-term and long-term exposure to PM2.5 has been associated with mortality from cardiovascular and respiratory diseases, as well as various types of cancer[10]. Regarding exposure duration, it is important to emphasize that acute respiratory effects are linked to recent exposure, typically lasting hours or days, whereas chronic respiratory effects are associated with prolonged exposure, generally exceeding six months[2].

Research into the toxicity mechanisms of PM2.5 suggests that it contributes to mortality through various pathways, including inflammation, pulmonary oxidative stress, and DNA damage. Due to their inhalable nature and small size of less than 2.5 micrometers, PM2.5 particles can migrate from the interstitial spaces to other organs, potentially increasing the risk of developing lung cancer and other malignancies[10]. In addition to PM2.5, pollutants such as PM10, NO_2, SO_2, and O_3 are associated with increased adverse respiratory events and are believed to operate through mechanisms similar to those of PM2.5 toxicity, although these mechanisms are less well elucidated. Particulate matter appears to exert its effects through inflammatory mediators and oxidative stress, with responses varying according to the substances present in the particle composition, which may include metals, organic carbon, ions (sulfates and nitrates), and other components[11].

Table 2. Pollutants analyzed per references (designed by authors).

Pollutants analyzed	References
CO	2,3,5,8.9,10,11,12,13,15,17,18,19
PM10	2,3,4,5,8,9,11,12,13,15,16, 18
SO_2	2,3,4,5,8.9.11,12,15,19
PM2,5	1,2,3,4,5,9,10,13,17,18,23
NO_2	2,3,4,5,9,10,11,12,13,15
O3	2,3,4,5,9.10,11,12,13,15, 16,19
NO	2,8,11,13
NMHC	8
HC	8
PMx	14, 15
SOx	8
RCHO	8
Metals	11,20,21
VOCs	15

Other gasses, such as carbon monoxide (CO), have demonstrated an eightfold increase in total hospitalizations with a 1 ppm rise in their levels, while sulfur dioxide (SO_2) showed a 2.6-fold increase with an additional 10 μg/m³[12]. Consequently, it can be asserted that air pollution and its effects on respiratory diseases impose high costs on public health services, leading to significant and avoidable additional expenses in Brazil, estimated at approximately 1.7 billion reais annually[13].

In addition to the economic impact related to healthcare costs, diminished productivity, activity limitations, and premature deaths, it is estimated that air pollution results in over 20,000 deaths annually in Brazilian metropolitan regions. The financial burden of these preventable losses is expected to motivate the implementation of measures to reduce air pollution and control particulate emissions.[14].

Although the concentrations of PM10, SO_2, NO_2, and O_3 comply with standards established by Brazilian legislation and the WHO, there is a significant correlation between these pollutants and

the increase in emergency visits for respiratory diseases in children aged 0 to 6 years. This underscores the notion that no safe concentration threshold exists for human health. It is essential to note that the rise in emergency visits was recorded from March to June, a period that coincides with autumn and the start of winter. During such seasonal periods, factors such as lower temperatures, higher pollutant concentrations due to temperature inversion, and reduced rainfall exacerbate respiratory infections. Therefore, further studies are needed to better understand the relationship between seasonality and air pollution[15].

Air pollution from vehicular emissions

Beginning in the 1990s, motor vehicles have been identified as the predominant contributors to pollution in Brazilian metropolitan and urban areas. As a response, in 1995, stringent emission controls for motor vehicles were established, aiming to reduce emissions and promote sustainable technologies. According to the WHO, elevated levels of air pollution are frequently a byproduct of unsustainable policies in sectors such as transportation. Therefore, investing in improvements in this sector could result in substantial healthcare savings[14].

Studies conducted in Brazil, particularly in São Paulo, have associated atmospheric pollution from vehicular emissions with a rise in respiratory diseases and other health issues[8,16-18]. A significant correlation has been found between elevated PM10 emissions and increased hospitalizations for heart failure, with higher morbidity rates observed in cities with dense vehicular traffic.[16]. In the state of São Paulo, it is projected that approximately 250,000 deaths will be attributable to pollution by 2030 if PM2.5 levels remain consistent with those in 2011[17].

Similarly, individuals residing near high-traffic roads are more susceptible to mortality from heart diseases. It is important to consider that high-traffic areas generally have lower real estate market values, which may lead to their occupation by lower-income populations[19]. Individuals with lower income also face greater difficulties in accessing healthcare services, which can introduce a confounding factor in research. Conversely, in the municipality of São Paulo, higher

socioeconomic status was found to be associated with living in high-traffic areas, which correlates with an increased risk of hospitalization for respiratory system cancers[18].

In light of this socioeconomic disparity, various studies advocate for public policies that advance infrastructure development, better public transportation, clean technology usage, and sustainable development[12,14-18]. Such measures would lead to better air quality in regions housing vulnerable populations, thereby enhancing public health and reducing the incidence of various diseases.

Exposure to pollutants from occupational activities

Occupational activities can result in work-related intoxication due to daily exposure to pollutants. In a study conducted in Mato Grosso[20], identified pesticides and industrial dust as the main sources of exposure, predominantly affecting males, older age groups, and individuals with lower educational levels[20]. Considering these findings, it is essential to account for the complex variables in the illness process, including production methods and pollutant exposure patterns across different populations.

It is important to note that workers often do not perceive the pollution conditions to which they are subjected. In Moniz's study[21], it was found that the daily burning of small amounts of biomass by the ceramic industry in Itaboraí (RJ) significantly contributes to poor air quality due to the dispersion of dust, clay, and other particulates.

However, the smoke from the kilns was not perceived by the workers and the local population as a health risk. It is believed that the acceptance of these conditions is a form of collective defense mechanism among communities exposed to industrial hazards, given their inability to effectively change the situation over time[21].

Within the context of agricultural worker health, it is emphasized that the current large-scale monoculture production model fosters reliance on chemical products[22] and promotes the practice of agricultural burnings to increase profits[13]. Family farms attempting to abstain from the usage

of pesticides often face suppression within this prevailing production paradigm[22]. Intoxications are most frequently reported during harvesting, spraying, and seed treatment phases[22], although underreporting is presumed due to the pressures workers face to keep information undisclosed.

Atmospheric pollution from agricultural burning

Another relevant point in the discussion on this topic is the impact of agricultural burnings on atmospheric pollution, with consequences for air quality and human health. The practice of burning sugarcane crops, conducted to facilitate harvesting and increase profits, is widespread and constitutes a significant source of particulate matter dispersion in the air, especially PM2.5[13]. Additionally, in Brazil, the deforestation of the Amazon rainforest and the biomes of the Midwest region contribute to increasingly severe wildfires, which, propelled by air currents, have the potential to disperse pollutant particles at a continental level, leading to numerous effects on human health[22].

From this perspective, despite burnings being a common practice strongly linked to the economy, it is crucial to explore more sustainable alternatives that pose fewer health risks, such as green harvesting. This approach aims to prevent the development of respiratory diseases and consequently reduce public health expenditures. According to Gao et al. (2024)[1], their study was the first to establish an association between PM2.5 levels from burnings and cardiovascular deaths, ischemic heart disease, and stroke, resulting in a total of 35,847 cardiovascular deaths attributed to PM2.5 over an eight-year period (2010-2018)[1]. These alarming numbers underscore the necessity for governmental actions to mitigate mortality and expenditures associated with cardiovascular diseases caused by air pollution, as well as the need for further studies to validate this connection.

Atmospheric pollution and its effects on human health encompass a vast and intricate topic requiring numerous considerations and in-depth analyses. However, there is a considerable deficit in research exploring the impacts of pollutants on systems other than the respiratory and

cardiovascular. Additionally, there is a notable scarcity of information on various atmospheric pollutants, which can compromise or hinder the interpretation of available evidence. More than half of the studies also face data quality issues, such as the absence of monitoring stations in certain locations, data loss due to instrument failures, lack of data on hospital admissions in non-SUS hospitals, seasonal variability affecting values, and the absence of data that should be available in the database during collection. These challenges present substantial obstacles to the meticulous analysis of statistics[1,8,9,11,12,15-19]. In this context, conducting further research on this topic is essential to fill existing gaps and provide a more comprehensive and complete understanding of this crucial issue.

CONCLUSION

The literature analysis revealed that the majority of research focused on the link between air pollution and health impacts, primarily within the metropolitan region of São Paulo. The results indicate that even at atmospheric levels considered safe, pollutants continue to pose risks to public health. Moreover, a significant correlation was identified between the increase in respiratory disease cases and the emission of atmospheric pollutants, with an emphasis on fine particulate matter (PM10 and PM2.5). Given the documented harmful effects, it is essential to leverage these data towards the development of specific public policies targeting the reduction of pollutant gas emissions.

The assessment of both short- and long-term effects of air pollution on public health is a continually evolving research area, with new studies expected to be published in the coming months and years. Our review of existing studies examined the evidence and identified the statistical challenges researchers face when analyzing the link between air pollution and respiratory comorbidities. Additionally, we offer recommendations for future research.

REFERENCES

1. Gao Y, Huang W, Yu P, Xu R, Gasevic D, Yue X, et al. Wildfire-related PM2.5 and cardiovascular mortality: A difference-in-differences analysis in Brazil. Environmental pollution [Internet]. 2024 [cited 2024 Jun 21];347:e123810. Available from: https://doi.org/10.1016/j.envpol.2024.123810
2. Santos UP, Arbex MA, Braga ALF, Mizutani RF, Cançado JED, Terra-Filho M, et al. Environmental air pollution: respiratory effects. Jornal Brasileiro de Pneumologia [Internet]. 2021; 47(1). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7889311/
3. World Health Organization (WHO). Ambient (outdoor) air pollution [Internet]. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health?gad_source=1&gclid=Cj0KCQjw-ai0BhDPARIsAB6hmP5PF_14EhQTqs1mpBKwjrtDpEnuEwKVZdixr3d9KNn93vDCD6DhlNoaAqtWEALw_wcB. [cited 2024 Jun 21]. Available from: https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health?gad_source=1&gclid=Cj0KCQjw-ai0BhDPARIsAB6hmP5PF_14EhQTqs1mpBKwjrtDpEnuEwKVZdixr3d9KNn93vDCD6DhlNoaAqtWEALw_wcB
4. Machin AB, Nascimento LFC. Effects of exposure to air pollutants on children's health in Cuiabá, Mato Grosso State, Brazil. Cadernos de Saúde Pública [Internet]. 2018 [cited 2020 Nov 14];34(3). Available from: https://www.scielo.br/j/csp/a/PHTDFfhv4DFmNBXnGH4Q3tJ/?lang=en
5. WHO. WHO global air quality guidelines [Internet]. Geneva Who; 2021 [cited 2024 Jun 21]. Available from: https://iris.who.int/bitstream/handle/10665/345329/9789240034228-eng.pdf?sequence=1
6. Souza MT de, Silva MD da, Carvalho R de. Integrative Review: What Is It? How to Do It? Einstein (São Paulo) [Internet]. 2010 Mar [cited 2024 Jun 21];8(1):102–6. Available from: https://doi.org/10.1590/s1679-45082010rw1134

7. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a Web and Mobile App for Systematic Reviews. Systematic Reviews [Internet]. 2016 Dec [cited 2024 Jun 21];5(1). Available from: https://systematicreviewsjournal.biomedcentral.com/articles/10.1186/s13643-016-0384-4
8. Gouveia N, Corrallo FP, Leon ACP, Junger W, Freitas CU. Air pollution and hospitalizations in the largest Brazilian metropolis. Revista de Saúde Pública [Internet]. 2017 [cited 2022 Nov 18];51(117). Available from: https://www.scielo.br/j/rsp/a/rSgQ5T44VBS3Qjf3HNnsMfM/
9. Freitas CU, Leon AP, Junger W, Gouveia N. Air pollution and its impacts on health in Vitoria, Espirito Santo, Brazil. Revista de Saúde Pública [Internet]. 2016;50(4). Available from: https://www.scielo.br/j/rsp/a/wvKyFxwc3tTxGqwVYwvnHmz/
10. Yu P, Xu R, Wu Y, Huang W, Coelho MSZS, Saldiva PHN, et al. Cancer Mortality Risk from Short-Term PM2.5 Exposure and Temporal Variations in Brazil. Journal of hazardous materials [Internet]. 2024 [cited 2024 Jun 21];473:e134606. Available from: https://doi.org/10.1016/j.jhazmat.2024.134606
11. Negrisoli J, Nascimento LFC. Atmospheric pollutants and hospital admissions due to pneumonia in children. Revista Paulista de Pediatria [Internet]. 2013 [cited 2022 Nov 18];31(4):501-6. Available from: https://www.scielo.br/j/rpp/a/wPqBWTxyjbyDqbkLC8BHZRQ/
12. Gouveia N, Leon AP, Junger W, Lins JF, Freitas CU. Air pollution and the impacts on health in the Metropolitan Region of Belo Horizonte in the State of Minas Gerais, Brazil. Ciência & Saúde Coletiva. 2019 24(10):3773–81. Available from: https://www.scielo.br/j/csc/a/LyXXLzVHpYkXch7NQ6ZVKKn/
13. Mantovani KCC, Nascimento LFC, Moreira DS, Vieira LCPFS, Vargas NP. Air pollutants and hospital admissions due to cardiovascular diseases in São José do Rio Preto. Brazil.

Ciência & Saúde Coletiva [Internet]. 2016 [cited 2022 Nov 24];21(2):509–16. Available from: https://www.scielo.br/j/csc/a/J8PXmSpcpsFKPncfsp3xmnj/?lang=en

14. Miraglia SGEK, Gouveia N. Costs of air pollution in Brazilian metropolitan regions. Ciência & Saúde Coletiva [Internet]. 2014 [cited 2022 Jul 5];19:4141–7. Available from: https://www.scielosp.org/article/csc/2014.v19n10/4141-4147/pt/
15. Matos EP, Reisen VA, Serpa FS, Prezotti Filho PR, Leite MFS. Space-time analysis of the effect of air pollution on children 's health. Cadernos de Saúde Pública [Internet]. 2019 [cited 2022 Mar 20];35(10):e00145418. Available from: https://www.scielo.br/j/csp/a/ZvLqPkynhf5gtxFvSVgRvyC/?lang=en
16. Vassari-Pereira D, Valverde MC, Asmus GF. Impact of climate change and air quality on hospitalizations for respiratory diseases in municipalities in the Metropolitan Region of São Paulo (MRSP), Brazil. Ciência & Saúde Coletiva [Internet]. 2022 [cited 2024 Jun 21];27:2023–34. Available from: https://www.scielo.br/j/csc/a/NcDWYBLcFVvncVKGJJtVrfR/
17. Araujo OR, Araujo MC. The zero impact of the vehicle inspection program on public health in São Paulo, SP. Rev saúde pública [Internet]. 2020 [cited 2024 Jun 21];54 (84). Available from: https://www.scielosp.org/article/rsp/2020.v54/84/
18. Ribeiro AG, Baquero OS, Almeida SL, Freitas CU, Cardoso MRA, Nardocci AC. Influence of vehicular traffic density on hospital admissions due to respiratory tract cancer in the city of São Paulo, Brazil. Cadernos de Saúde Pública [Internet]. 2019 [cited 2023 Apr 12];35(1):e00128518. Available from: https://www.scielo.br/j/csp/a/JJd4sMPbNJz7ypgcRgD7n8H/?lang=pt
19. Rodrigues PCO, Santos ES, Hacon SS, Ignotti E. Risk factors in cardiovascular disease mortality associated with high exposure to vehicular traffic. Revista Brasileira de Epidemiologia [Internet]. 2017 [cited 2022 May 24];20(3):423–34. Available from: https://www.scielo.br/j/rbepid/a/JZ6zNDJNCbg9q8zyQH869kv/?lang=en

20. Soares MR, Rocon PC, Andrade ACS, Machado JMH, Galvão ND, Corrêa MLM, et al. Association between exogenous intoxication and occupational and environmental exposure of cancer patients in Mato Grosso. Saúde em Debate [Internet]. 2023 [cited 2024 Jun 21];47(139):746–57. Available from: https://www.saudeemdebate.org.br/sed/article/view/8285/1744
21. Moniz MA, Sabóia VM, Carmo CN, Hacon SS. Participatory environmental diagnosis and of health risks from the surrounding communities the Petrochemical Complex of Rio de Janeiro, Brazil. Ciência & Saúde Coletiva [Internet]. 2017 [cited 2021 Mar 29];22(11):3793–806. Available from: https://www.scielo.br/j/csc/a/jcF9qtGRpvH4J6RGx3bXsJy/?lang=en
22. Beserra L, Hennington EA, Pignatti MG. Work and health conditions of women rural workers: an integrative review. Saúde em Debate [Internet]. 2023 [cited 2024 Jun 21];47(137):298–315. Available from: https://www.saudeemdebate.org.br/sed/article/view/7313/1342
23. Oliveira IN, Oliveira BFA, Silveira IH, Machado LMG, Villardi JWR, Ignotti E. Air pollution from forest burning as environmental risk for millions of inhabitants of the Brazilian Amazon: an exposure indicator for human health. Cadernos de Saúde Pública [Internet]. 2023 [cited 2023 Sep 1]; 39:e00131422. Available from: https://www.scielosp.org/article/csp/2023.v39n6/e00131422/

AUTHORS' CONTRIBUTION

Each author has made substantial contributions to the study, adhering to the specific roles delineated by the CRediT (Contributor Roles Taxonomy) guidelines.

Virgilio Astori: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing; **Wdmila Maria Uliana:** Data curation, Formal analysis, Supervision, Writing - original draft, Writing - review & editing; **Bruna Veríssimo Lopes:** Data curation, Formal analysis, Supervision, Writing - original draft, Writing - review & editing; **Letícia Pontes de Oliveira:** Conceptualization, Resources, Visualization, Writing - original draft, Writing - review & editing; **Fellipe Pesente:** Investigation, Writing - original draft, Writing - review & editing; **Lucas Rocha Dalto:** Investigation, Writing - original draft; **Luciene Lage da Motta:** Supervision.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

RESEARCH DATA AVAILABILITY

The entire dataset supporting the results of this study was published in the article itself.

This preprint was submitted under the following conditions:

- The authors declare that they are aware that they are solely responsible for the content of the preprint and that the deposit in SciELO Preprints does not mean any commitment on the part of SciELO, except its preservation and dissemination.
- The authors declare that the necessary Terms of Free and Informed Consent of participants or patients in the research were obtained and are described in the manuscript, when applicable.
- The authors declare that the preparation of the manuscript followed the ethical norms of scientific communication.
- The authors declare that the data, applications, and other content underlying the manuscript are referenced.
- The deposited manuscript is in PDF format.
- The authors declare that the research that originated the manuscript followed good ethical practices and that the necessary approvals from research ethics committees, when applicable, are described in the manuscript.
- The authors declare that once a manuscript is posted on the SciELO Preprints server, it can only be taken down on request to the SciELO Preprints server Editorial Secretariat, who will post a retraction notice in its place.
- The authors agree that the approved manuscript will be made available under a Creative Commons CC-BY license.
- The submitting author declares that the contributions of all authors and conflict of interest statement are included explicitly and in specific sections of the manuscript.
- The authors declare that the manuscript was not deposited and/or previously made available on another preprint server or published by a journal.
- If the manuscript is being reviewed or being prepared for publishing but not yet published by a journal, the authors declare that they have received authorization from the journal to make this deposit.
- The submitting author declares that all authors of the manuscript agree with the submission to SciELO Preprints.