

Environment and Public Health: Air Pollution and Chronic Diseases [†]

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Abstract: Air pollution is a major environmental risk to human health and wellbeing, and a major cause of mortality and morbidity worldwide. Particularly affected are the vulnerable populations of women, pregnant women, children, people with disabilities, and the elderly, who make up the majority of the world's poor. In this work, we present a series of pieces of evidence linking the main air pollutants to chronic diseases in adults and children. The WHO has concluded that air pollution affects children's neurodevelopmental and cognitive abilities, and can cause chronic diseases, such as childhood asthma and cancer. Epidemiological studies have shown significant effects caused by PM 2.5 and PM 10 particles toward mortality from different types of cancer. Finally, household air pollution increases the risk for a wide range of adverse cardiorespiratory, pediatric, and maternal health outcomes, particularly in poorer low- and middle-income countries.

Keywords: air pollution; chronic diseases; cancer; public health



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1. Introduction

Atmospheric gusts are collectively classified as a known human carcinogen that affects public health. Benzene is a frequent component of air pollution, and strategies must protect individuals from unavoidable exposure to it and other airborne carcinogens [1].

Free access to clean air is undoubtedly a fundamental human right. A person breathes an average of 10 million times in a year. Children naturally breathe faster than adults, and living in a polluted environment results in more pollutants being absorbed [2]. Toxic pollutants, through the respiratory function, can reach all the organs of the human body, and cause disorders in, or impairment of, their function, as a result of which they become burdened, and vulnerable to other diseases [3].

Air pollution is linked to chronic diseases, such as heart disease, stroke, lung disease, various types of cancer, and a reduction in life expectancy and healthy life years. Air pollutants are collectively classified as a known human carcinogen and, more broadly, affect the health of hundreds of millions of people worldwide [4].

The foci of pollution are mainly: factories, power plants, vehicles powered by fossil fuels, dust and waste burning, and pollution caused by coal [5].

Although some high-income countries have shown improvement in their air quality in recent decades, approximately 90% of the world's population still live in areas that do not meet the standard air quality guidelines presented by the WHO [6].

The WHO estimates that nearly 3 billion people worldwide rely on polluting fuels, such as wood, coal, crop waste, animal manure, or charcoal, combined with inefficient cooking and heating stoves within households [7].

The burden of cardiorespiratory, pediatric, and maternal diseases related to household air pollution has decreased globally, but remains high in the world's poorest regions [7].

The aim of this study was to draw attention to: (a) the relationship between indoor and outdoor air pollution and increased morbidity and mortality worldwide, and especially in low- and middle-income countries; and (b) the current gap in the form of specialized environmental policies and ways of life to stop this relationship.

2. Materials and Methods

Following PRISMA guidelines, we searched the PubMed database for clinical trials and meta-analyses from 2018 to 2023 that provided the full research text for free, with the keywords “air pollution and chronic diseases”. A total of 42 articles were identified, of which 15 were rejected after their title was studied. Then, 27 abstracts were studied; 3 were rejected from the study of abstracts, and 3 from the full-text study. A total of 21 articles were included in the present study, of which 11 were clinical studies, and 10 were meta-analyses (Figure 1).

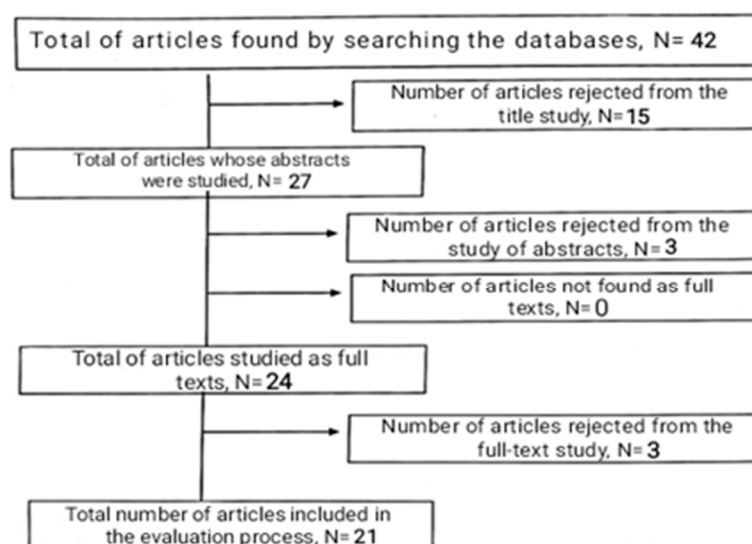


Figure 1. Flow chart illustrating the process of searching and locating research articles.

3. Results

It is known that air pollution can have several acute and long-term effects on human health. Several epidemiological studies have shown that the degree of exposure to ambient particulate matter (PM) or nitrogen dioxide (NO₂) is associated with daily mortality, mainly from cardiovascular and respiratory diseases. The size of the PM has a negative correlation with its level of lung toxicity, which means that PM 2.5 has more harmful effects than PM 10. Fine PM 2.5 particles (with an aerodynamic diameter < 2.5µm) cause a huge burden of disease. Findings suggest a positive association between the PM 2.5 constituents and cause-related mortality, particularly due to myocardial infarction. Emerging evidence suggests that long-term ambient PM 2.5 levels increase the magnitude of the association between PM 2.5 and elderly systolic blood pressure and cardiovascular risk [6–9].

Evidence suggests that nitrogen dioxide and ozone adversely affect human health, impacting respiratory function, and causing hospitalization and premature death in any population, including subgroups of vulnerable adults and children. A review of cohort studies found positive associations between long-term NO₂ concentrations and mortality, and limited evidence linking O₃ and mortality [10].

Environmental pollution from particulate matter is a high risk factor for mortality worldwide. The burden of disease is extremely high in China, and it has been estimated that approximately 1.2 million deaths in 2017 are attributable to particulate matter. PM 2.5 is a mixture of various organic and inorganic substances, and among the main components are

organic carbon, elemental carbon, and ammonium nitrate sulfate. Along with measures to monitor and control air pollutants, future strategic plans should incorporate the protection of populations vulnerable to these components, especially those with chronic diseases [4,11].

Significant harmful effects of PM 2.5 on lung cancer mortality, and mortality from liver cancer, colon cancer, bladder cancer, and kidney cancer have been observed, while PM 10 has shown harmful effects on mortality from lung cancer, pancreatic cancer, and laryngeal cancer. Therefore, they may act through different mechanisms. Meta-analyses of cohort studies have shown that exposure to the main air pollutants is associated with increased mortality from all cancers, and an increased risk of chronic liver disease [12,13]. The results also show that an increase in exposure to PM 2.5 significantly increases the risk of liver cancer, liver cirrhosis, and fatty liver disease. Future research is needed, to strengthen the association between certain types of air pollutants and specific chronic liver diseases [13].

The epidemiological literature on the associations between exposure to the ambient air pollutants PM 2.5, PM 10, and NO₂ and the incidence of breast cancer has recently developed strongly. It has been estimated from dose–response functions that approximately 1700 cases of breast cancer could be attributed annually to exposure to NO₂ or associated air pollutants, but it is not yet possible to claim that this association is a consequence of NO₂ exposure itself. Premenopausal women appear to be at more risk than postmenopausal women, but further studies are needed, to better understand the role of pollutants in the pathophysiology of breast cancer, especially in premenopausal women. Breast cancer deserves consideration, in order to fully appreciate the burden of air pollution on women's health [14].

The development of COPD has been associated with air pollutants from outdoor and indoor sources, such as burning solid fuels and cooking. The degree of exposure to PM depends not only on the air quality of indoor and outdoor environments, but also on the percentage of time a person spends in these spaces. Although public policy has a primary role in reducing air pollution, modifications in personal lifestyles can reduce the harmful effects of PM. Interventions to reduce the exposure to PM air pollutants in the daily life of patients with COPD can be important [15]. The use of an air purifier indoors has been shown to reduce the incidence of COPD and childhood asthma, as has the use of a personal mask outdoors on days with increased air pollution [16,17].

A meta-analysis including 59 studies showed that short-term exposure to all gases and particulate pollutants was significantly associated with the risk of the acute exacerbation of COPD (AECOPD). Among them, O₃ and NO₂ showed the strongest associations, SO₂ and CO showed weak correlations, and PM 10 showed a higher correlation than PM 2.5 between particle types, with the strongest effect on the exposure day and lag. The incidence of COPD can be reduced through the control of the air pollutants PM 2.5 and NO₂. Furthermore, as both MMP-9 and IL-8 are neutrophil-associated inflammatory markers, air-pollution-induced airway inflammation is primarily driven by neutrophils. Therefore, the development of drugs that target neutrophil-mediated inflammation will be important in future therapies [18].

Biomass fuel (wood, charcoal, coal, manure, and crop residues) for cooking and/or heating is associated with an increased risk of esophageal squamous cell carcinoma (ESCC). Importantly, the ESCC risk varies according to the study setting and population. While current evidence demonstrates an association between age, gender, and lifestyle (smoking and alcohol use), environmental factors may be responsible for the increased risk in low-income countries. The biomass fuel status should be considered in the risk assessment for squamous esophageal carcinoma in low-income countries [19].

There is now substantial evidence linking household air pollution to a wide range of cardiorespiratory, pediatric, and maternal conditions, with these disease categories being specifically highlighted by the WHO. Household exposure to air pollution is among the top 10 risk factors for disease, with the highest prevalence seen in poorer communities in low- and middle-income countries [20].

Traffic-related air pollution, particularly exposure to benzene, was almost linearly associated with the risk of childhood leukemia. No minimum exposure threshold emerged for benzene, while analyses of traffic density and nitrogen dioxide NO₂ showed such a limit. The disease subtype, exposure time, and age of the child appear to modify these associations [21,22].

Air pollution can contribute to a significant burden of childhood asthma cases. For other allergic diseases, e.g., conjunctivitis, eczema, and sensitization, there are substantially fewer studies, and the evidence is less strong [7]. Early life upper-respiratory tract infections are associated with an increased risk of school-age asthma. Early childhood lower-respiratory tract infections have a direct impact on lung development and subsequent chronic respiratory diseases [23].

The fetal oxidative balance achieved when protective prenatal factors neutralize sources of oxidative stress may be critical in the prevention of asthma and allergic diseases. Potentially protective prenatal exposures to nutrients such as vitamin D have been identified, as well as prenatal exposures to prooxidants, such as smoking and prenatal air pollutants, that may increase the risk of asthma and allergic outcomes in adolescence. Protective nutrients may offset the adverse effects of prooxidant exposure [24].

A growing body of research links traffic-related environmental factors to childhood obesity. Long-term traffic pollution shows a weak positive association with an increased BMI in children, and traffic flow, pollution, and noise could influence weight-related behaviors. The relationship between traffic environmental factors and obesity is receiving increasing attention in the fields of children's health and life-course epidemiology [25].

4. Discussion

This systematic review analyzed twenty-one studies evaluating the association between particulate air pollution with some chronic diseases, and the increased morbidity and mortality due to air pollution worldwide, in adults and children.

The findings show that air pollution has several acute and long-term effects on human health, especially in urban areas with a high traffic density, from PM 2.5 and PM 10 particles, and their main components, such as organic carbon, elemental carbon, ammonium nitrate sulfate, nitrogen dioxide, and benzene [26]. A poor air quality also has significant economic implications, increasing medical care costs, and reducing worker productivity [27].

More prospective studies with large numbers of participants are needed in developing countries. The evidence gap map (EGM) is an emerging method of evidence synthesis that can provide a strategic approach to generating issue-based evidence, and support evidence-based environmental policy-making [11,28].

Systematic reviews of both short-term and long-term studies concerning air pollutants, morbidity, and mortality are needed to further support our findings [9,15].

The limitations of our study were the use of English-language literature only, the time limitation of the last five years, and the fact that we were limited to including articles only from the PubMed database.

5. Conclusions

Air pollution is a serious environmental problem and a major worldwide public health problem that poses serious risks to human health, especially in developing countries, accelerated by industrialization and urbanization. There is an urgent need for informed policy and decision-making to ensure that children and adults living in low- and middle-income countries (LMICs) will have clean air to breathe in their homes. The studies conducted in LMICs are still scarce. Strict environmental health policies are needed, to keep air pollution levels and, consequently, death rates from cancer and other chronic diseases, as low as possible. As new scientific evidence is generated, air quality guidelines should be reviewed periodically, and updated where necessary.

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