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Multifaceted Impacts of Environmental Pollution on Human Health: Respiratory, Cardiovascular, and Mental Disorders Amid Socioeconomic Disparities

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Abstract

In recent decades, rapid urbanization, industrial growth, extensive use of fossil fuels, and climate change have markedly increased environmental pollution worldwide. Air, water, soil, noise, and light pollution threaten both the environment and human health, acting as key, often hidden factors in chronic, debilitating, and fatal diseases, especially among vulnerable populations. Despite advances in environmental and public health sciences, gaps remain in understanding pollution sources, exposure pathways, and health outcomes. Countermeasures also require review and strengthening. This study aims to comprehensively examine the impacts of various environmental pollutions on human health, analyze physical and psychological consequences, and review effective policies and technologies for mitigation through a systematic literature review. This review study involved structured searches in reputable databases to explore the health consequences of environmental pollution and potential countermeasures. Environmental pollution exerts profound, multifaceted effects on public health. Air pollution is linked to higher risks of cardiovascular and respiratory diseases, cancer, and dementia. Water and soil pollution contribute to renal failure, hormonal disorders, chronic poisoning, and certain cancers. Noise and light pollution are associated with sleep disturbances, anxiety, hypertension, and cognitive decline. Climate change exacerbates these issues and increases the emergence of diseases and environmental migration. These findings highlight the need for global preventive measures, effective policymaking, and the development of clean technologies. Environmental pollution represents a major contemporary public health challenge due to its widespread physical, psychological, and long-term impacts on quality of life and healthcare systems. Effective mitigation requires integrated environmental policymaking, public education, technological innovation, and international cooperation. Prioritizing inseparable human and environmental health in development programs is essential to prevent health inequalities and enhance societal resilience.

Keywords: Environmental pollution, Public health, Air pollution, Water pollution, Soil pollution, Noise pollution, Climate change, Health impacts.

1 | Introduction

Environmental pollution, particularly air, water, and soil pollution along with climate change, represents one of the greatest threats to public health in the 21st century. These pollutants not only endanger human health but also have widespread impacts on the environment and the global economy. With accelerating population

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growth, industrialization, and climate change, exposure to environmental pollutants is rapidly expanding, intensifying health crises. Recent reports indicate that air pollution, especially particulate matter (PM2.5 and PM10) and chemical pollutants such as Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2), has been responsible for a significant proportion of respiratory diseases, cardiovascular disorders, and certain cancers in recent years. According to World Health Organization (WHO) studies, environmental pollution caused over 9 million premature deaths in 2019 and negatively affected the quality of life of billions of people. This public health crisis is evident not only in developing countries but also in developed ones. In developing countries, particularly in industrial and densely populated areas, environmental pollution poses a specific threat to vulnerable groups, including children, the elderly, and individuals with chronic diseases. A key issue in this field is the insufficient attention paid to psychological problems arising from pollution. In addition to physical illnesses, environmental pollution can lead to mental disorders such as anxiety, depression, and cognitive impairments, which in turn affect quality of life and the treatment process for physical diseases. This concern is particularly pronounced in areas with severe pollution and among individuals with chronic conditions. The objective of this study is to investigate the impacts of environmental pollution on public health, with an emphasis on both physical and psychological factors. This research also aims to identify strategies to reduce negative effects and enhance public health resilience. Given that preventing environmental pollution and effectively managing health crises require international cooperation and policymaker actions, this article specifically highlights the importance of adopting efficient policies and technological solutions to address this global crisis. The effects of environmental pollution vary across individuals, with vulnerability depending on multiple factors [1], [2]. *Table 1* summarizes the key parameters influencing vulnerability to environmental pollution, the higher-risk groups, main mechanisms, and related disease examples.

Table 1. Key parameters in vulnerability to environmental pollution.

Vulnerability Parameter	High-Risk Groups	Main Mechanism/Reason	Example Disease or Effect
Age	Children and the elderly	Developing or weakened immune/respiratory system	Respiratory diseases in children; stroke in >65 years
Socioeconomic Status (SES)	Low-income individuals, marginalized areas	Higher exposure to industrial/traffic pollution; limited healthcare access	Cardiovascular diseases, lung cancer, and renal failure
Gender	Women (especially in developing countries and during pregnancy)	Indoor pollution (cooking), hormonal changes	Cardiovascular diseases; fetal impacts
Pre-existing health and lifestyle	Chronic patients (asthma, Chronic Obstructive Pulmonary Disease (COPD), diabetes), smokers	Stronger reactions to pollutants	More frequent respiratory attacks; heart disease
Pregnancy	Pregnant women	Direct impact on fetal development	Preterm birth, low birth weight, neonatal issues
Race and ethnicity	Racial minorities (e.g., Black/Latino in the USA)	Living in higher-pollution areas, with limited access	25% higher risk of lung diseases and cancer
Access to healthcare/infrastructure	Low-income communities	Lack of ventilation, clean water, and green spaces	Exacerbated pollution and heat effects
Geographic location	Industrial, densely populated areas	Proximity to pollution sources	COPD and premature mortality

2 | Diagnosis of Diseases Associated with Environmental Pollution

Accurate and early diagnosis of diseases, particularly those linked to environmental pollution, is a key aspect of preventing chronic illnesses, reducing premature mortality, and promoting public health. This process involves identifying initial symptoms, risk assessment, and employing various techniques for diagnosis and disease classification.

2.1 | Diagnosis and Screening of Pollution-Related Diseases

Accurate and early diagnosis of diseases linked to environmental pollution is critical for preventing chronic conditions, reducing premature mortality, and improving public health outcomes. The process begins with identifying initial clinical symptoms and assessing personal history of pollutant exposure, followed by advanced screening and diagnostic techniques. Diagnosis typically starts with clinical symptoms and the individual's exposure history. Environmental pollution primarily affects the respiratory, cardiovascular, and nervous systems. Common symptoms include shortness of breath, chronic cough, chest pain, and cognitive impairments in conditions such as asthma, bronchitis, cardiovascular diseases, and certain cancers. Physicians use detailed questioning and patient history to identify underlying factors, with particular attention to residence in areas with high PM2.5 levels, industrial pollution, or proximity to pollution sources, which elevate the risk of chronic respiratory and cardiovascular diseases. For example, a study in India demonstrated a direct correlation between increased air pollutants and higher risks of lung diseases and lung cancer across various age groups [3]. Beyond initial clinical assessment, screening tools enable early detection even before symptoms manifest. Pulmonary function tests, such as spirometry, are effective for identifying respiratory diseases and lung obstructions (e.g., Chronic Obstructive Pulmonary Disease (COPD)) associated with air pollution. For chemical pollutant exposure, blood tests detecting toxins, heavy metals, and residual chemicals (e.g., lead, mercury, or arsenic) facilitate accurate diagnosis. These methods are particularly valuable in communities with prolonged exposure to pollution [4].

2.2 | Molecular and Genetic Diagnosis

Advances in omics technologies (e.g., genomics, proteomics, metabolomics, and epigenetics) enable more precise diagnosis. Environmental pollution can induce changes at the DNA and protein levels, altering biological processes. Genetic tests, such as Polymerase Chain Reaction (PCR), represent modern approaches to detecting gene mutations caused by pollutant exposure. Furthermore, protein and metabolic profiles provide detailed insights into damage to various body systems. For instance, analysis of specific blood proteins can aid in diagnosing cardiovascular and respiratory diseases resulting from air pollution.

2.3 | Biological Tests and Biomarkers

Environmental pollution can lead to toxin accumulation in the body, detectable through urine, blood, or specific tissues. Biomarkers are highly valuable for identifying exposure to pollutants and resulting damage. For example, measuring blood lead levels or detecting chemicals like dioxins can indicate exposure to industrial and agricultural pollution. Additionally, elevated levels of inflammatory proteins (e.g., C-Reactive Protein (CRP)) and oxidative stress markers in blood may signal inflammation and cellular damage caused by pollution [5], [6].

2.4 | Technological Advances in Diagnosing Environmental Pollution

Technological advances in sensors and big data have enhanced pollution monitoring. Portable environmental sensors for measuring PM2.5, NO_2, and other pollutants in urban and industrial areas enable faster identification of pollution sources and assessment of public health impacts. Moreover, emerging technologies such as machine learning and predictive models can simulate disease progression and identify at-risk individuals. By analyzing data from sensors, health records, and socioeconomic variables, these technologies facilitate preventive measures [7].

3 | Screening for Diseases Associated with Environmental Pollution

Disease screening helps identify at-risk individuals and support early detection, especially for environmental pollution exposures that may manifest over time. Screening employs various methods to detect vulnerable individuals and potential damage, playing a vital role in mitigating negative impacts and preventing disease progression [8]–[10].

3.1 | Screening to Identify Individuals at Risk

The first step in screening is identifying those with higher exposure to environmental pollution. Such individuals may be at greater risk due to residence, occupation, age, gender, or pre-existing health conditions. For example, people living in industrial areas, cities with high air pollution, or near pollution sources (e.g., factories or busy roads) face elevated risks of respiratory, cardiovascular, and neurological diseases. At this stage, risk assessments based on environmental criteria (e.g., air, water, and soil pollution, as well as climatic conditions) can be utilized.

3.2 | Screening Tests for Disease Diagnosis

Following the identification of at-risk individuals, performing appropriate screening tests is essential for diagnosing diseases associated with environmental pollution. These tests may include the following:

I. Pulmonary function tests (spirometry): these tests are used to diagnose respiratory diseases such as asthma, COPD, and bronchitis. Individuals exposed to air pollution, particularly in urban areas, should undergo these tests regularly.

II. Blood tests: assays measuring levels of lead, arsenic, mercury, and other heavy metals in blood can be useful for identifying exposure to these toxins. Such tests are especially crucial for those living in areas contaminated with chemicals or industrial pollutants.

III. Genetic and molecular tests: genetic testing can detect DNA alterations resulting from pollutant exposure. For example, examining specific gene mutations can reveal the negative effects of environmental pollution on DNA integrity [11].

3.3 | Screening for Cardiovascular Diseases

Air and water pollution are directly linked to increased risks of cardiovascular diseases and stroke. In particular, Particulate Matter (PM2.5) and toxic gases such as NO_2 and SO_2 can damage arteries and blood vessels, elevating blood pressure. Due to these risks, regular screening for cardiovascular diseases is essential in individuals exposed to severe pollution. Tests such as blood pressure measurement and cholesterol assays can be effective for early detection.

3.4 | Screening for Neurological and Brain Diseases

Environmental pollution, especially air pollution and chemicals in water and soil, can damage the nervous system, leading to neurological disorders such as dementia and cognitive impairments. Various studies have shown that children and the elderly are more susceptible to these harms. In this context, screening should include cognitive tests and neurological evaluations to detect the adverse effects of pollution on the nervous system.

3.5 | Screening for Cancer

Environmental pollution, particularly air and soil contamination, is associated with increased risks of cancers such as lung, liver, and gastrointestinal cancers. Regular screening and diagnostic tests such as mammography for breast cancer, colonoscopy for colorectal cancer, and CT scans for lung cancer can be effective in early identification of these diseases [6].

3.6 | Challenges and Limitations in Screening for Environmentally Related Diseases

I. Limited access to technology and resources: in many areas with severe pollution, access to essential screening equipment and technologies may be restricted. This issue is particularly evident in developing countries or impoverished regions.

II. Low public awareness: in some communities, public awareness of the link between environmental pollution and disease, as well as the need for screening, is insufficient. Public education and awareness campaigns can help increase participation in screening programs.

III. Costs and resources: the high costs of screening and medical tests can pose significant challenges for many individuals and countries, especially in regions with limited access to high-quality healthcare systems.

4 | Self-Care Education in Diseases Associated with Environmental Pollution

Environmental pollution, including air, water, and soil contamination, poses numerous risks to human health and can lead to various diseases such as respiratory disorders, cardiovascular diseases, cancer, reproductive problems, and mental health issues. In this context, self-care emerges as one of the most important strategies for prevention and disease management.

4.1 | Self-Care in Respiratory Diseases (e.g., Asthma and Chronic Obstructive Pulmonary Disease)

Air pollution is one of the primary exacerbating factors for chronic respiratory diseases such as asthma and COPD. For managing these conditions, self-care involves a set of actions that help patients reduce symptoms and prevent exacerbations. These actions include:

I. Awareness of air quality: using apps and websites that report the Air Quality Index (AQI) daily can help individuals avoid exposure to severe pollution.

II. Avoiding triggers: patients should learn to steer clear of environmental pollutants and triggers (e.g., cigarette smoke, dust, and industrial pollution).

III. Medication adherence: regular use of prescribed medications, such as steroids and bronchodilators (e.g., inhalers for asthma), to prevent symptom worsening.

IV. Exercise and proper breathing: training in deep breathing techniques and respiratory exercises helps strengthen lung capacity and prevent respiratory attacks.

4.2 | Self-Care in Cardiovascular Diseases Caused by Air Pollution

Air pollution, particularly PM2.5 and toxic gases such as NO_2, significantly increases the risk of cardiovascular disease. Self-care in this area includes preventive measures to help individuals avoid pollution-related cardiovascular issues:

I. Blood pressure and cholesterol control: regular use of blood pressure and lipid-lowering medications, along with routine screenings to assess cardiovascular risk.

II. Physical activity and healthy diet: engaging in regular exercise, reducing salt and saturated fat intake, and following a diet rich in fruits, vegetables, and oily fish to maintain heart health. However, the benefits of physical activity can be diminished or even reversed in highly polluted environments due to increased inhalation of pollutants. *Fig. 1* illustrates this critical balance, showing that exercise in clean air benefits pulmonary and cardiovascular function, whereas in polluted air, greater ventilation increases pollutant exposure and negative health outcomes.

III. Avoiding smoke and environmental pollution: staying away from high-pollution areas and minimizing time spent in polluted environments.

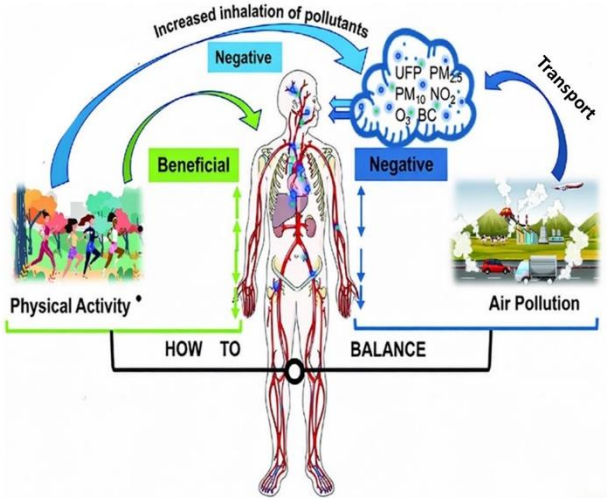

Fig. 1. Balance of beneficial and negative effects of physical activity in clean vs. polluted air, with suggested PM2.5 thresholds for safe exercise.

4.3 | Self-Care in Mental Health Disorders Caused by Pollution

Environmental pollution affects not only physical health but also mental well-being. Studies have shown that air pollution can increase stress, anxiety, and even depression. In this regard, self-care for mental health includes the following methods:

I. Stress and anxiety management: utilizing techniques such as meditation, yoga, and deep breathing to alleviate stress induced by environmental pollution.

II. Building psychological resilience: training in coping skills for stressful situations and pollution exposure. These skills may include improving sleep quality, relaxation methods, and engaging in enjoyable activities.

III. Social and family support: strengthening social networks and seeking psychological counseling to mitigate the negative mental health impacts of environmental pollution.

4.4 | Self-Care in Cancers Caused by Pollution

Environmental pollution, particularly toxic chemicals such as dioxins and pesticides, is directly linked to various cancers. In this context, self-care may include:

I. Awareness of chemical pollution sources: educating individuals to identify chemical pollution sources in home and work environments, especially exposure to industrial chemicals, agricultural pesticides, and plastics.

II. Anti-cancer diet: consuming anti-cancer foods such as leafy greens, fruits, and antioxidant-rich foods to counteract the harmful effects of chemicals and prevent cancer development.

III. Avoiding tobacco and alcohol: refraining from smoking and alcohol consumption, which can heighten the body's vulnerability to toxins and carcinogens.

4.5 | Public Education and Awareness Raising

Public education on self-care to reduce the effects of environmental pollution is essential. These programs should provide comprehensive information on pollution sources, their health consequences, and preventive strategies for vulnerable groups (children, the elderly, and those with chronic diseases). Through media, schools, and public health initiatives, people should be informed about how to protect themselves from the negative effects of pollution by adopting healthy behaviors [12].

5 | Treatment of Diseases Associated with Environmental Pollution and Associated Challenges

Environmental pollution is recognized as a major contributor to chronic and acute diseases worldwide, including respiratory, cardiovascular, neurological, psychological disorders, and cancers. Treating these conditions, especially under prolonged exposure to pollutants, involves significant challenges. *Table 2* summarizes the main treatments and associated challenges for key disease categories.

Table 2. Main treatments and associated challenges for diseases caused by environmental pollution.

Disease Category	Main Treatments	Associated Challenges
PM2.5, NO_2, and other air pollutants cause respiratory diseases (e.g., asthma, chronic bronchitis, COPD).	1) Inhaled medications (bronchodilators such as salbutamol; steroids such as beclomethasone and fluticasone) 2) Breathing techniques and pulmonary physiotherapy 3) Patient education on prevention (masks, air purifiers, staying indoors during high pollution)	1) Development of resistance to medications in long-term exposure 2) Limited access to drugs and healthcare facilities in developing countries
Cardiovascular diseases caused by air pollutants (e.g., elevated blood pressure, vascular inflammation)	1) Antihypertensive drugs (ACE inhibitors such as enalapril; beta-blockers such as metoprolol) 2) Anticoagulants (aspirin, warfarin) 3) Lifestyle modifications (healthy diet, regular exercise, smoking cessation)	1) Rapid disease progression (often asymptomatic until advanced stages) 2) Need for long-term, continuous treatment in chronic exposure
Neurological and Psychological Diseases Caused by air, water, and soil pollution (e.g., dementia, anxiety, depression)	1) Antidepressants and anti-anxiety medications (SSRIs such as citalopram; SNRIs such as duloxetine) 2) Psychological therapy (e.g., Cognitive Behavioral Therapy (CBT)) 3) Supportive care and social support	1) Delayed diagnosis (effects may appear years later) 2) Increased complexity due to the combined effects of multiple pollutants
Cancers caused by air pollution and chemical compounds (e.g., lung, liver, bladder, gastrointestinal)	1) Surgery (tumor removal) 2) Chemotherapy and radiotherapy 3) Targeted therapy (e.g., imatinib in specific cases)	1) Diagnosis is often in advanced stages 2) Limited access to advanced treatments in low-income and developing regions

6 | Psychological Problems and Their Impact on Quality of Life in Patients

Patients with chronic diseases caused by environmental pollution, such as respiratory, cardiovascular, and neurological conditions, frequently experience psychological issues, including chronic anxiety and stress. These anxieties may stem from concerns about the disease prognosis, physical limitations, long-term treatments, or medication side effects. Chronic stress not only affects mental health but can also weaken the immune system and disrupt recovery processes. Studies have shown that air pollution and exposure to pollutants can elevate stress and anxiety levels. For example, patients living in areas with high PM2.5 levels experience significantly higher anxiety due to respiratory problems and asthma attacks. Recent research in China and India has demonstrated that severe urban pollution increases cases of anxiety and depression in vulnerable populations, such as women and the elderly [13].

6.1 | Depression

Depression is another common psychological problem among patients with chronic diseases. It is particularly evident in conditions with long-term impacts on quality of life. For instance, patients with COPD, asthma, or lung cancer exposed to air pollution are more prone to depression than others. Persistent respiratory difficulties and physical pain can reduce patients' ability to perform daily activities and lead to loss of independence. Studies indicate that patients with chronic respiratory diseases living in polluted areas have a higher risk of depression. Additionally, some prescribed medications for these conditions may contribute to depression and other mental disorders. A U.S. study reported that over 45% of COPD patients exhibited moderate to severe depressive symptoms [8].

6.2 | Sleep Disorders

Sleep disturbances are a major issue for patients with chronic diseases linked to environmental pollution. Noise and light pollution, especially in densely populated urban areas, significantly affect sleep quality. In patients with asthma, COPD, and other respiratory diseases, sleep disorders are more common due to breathing difficulties or the use of medical devices such as oxygen therapy and inhalers. Exposure to environmental pollution, particularly nighttime noise and light, can lead to insomnia, fragmented sleep, and insufficient rest. These disturbances not only impair quality of life but also slow treatment progress and exacerbate stress and anxiety. A study in Germany found that individuals with respiratory diseases in areas with high noise pollution experienced sleep disorders 35% more frequently than others.

6.3 | Cognitive Impairments and Reduced Mental Abilities

Patients with chronic diseases and environmental pollution exposure, particularly neurological conditions like dementia and Alzheimer's, may face declining cognitive abilities. Pollutants such as PM2.5 particles, NO_2, and others can affect the brain by inducing inflammation and oxidative stress, contributing to the progression of neurological diseases. Recent studies have seriously examined the link between air pollution and dementia in the elderly. A UK study found that older adults living in areas with higher air pollution experience significantly more cognitive impairment than those living in less polluted areas.

6.4 | Reduced Quality of Life

Reduced quality of life is a direct consequence of psychological problems arising from chronic diseases. Patients affected by environmental pollution often feel incapacitated, with decreased energy, diminished motivation for daily activities, and ultimately reduced social interactions. These issues can lead to social isolation and, in some cases, suicide. A study in India found that patients with asthma and COPD living in PM2.5-polluted areas have a lower quality of life compared to similar patients in less polluted areas, facing more psychological problems such as anxiety, depression, and sleep disorders [14].

7 | Discussion

Environmental pollution represents one of the greatest threats to public health in the modern world, exerting widespread effects on human health. These pollutants from urban air pollution to water and soil contamination directly influence chronic diseases, cancers, respiratory disorders, and cardiovascular conditions. Numerous studies have demonstrated that air pollution, particularly Particulate Matter (PM2.5) and pollutant gases such as NO_2, can cause COPD, asthma, cardiovascular diseases, and strokes. Furthermore, continuous exposure to air pollution increases the risk of neurological diseases, dementia, and mental disorders such as anxiety and depression. Environmental pollution has its most profound impacts in industrial and densely populated communities. In these societies, air and noise pollution, alongside water and soil contamination, have become major health threats [4]–[6]. Additionally, pollution exacerbated by climate change, such as higher temperatures, severe storms, floods, and altered precipitation patterns, can impose significant negative effects on public health, particularly among vulnerable groups like the elderly, children,

and individuals with pre-existing health conditions. Recent studies indicate that socioeconomic inequalities also play a crucial role in this domain. Vulnerable groups, including ethnic minorities, women, and low-income individuals, face greater exposure to environmental pollution and are more likely to develop related diseases compared to others. Moreover, limited access to healthcare services in low-income communities complicates treatment and slows recovery processes. Treating diseases associated with environmental pollution involves several challenges. First, pollution-related diseases often present with mild symptoms in early stages, leading to delays in diagnosis and treatment. Additionally, existing treatments are frequently limited to symptom management, and many diseases, especially those from chronic pollution ,require long-term and complex interventions. To effectively address these challenges at a population level, comprehensive health impact and economic assessments are essential. *Fig. 2* shows a flowchart of the health and economic impact assessment methodology for air pollution, including predictive modeling, population exposure estimates, adverse health effects, and revenue generation. Key data inputs include cross-sectional or cohort studies, air quality monitoring data, baseline incidence rates, and medical/economic treatment costs. In such circumstances, delivering precise and effective treatments to patients, particularly in communities with severe exposure to pollution, requires the development of healthcare infrastructure and international cooperation.

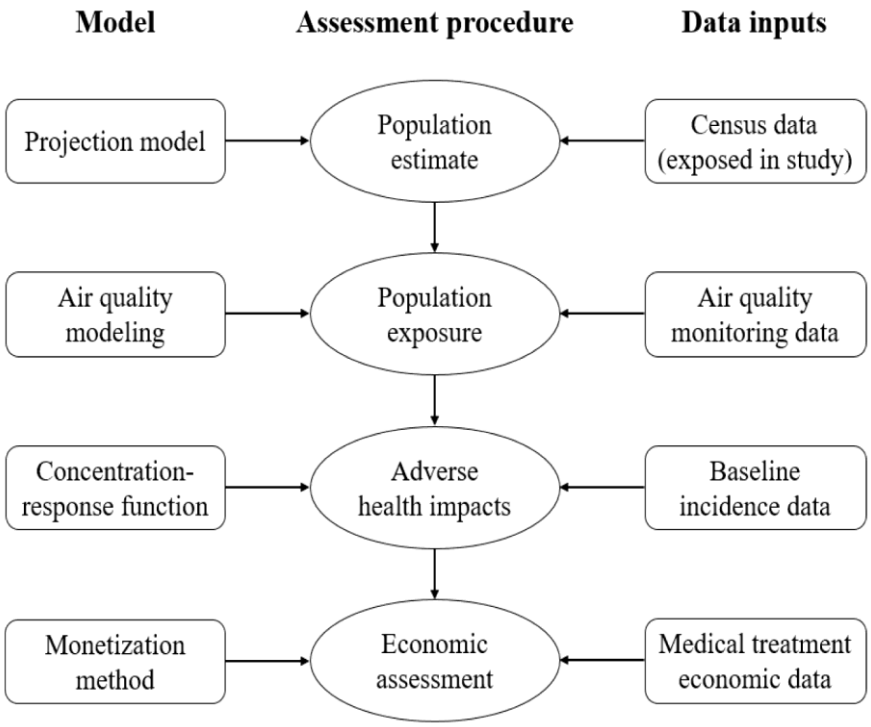

Fig. 2. Flowchart of health impact and economic assessment for air pollution effects using modeling, exposure estimation, and monetization methods.

8 | Conclusion

In recent decades, environmental pollution has emerged as a serious threat to public health, with extensive effects on both physical and mental well-being. The findings of this study reveal that air, water, and soil pollution, along with climate change, can lead to chronic diseases, cognitive impairments, depression, anxiety, and sleep problems. These psychological issues not only reduce patients' quality of life but also complicate treatment processes and negatively affect the body's resilience against diseases [15]. To address this crisis, it is essential to revise health and environmental policies and adopt effective strategies for reducing environmental pollution. Pollution prevention, healthcare infrastructure development, and public education can help mitigate negative effects and improve patients' quality of life.

Furthermore, enhancing public awareness and providing early screening and diagnostic services can lead to faster disease identification and more effective treatment. Ultimately, confronting environmental pollution requires a multifaceted approach encompassing international cooperation, sound policymaking, public awareness raising, and the development of clean technologies. Future research should focus on longitudinal studies in diverse socioeconomic contexts to better quantify the combined physical and psychological impacts of emerging pollutants and inform targeted interventions. In this way, we can mitigate the negative impacts of this global crisis and enhance public health in the face of environmental pollution threats.

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