



Impact of Environmental Pollution on Infectious Disease Incidence: Challenges and Preventive Solutions: A Review Article

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Uncovering the Regulatory Role of Impact of Environmental Pollution on Infectious Disease Incidence: Challenges and Preventive Solutions: A Review Article.

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ABSTRACT

Background: Environmental pollution poses serious threats to public health and contributes significantly to the spread of infectious diseases. This study examined the effects of air, water, and soil pollution on the incidence of infectious diseases while proposing preventive measures and relevant public policies.

Methods: This systematic review was conducted using Google Scholar, PubMed, Science Direct, and Springer Link databases covering 2020 to 2024 to investigate the link between environmental pollution and infectious disease spread. Reputable scientific articles from reliable databases were reviewed to ensure comprehensive coverage.

Results: Twenty six selected studies indicate a significant association between environmental pollution—particularly air, water, and soil pollution—and the increased incidence of infectious diseases.

Conclusion: Environmental pollution has extensive and serious impacts on human health and the spread of infectious diseases. Effective pollution control and reduction can play a crucial role in lowering infectious disease rates. Further research is essential to deepen our understanding of this issue and develop effective strategies.

Keywords: Environmental pollution, Infectious diseases, Air pollution, Water pollution, Soil pollution.

Introduction

Many environmental pollutants significantly impact human diseases, contributing to climate change and compromising public and individual health, ultimately leading to increased mortality and disease rates (1). The effects of these pollutants on human health are especially severe and widespread in developing countries, where healthcare and regulatory infrastructures are less robust (2). Oil pollution, for instance, can severely affect marine ecosystems, posing significant environmental and health risks (3). Oil spills lead to extensive destruction of natural habitats and can result in a rise in diseases caused by chemical pollutants (4).

Air pollution is recognized as a major factor in the development of lung cancer and can contribute to the spread of infectious diseases (5). Water pollution, arising from industrial waste, using detergents and fertilizers, and waste disposal, can cause communicable diseases and serious health problems in humans, while also threatening aquatic life (6).

Climate change and environmental pollution play critical roles in increasing cancer incidence by affecting air quality, nutrition patterns, exposure to chemical pollutants, and potentially altering patterns of infectious diseases (7). Air pollution has a significant impact on respiratory



infections. In Poland, a direct correlation between pollutants such as PM_{2.5}, PM₁₀, and NO₂ with increased hospital admissions due to RSV infections was reported (8). Nitrogen oxides, sulfur dioxide, volatile organic compounds (VOCs), dioxins, and polycyclic aromatic hydrocarbons (PAHs) are recognized as harmful air pollutants for humans, with carbon monoxide capable of causing direct poisoning when inhaled in large amounts. Additionally, pollution-induced climate change affects the geographic distribution of many infectious diseases (6).

Soil pollution is associated with the prevalence of certain infectious diseases. The presence of heavy metals such as lead and cadmium in agricultural soils leads to reduced crop quality and an increased risk of transmitting pathogens to humans (9). This issue is particularly concerning in rural areas where agriculture is the primary source of income (10). Soil pollution, as a significant factor in the spread of infectious diseases, must be addressed. Controlling and reducing the use of chemicals and heavy metals in agriculture, and adopting sustainable soil management practices, are among the measures that can help mitigate the health risks associated with soil pollution (9, 10).

Infectious diseases can significantly affect thyroid function. Recently, the SARS-CoV-2 pandemic has provided critical lessons. Understanding how environmental factors and pollutants impact thyroid function is crucial for developing preventive strategies and policies that ensure healthy growth and metabolism in future generations, while preventing thyroid diseases and cancer in adults and the elderly (11). Given that infectious diseases can easily spread from one country to another, international organizations, governments, and scientists must collaborate to identify these diseases in the wastewater of high-traffic urban areas and major transportation hubs such as bus stations, train stations, and airports. This effort will help prevent the spread of these diseases to new areas (12). The

COVID-19 pandemic demonstrated that the air quality in schools can be improved. The pandemic has led to increased attention to proper ventilation, which not only enhances indoor air quality but also reduces the risk of contracting infectious diseases (13).

The impact of environmental pollution on public health and the spread of infectious diseases is deeply concerning. However, comprehensive and systematic research in this area has been limited. Therefore, further studies are needed to better understand this relationship and to develop effective strategies to mitigate these risks (10). Collective action plays a crucial role in reducing environmental degradation and lowering the incidence of pollution-related diseases (14).

This study aimed to review existing studies and analyze the impact of environmental pollution on infectious diseases. Additionally, it sought to identify the knowledge gaps and provide recommendations for future research and the development of public policies in this area.

Methods

This qualitative library-based research investigated the relationship between environmental pollution and infectious diseases through a systematic review of credible scientific literature. The literature search was conducted using several electronic databases, including PubMed, Scopus, Web of Science, and Google Scholar. These databases were selected to ensure a comprehensive retrieval of peer-reviewed articles related to environmental pollution and infectious diseases.

The search strategy employed a combination of relevant keywords and phrases to maximize the relevance of the retrieved articles. The databases were checked for articles published between 2020 and 2024. Specific search terms included “environmental pollution,” “air pollution,” “water pollution,” “soil pollution,” “infectious diseases,”

“respiratory infections,” “waterborne diseases,” and “heavy metals.” These terms were combined using Boolean operators (AND, OR) to refine the results effectively. For instance, the search query “air pollution AND respiratory infections” was utilized to identify articles specifically addressing the relationship between these factors.

The studies included in this review were selected based on specific inclusion and exclusion criteria. The inclusion criteria encompassed peer-reviewed articles published in English from recent and updated studies, empirical studies investigating the impact of air, water, and soil pollution on the incidence and severity of specific infectious diseases, and articles focusing on the effects of pollutants such as particulate matter, heavy metals, and pathogens on human health. Conversely, non-peer-reviewed articles, commentaries, and editorials were excluded, as well as studies that did not provide empirical data related to infectious diseases or were not

directly relevant to the study's focus on environmental pollution.

The systematic literature search resulted in 500 sources. After removing duplicates, 450 sources were screened, and 400 were excluded for irrelevance or non-compliance with inclusion criteria. This left 50 full-text sources to be assessed for relevance. Of these, 30 studies were excluded with justifications provided, resulting in 26 studies included in the qualitative synthesis, corresponding to the 26 references listed in the Reference section. The consistency between the number of selected studies and the references ensures accuracy and compliance with the PRISMA guidelines. The quality of these studies was assessed based on PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, considering several indicators, including study design, sample size, data collection methods, analytical techniques, and clarity of results (Figure 1).

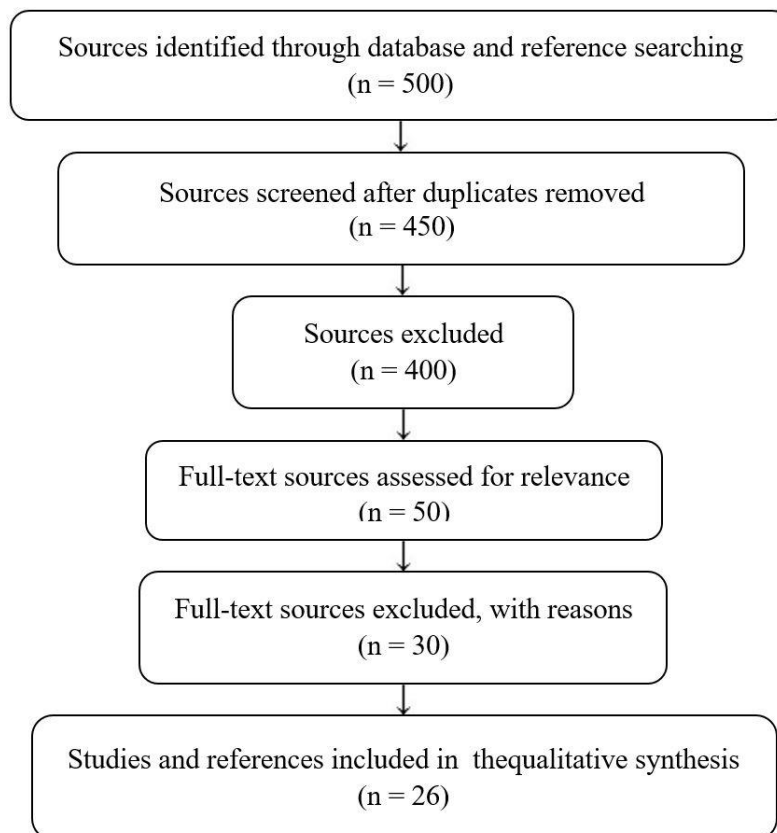


Figure 1: Flow diagram of the study selection process.

Results

Environmental pollution—particularly air, water, and soil pollution—significantly contributes to the increased incidence and severity of infectious diseases. Numerous studies have documented the correlation between different types of pollutants and their adverse health effects. To provide a

comprehensive overview of key findings from the selected studies, Table 1 summarizes the 26 references, highlighting the types of environmental pollution examined and their associated health impacts. This table is valuable for understanding how various pollutants contribute to public health risks, particularly in vulnerable populations and regions.

Table 1: Summary of selected references on environmental pollution and health impacts.

<i>Reference Number</i>	<i>Type of Study</i>	<i>Key Findings</i>	<i>Relevance to Infectious Diseases</i>
1	Review	Highlights the impact of air, water, and soil pollution on health	Shows how pollutants can weaken immune systems, increasing disease risk
2	Book Chapter	Discusses purification processes for water and air	Provides insights into mitigating pollutant-induced health risks
3	Book Chapter	Examines the effects of water pollution on marine life	Highlights the spread of waterborne pathogens due to pollution
4	Book Chapter	Focuses on oil spills affecting soil and water quality	Discusses soil contamination leading to bacterial growth
5	Review	Reviews air pollution's role in respiratory diseases	Links air pollution to increased respiratory infections
6	Conference Paper	Explores pollution's impact on sustainable development goals	Emphasizes public policies for pollution control to reduce diseases
7	Review	Analyzes the relationship between pollution and climate change	Discusses indirect effects on infectious disease spread
8	Journal Article	Shows the effects of air pollutants on children's respiratory health	Demonstrates the vulnerability of children to airborne infections
9	Journal Article	Explores pollutants' impact on endocrine health	Highlights the role of pollutants in weakening immunity
10	Journal Article	Reviews the impact of environmental changes on disease spread	Identifies climate-related pollution as a trigger for disease outbreaks
11	Journal Article	Discusses recent advances in air pollution research	Provides updated data on the health impacts of air pollution
12	Journal Article	Focuses on detecting diseases through wastewater monitoring	Highlights the importance of tracking pollutants in water systems
13	Journal Article	Examines how ventilation reduces airborne virus transmission	Links poor air quality to increased risk of respiratory infections
14	Review	Studies long-term collective actions against pollution	Emphasizes community efforts in reducing health risks

15	Journal Article	Explores the link between air quality and viral infections	Discusses how polluted air increases the risk of respiratory diseases
16	Journal Article	Examines long-term exposure to air pollution and immune health	Shows how pollutants compromise immune responses
17	Journal Article	Discusses current challenges in ensuring safe drinking water	Highlights the link between waterborne pathogens and infectious diseases
18	Book Chapter	Reviews the impact of climate change on waterborne infections	Discusses preventive measures to reduce disease transmission
19	Book Chapter	Analyzes agricultural pollutants in soil	Shows how contaminated soil can harbor infectious pathogens
20	Review	Explores urban pollution and its impact on health	Discusses respiratory infections linked to urban air pollution
21	Journal Article	Analyzes public health policies for water sanitation	Emphasizes hygiene measures to reduce waterborne diseases
22	Journal Article	Studies the impact of heavy metals on crop health	Discusses the transmission of heavy metals through food and water
23	Journal Article	Explores different soil management strategies	Emphasizes the importance of soil health in preventing infections
24	Journal Article	Discusses how climate change exacerbates health risks	Identifies pollution as a contributing factor in infectious diseases
25	Journal Article	Reviews the multifaceted health effects of climate change	Highlights the compounded impact of pollution and climate change
26	Journal Article	Provides a global overview of pollution and its health impacts	Summarizes key health risks associated with various pollutants

Air Pollution impact on infectious diseases

Air pollution, which includes particulate matter and harmful gases like NO₂, is linked to a higher risk of respiratory diseases such as pneumonia, influenza, and other viral respiratory infections (15). The review shows that as the levels of these pollutants rise, the number of hospitalizations due to respiratory infections also increases. Moreover, prolonged exposure to air pollution can weaken the immune system, making individuals more susceptible to infectious diseases. This study also found evidence of a direct correlation between air pollution and the increased occurrence of lung cancer and other respiratory-related diseases (16).

Water pollution and waterborne diseases

In the realm of water pollution, the results demonstrate that the prevalence of waterborne diseases such as cholera, dysentery, and typhoid fever is higher in areas with elevated levels of water contamination. These pollutants primarily stem from the discharge of industrial and urban wastewater, the use of chemical fertilizers in agriculture, and the dumping of waste into water sources. Water pollution directly leads to a decline in the quality of drinking water sources, which in turn contributes to the increased spread of infectious diseases in vulnerable communities (17). Additionally, there is evidence that climate change and water

pollution are altering the geographical distribution of infectious diseases, causing regions previously unaffected by these diseases to become new hotspots (18).

Soil pollution's role in infectious disease spread

Soil pollution also plays a critical role in the spread of infectious diseases (19). This study found that the presence of heavy metals such as lead, cadmium, and mercury in agricultural soils is associated with reduced food quality and an increased risk of transmitting pathogens to humans. These heavy metals can directly affect the growth of microorganisms, creating conditions conducive to the spread of infectious diseases. Furthermore, chemical pollutants in the soil can be transferred to humans through the food chain, leading to the development of various illnesses, including infectious diseases and cancers. This matter is especially troubling in rural regions where the main source of livelihood is agriculture. Studies have shown that controlling and reducing the use of chemicals in agriculture can effectively mitigate the health risks associated with soil pollution.

Discussion

This study offers an in-depth investigation into the role of environmental pollution and its impacts on public health, revealing significant links between pollution and the spread and severity of infectious diseases. Findings align with existing literature, affirming that environmental pollutants harm individual health and can exacerbate disease prevalence and worsen health outcomes.

Air Pollution

Air pollution, particularly in urban areas, poses a critical threat to public health, primarily through particulate matter, toxic gases, and various chemical compounds (20). The results indicate a direct association between air pollution and

elevated mortality from respiratory and cardiovascular diseases, which is consistent with prior findings. However, a noticeable gap remains regarding the long-term impacts of low-level pollutants on neurological health. Addressing this issue through regulatory measures, such as reducing greenhouse gas emissions and particulate matter, could significantly lower the burden of air-pollution-related diseases in high-density areas.

Water Pollution

The role of water pollution in spreading diseases such as cholera, typhoid fever, and hepatitis A is well-documented and supported by this study. Contaminated water sources, especially in areas with limited access to clean drinking water, are linked to disease outbreaks. These findings underscore the need for healthcare infrastructure improvement and increased access to sanitary water for at-risk communities. Prior research supports these observations, but certain studies highlight that underreporting of waterborne diseases in developing regions may obscure the true scale of the problem. Enhanced water purification and public health education programs would mitigate the spread of waterborne diseases (21).

Soil Pollution

Soil pollution, through heavy metals like lead, cadmium, and mercury, directly threatens public health by introducing contaminants into the food chain (22). This study confirms a link between soil pollution and diseases such as cancer and gastrointestinal disorders, which aligns with existing evidence. However, some studies report variability in health outcomes depending on regional soil composition and agricultural practices (23). This variability underscores the need for stricter monitoring of industrial and agricultural chemicals. Adopting natural fertilizers and managing industrial waste could reduce soil pollution and related health risks.

Climate Change and Environmental Health

As a worsening factor, climate change significantly influences the prevalence of infectious and non-infectious diseases (24). This study shows that climate change, with rising temperatures and altered precipitation patterns, creates conditions favorable for infectious pathogen spread, a finding consistent with previous research. However, the compounded effects of climate change and pollution on global health remain underexplored (25). Increased international cooperation, effective environmental policies, and advancements in pollution control technologies are critical for mitigating these impacts on public health (26).

Study Limitations

This study primarily relies on existing literature, which may introduce bias due to publication limitations and regional variability in study outcomes. Additionally, data scarcity in low-resource settings limits the generalizability of findings across diverse environmental and socioeconomic contexts. The use of self-reported data in some studies reviewed may also affect result accuracy. These limitations highlight the importance of further empirical research to comprehensively understand the intricate relationship between environmental pollution and health.

Implications for Policy and Practice

The findings underscore an urgent need for comprehensive policies to reduce pollution and safeguard public health. Strengthened international collaboration, adoption of advanced monitoring technologies, and effective environmental policies are necessary to address the global health impacts of pollution. Policymakers should prioritize strategies tailored to the unique needs of affected communities, particularly those in resource-limited areas. Integrating pollution reduction measures into public health agendas will be critical to mitigating

health risks and controlling pollution-related diseases.

Addressing environmental pollution's health impacts requires a committed, multi-level response at national and international levels. This study reinforces the necessity of pollution reduction measures to protect public health and control the spread of associated diseases.

This study's novel contribution lies in its holistic analysis of pollution types and their collective influence on infectious disease rates, especially in developing regions where healthcare resources are often limited. By emphasizing the pressing need for both national policies and international collaborations to reduce pollutants, this study calls for stronger policies on water resource management, stricter air pollution controls, and limitations on harmful agricultural chemicals. These strategies could collectively mitigate pollution and reduce related health issues in vulnerable populations.

Conclusion

This study provides critical insights into the significant impacts of air, water, and soil pollution on public health, particularly regarding the spread of infectious diseases. The findings underscore the urgency for targeted environmental policies and practical interventions to curb pollution-related health risks. Specifically, air pollution has been identified as a major contributor to respiratory infections, water pollution increases waterborne diseases, and soil pollution affects food safety, highlighting the complex but clear link between environmental contamination and disease prevalence. For future research, further investigation into specific pollutants and their long-term effects on health is essential, as is the development of localized interventions that consider socio-economic and environmental differences across regions. Policymakers and health officials are encouraged to prioritize sustainable environmental management practices,

ensuring that the reduction of environmental pollution remains central to public health strategies. Addressing these challenges collectively on a global scale has the potential to reduce pollution-driven health crises and foster a healthier global population.

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Data Availability

All data used to support the findings of this study are included in the article.

Conflicts of Interest

The author declares no conflicts of interest.

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