Intersecting Environmental and Health Crises: A Review of Respiratory And Infectious Disease Risks in Changing Ecosystems

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Abstract

Background: Environmental change—driven by climate variability, pollution, urbanization, and ecosystem disruption—has emerged as a major determinant of population health.

Objective: This review aims to synthesize current evidence on how environmental changes influence the emergence, transmission, and severity of respiratory diseases and infectious outbreaks.

Methods: A narrative or systematic literature review was conducted using peer-reviewed studies focusing on climate factors, air quality, ecosystem disruption, and disease outcomes.

Results: Findings indicate strong associations between environmental stressors and increased respiratory morbidity, altered infectious disease dynamics, and heightened outbreak risks.

Conclusion: Integrated environmental and health strategies are essential to mitigate disease risks in changing ecosystems.

Keywords: Environmental change; respiratory diseases; Infectious outbreaks; Climate change; Ecosystem health; Public health

INTRODUCTION

Environmental change has emerged as one of the most significant global challenges influencing human health in the twenty-first century. Rapid climate change, increasing air pollution, urban expansion, deforestation, and ecosystem degradation have collectively altered environmental conditions in ways that directly and indirectly affect disease patterns. These changes are no longer viewed solely as environmental or ecological concerns but are increasingly recognized as critical determinants of population health, contributing to rising morbidity, mortality, and health system pressures worldwide (Watts et al., 2019; Romanello et al., 2023).

Respiratory diseases are among the health conditions most strongly linked to environmental factors. Exposure to ambient air pollutants such as particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide, and ozone has been consistently associated with increased incidence and severity of asthma, chronic obstructive pulmonary disease (COPD), acute respiratory infections, and premature mortality (GBD 2019 Risk Factors Collaborators, 2020; Schraufnagel et al., 2019). Climate-related stressors, including rising temperatures, heat waves, and altered weather patterns, further exacerbate respiratory vulnerability by intensifying air pollution levels, extending pollen seasons, and increasing susceptibility to respiratory infections (Li et al., 2022).

In parallel, environmental change plays a central role in the emergence and transmission of infectious diseases. Climate variability influences pathogen survival, vector distribution, and human–animal interactions, thereby reshaping infectious disease dynamics. Ecosystem disruption caused by deforestation, biodiversity loss, and land-use change has been linked to increased zoonotic spillover events, facilitating the emergence of novel infectious diseases and recurrent outbreaks (Keesing et al., 2021; Morse et al., 2020). Extreme weather events such as floods, droughts, and storms further increase infectious risks by disrupting water and sanitation systems, displacing populations, and overwhelming public health infrastructures (Ryan et al., 2021).

The concept of intersecting environmental and health crises highlights the convergence of these challenges, where environmental degradation simultaneously amplifies respiratory disease burden and infectious outbreak risks. These interactions are particularly evident in vulnerable populations, including children, older adults, individuals with chronic illnesses, and communities facing socioeconomic disadvantage. In such settings, environmental exposures compound existing health inequities, leading to disproportionate disease impacts and reduced resilience to health emergencies (Haines & Ebi, 2019).

Despite growing recognition of these links, evidence remains fragmented across disciplines such as environmental science, epidemiology, and public health. Many studies focus on isolated outcomes without fully addressing the interconnected pathways through which environmental change affects both respiratory and infectious diseases. Therefore, this review aims to synthesize current evidence on how changing ecosystems shape respiratory and infectious disease risks, adopting an integrated perspective that supports preventive strategies, informed policy-making, and resilient health systems in the context of accelerating environmental change.

METHODOLOGY

This review adopted a structured narrative review design to synthesize current evidence on the relationships between environmental change, respiratory diseases, and infectious disease risks. A comprehensive literature search was conducted to identify peer-reviewed studies examining environmental determinants—such as climate variability, air pollution, ecosystem disruption, and urbanization—and their associations with respiratory morbidity and infectious disease emergence.

The search was performed across major scientific databases, including **PubMed**, **Scopus**, **Web of Science**, and **Google Scholar**. Searches covered publications from January 2015 to December 2024 to capture recent and relevant evidence. Key search terms and their combinations included: *environmental change*, *climate change*, *air pollution*, *ecosystem disruption*, *respiratory diseases*, *infectious diseases*, and *disease outbreaks*. Boolean operators ("AND," "OR") were used to refine and optimize retrieval.

Studies were eligible if they: (1) were published in English in peer-reviewed journals; (2) examined human health outcomes related to respiratory or infectious diseases; and (3) explicitly addressed environmental or ecosystem-level exposures. Reviews, observational studies, and modeling studies were included to allow broad evidence synthesis. Articles focusing exclusively on non-health environmental outcomes, animal-only studies without human health relevance, editorials, and commentaries were excluded.

Titles and abstracts were screened for relevance, followed by full-text assessment of eligible articles. Data extraction focused on study design, environmental exposures, disease outcomes, population characteristics, and key findings. Extracted information was organized into thematic categories reflecting respiratory disease risks, infectious disease dynamics, and intersecting pathways.

A thematic synthesis approach was applied to integrate findings across diverse study designs. Evidence was interpreted using an ecosystem-based and public health lens, emphasizing shared environmental drivers and interaction pathways. This approach enabled identification of consistent patterns, knowledge gaps, and implications for integrated disease prevention and health system preparedness.

Environmental Changes and Respiratory Disease Risks

Environmental change plays a central role in shaping the global burden of respiratory diseases. Alterations in air quality, climate conditions, urban environments, and indoor exposures have been consistently linked to increased respiratory morbidity and mortality. These environmental stressors not only exacerbate pre-existing respiratory conditions but also contribute to the development of new respiratory illnesses, particularly among vulnerable populations.

Ambient air pollution is one of the most extensively studied environmental risk factors for respiratory disease. Fine particulate matter ($PM_{2.5}$), coarse particles (PM_{10}), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and ground-level ozone (O_3) have been strongly associated with asthma exacerbations, chronic obstructive pulmonary disease (COPD) progression, acute lower respiratory infections, and premature respiratory-related mortality (Schraufnagel et al., 2019; GBD 2019 Risk Factors Collaborators, 2020). Long-term exposure to $PM_{2.5}$ penetrates deep into the respiratory tract, inducing inflammation, oxidative stress, and impaired immune responses, thereby increasing susceptibility to infections and reducing lung function over time. Short-term exposure peaks are also linked to increased hospital admissions for respiratory symptoms, particularly in children and older adults.

Climate change acts as a multiplier of respiratory health risks through rising temperatures, heat waves, and changing weather patterns. Elevated temperatures enhance the formation of ozone and intensify wildfire frequency, both of which significantly worsen air quality (Reid et al., 2016). Heat stress can exacerbate respiratory symptoms by increasing respiratory demand and dehydration, while extreme cold events have been associated with higher rates of respiratory infections due to impaired mucociliary clearance and immune defenses (Li et al., 2022). In addition, climate change has extended pollen seasons and increased allergen concentrations, contributing to the growing prevalence and severity of allergic rhinitis and asthma worldwide.

Rapid urbanization has altered exposure patterns to respiratory hazards. High population density, traffic congestion, and industrial activities elevate urban air pollution levels, disproportionately affecting residents of low-income neighborhoods located near major roadways or industrial zones (Haines & Ebi, 2019). Urban heat islands further compound respiratory stress by intensifying temperature extremes and pollutant concentrations.

Moreover, limited access to green spaces reduces opportunities for natural air filtration and respiratory health promotion.

Indoor air quality represents a critical yet often underrecognized determinant of respiratory health. Exposure to household air pollution from biomass fuel use, tobacco smoke, mold, and volatile organic compounds is strongly associated with childhood pneumonia, asthma development, and chronic respiratory conditions in adults (WHO, 2021). Climate-driven factors such as increased humidity and flooding promote indoor mold growth, further aggravating respiratory symptoms and allergic responses.

Table 1. Environmental Factors and Associated Respiratory Health Outcomes

Environmental factor	**Key exposure pathways**	**Associated respiratory outcomes**
Ambient air pollution ($PM_{2·5}$, PM_{10}, NO_2, O_3)	Outdoor air inhalation, traffic and industrial emissions	Asthma exacerbations, COPD progression, respiratory infections, premature mortality
Climate change (heat waves, temperature extremes)	Increased ozone formation, wildfire smoke, thermal stress	Respiratory distress, asthma attacks, infection susceptibility
Urbanization	Traffic density, reduced green space, heat islands	Chronic respiratory symptoms, increased hospital admissions
Indoor air pollution	Biomass fuels, tobacco smoke, mold, VOCs	Childhood pneumonia, asthma development, chronic lung disease

Collectively, these environmental changes interact across outdoor and indoor settings to amplify respiratory disease risks. The convergence of air pollution, climate stressors, and urban living conditions creates cumulative exposure pathways that strain respiratory health and increase healthcare demand. Addressing respiratory disease prevention therefore requires integrated environmental policies that reduce pollution, mitigate climate impacts, and promote healthy living environments.

Environmental Change and Infectious Disease Emergence

Environmental change is a major driver of infectious disease emergence, transmission, and re-emergence. Climate variability, ecosystem disruption, and human-induced environmental transformations reshape the ecological conditions that govern pathogen survival, vector distribution, and human exposure pathways. As ecosystems change, the balance between hosts, pathogens, and environments is altered, increasing the likelihood of infectious disease outbreaks and the appearance of novel pathogens.

Climate variables such as temperature, rainfall, and humidity exert strong influences on pathogen viability and transmission dynamics. Warmer temperatures can accelerate microbial replication and prolong the environmental persistence of viruses and bacteria, while changes in precipitation patterns modify water quality and sanitation conditions (Carlson et al., 2022). Seasonal and interannual climate fluctuations have been associated with altered incidence patterns of influenza, respiratory syncytial virus, and other respiratory pathogens, as well as enteric infections linked to contaminated water sources. Extreme weather events—such as floods, heatwaves, and droughts—can overwhelm public health infrastructure, disrupt healthcare access, and facilitate the rapid spread of infectious diseases among displaced populations.

Deforestation, biodiversity loss, agricultural expansion, and urban encroachment into natural habitats increase contact between humans, wildlife, and domestic animals, creating conditions conducive to zoonotic spillover. Reduced biodiversity may eliminate natural buffers that regulate pathogen circulation, allowing disease reservoirs to proliferate (Keesing et al., 2021). Numerous emerging infectious diseases, including novel coronaviruses and hemorrhagic fevers, have been linked to land-use change and ecosystem degradation that bring humans into closer contact with animal hosts. These processes are especially pronounced in rapidly developing regions where environmental regulation may lag behind land transformation.

Climate change significantly influences the geographic distribution and seasonal activity of disease vectors such as mosquitoes and ticks. Rising temperatures and altered rainfall patterns have expanded the habitable range of vectors responsible for transmitting malaria, dengue, chikungunya, and Zika virus, exposing previously unaffected populations to new infectious risks (Ryan et al., 2021). Warmer climates also shorten pathogen incubation periods within vectors, increasing transmission efficiency and outbreak potential. These shifts complicate disease surveillance and challenge existing public health control strategies.

Environmental change undermines water security and sanitation systems, increasing the risk of waterborne and foodborne diseases. Flooding can contaminate drinking water supplies, while drought conditions may concentrate pathogens in limited water resources. Climate-driven disruptions to wastewater management and hygiene infrastructure disproportionately affect low-resource settings, where outbreaks of cholera, typhoid fever, and other enteric infections remain a persistent threat (World Health Organization, 2021). These conditions highlight the interconnected nature of environmental management and infectious disease prevention.

Table 2. Environmental Drivers and Pathways of Infectious Disease Emergence

Environmental change factor	Primary pathway	Associated infectious disease risks
Climate variability	Altered pathogen survival and seasonality	Influenza, respiratory viral infections
Deforestation and land-use change	Increased human–wildlife interaction	Zoonotic spillover, emerging viral diseases
Vector habitat expansion	Changes in temperature and rainfall	Malaria, dengue, Zika virus
Water and sanitation disruption	Contaminated water sources	Cholera, typhoid, diarrheal diseases

Overall, environmental change acts through multiple, interconnected pathways to accelerate infectious disease emergence. Climate variability, ecosystem disruption, vector expansion, and compromised water systems collectively intensify outbreak risks. Understanding these links is critical for developing integrated surveillance systems and preventive strategies that anticipate infectious threats in a rapidly changing environment.

Interactions Between Respiratory and Infectious Diseases

Respiratory and infectious diseases are deeply interconnected, sharing common environmental drivers and biological pathways that amplify disease burden in the context of environmental change. Rather than acting independently, environmental exposures such as air pollution, climate stressors, and ecosystem disruption often create synergistic conditions in which respiratory vulnerability and infectious disease risk reinforce one another, leading to more severe health outcomes and complex public health challenges.

One of the most well-documented interaction pathways involves air pollution and respiratory infections. Chronic exposure to particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide, and ozone impairs mucociliary clearance, disrupts epithelial barrier integrity, and induces chronic airway inflammation. These changes weaken innate and adaptive immune responses in the respiratory tract, increasing susceptibility to viral and bacterial infections such as influenza, pneumonia, and emerging respiratory viruses (Schraufnagel et al., 2019; Ciencewicki & Jaspers, 2007). Epidemiological studies have shown that populations exposed to higher pollution levels experience increased infection incidence, greater disease severity, and higher hospitalization and mortality rates during respiratory outbreaks.

Climate change further intensifies these interactions by modifying both respiratory vulnerability and infectious transmission dynamics. Heatwaves, temperature variability, and extreme weather events can exacerbate chronic respiratory conditions while simultaneously influencing pathogen survival and transmission efficiency. For example, individuals with asthma or chronic obstructive pulmonary disease (COPD) are more likely to experience severe complications during viral respiratory infections, particularly under conditions of poor air quality and thermal stress (Li et al., 2022). Wildfire smoke exposure provides a striking example of this convergence, as it both aggravates respiratory disease and increases respiratory infection risk by suppressing pulmonary immune defenses (Reid et al., 2016).

The interaction between respiratory and infectious diseases is also shaped by socioeconomic and environmental inequities. Populations living in densely populated urban areas, informal settlements, or regions with limited access to healthcare face simultaneous exposure to environmental hazards and elevated infection risk. In these contexts, pre-existing respiratory conditions amplify infectious disease severity, while recurrent infections accelerate respiratory function decline, creating a cyclical disease burden (Haines & Ebi, 2019). Children, older adults, and individuals with chronic illnesses are particularly vulnerable to these overlapping risks.

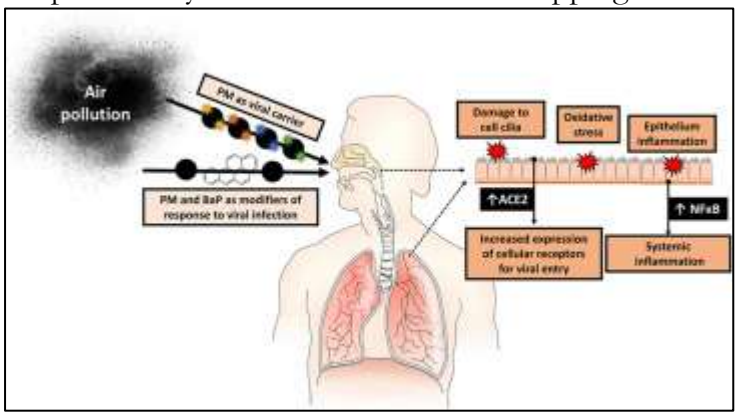

Figure 1. Interaction Pathways Between Environmental Change, Respiratory Vulnerability, and Infectious Disease Risk

This figure illustrates how environmental stressors (air pollution, climate extremes, and ecosystem disruption) increase respiratory vulnerability by impairing lung function and immune defenses, thereby facilitating infectious disease transmission and severity. The bidirectional relationship demonstrates how infections further worsen respiratory health, creating a reinforcing cycle of disease risk under changing environmental conditions.

From a public health perspective, these interactions highlight the need for integrated prevention and response strategies. Traditional disease-specific approaches may underestimate the compounded effects of environmental exposure on respiratory and infectious outcomes. Addressing air quality, climate resilience, and environmental protection can reduce both chronic respiratory morbidity and the severity of infectious disease outbreaks. Recognizing and responding to the interconnected nature of respiratory

and infectious diseases is therefore essential for strengthening health system preparedness in an era of accelerating environmental change.

Public Health Implications and Health System Challenges

The growing intersection between environmental change, respiratory diseases, and infectious outbreaks presents significant challenges for public health systems worldwide. As environmental stressors intensify, health systems are increasingly confronted with complex disease patterns characterized by higher incidence, greater severity, and recurrent surges in demand. These trends underscore the need for integrated, preventive, and adaptive public health approaches that move beyond traditional disease-specific frameworks.

One of the primary public health implications is the escalating burden on healthcare services. Increased exposure to air pollution, heat extremes, and climate-related disasters contributes to higher rates of respiratory exacerbations and infectious disease outbreaks, resulting in overcrowded emergency departments, increased hospital admissions, and strained critical care capacity (Romanello et al., 2023). During extreme environmental events—such as heatwaves or wildfires—health systems often experience simultaneous spikes in respiratory distress and infectious complications, challenging surge capacity and continuity of care.

Environmental change also complicates disease surveillance and early warning systems. Shifting climate patterns and altered vector distributions make infectious disease trends less predictable, reducing the effectiveness of historical surveillance models. Public health authorities must therefore integrate environmental and climate data into disease monitoring systems to anticipate outbreak risks more accurately (World Health Organization, 2021). However, many health systems—particularly in low- and middle-income countries—lack the infrastructure, workforce capacity, and digital integration needed to support such advanced surveillance approaches.

Health inequities represent another critical challenge. Vulnerable populations, including children, older adults, individuals with chronic respiratory conditions, and communities with lower socioeconomic status, are disproportionately affected by environmental exposures and infectious threats. These groups often reside in areas with higher pollution levels, limited green spaces, inadequate housing, and reduced access to healthcare services. Environmental change thus amplifies existing health disparities, placing ethical and equity considerations at the center of public health planning (Haines & Ebi, 2019).

From a health system preparedness perspective, workforce resilience and intersectoral coordination are essential. Healthcare workers face increased workloads and occupational health risks during environmental crises and disease outbreaks. At the same time, effective responses require collaboration between public health agencies, environmental authorities, urban planners, and emergency management sectors. Fragmented governance structures and siloed policies can undermine timely and coordinated action, limiting the effectiveness of preventive and response strategies (Watts et al., 2019).

Finally, environmental change highlights the importance of shifting public health priorities toward prevention and resilience. Reducing air pollution, strengthening climate adaptation measures, and promoting healthy urban environments can substantially decrease both respiratory disease burden and infectious outbreak severity. Investments in environmental protection and climate-resilient health systems should therefore be viewed not only as sustainability initiatives but also as foundational components of disease prevention and health security. Addressing these interconnected challenges is critical to ensuring that public health systems remain responsive and resilient in an era of accelerating environmental and health crises.

DISCUSSION

This review highlights the complex and interdependent relationships between environmental change, respiratory disease burden, and the emergence of infectious diseases. The findings demonstrate that environmental stressors—particularly air pollution, climate variability, ecosystem disruption, and urbanization—do not act in isolation but interact through shared biological, ecological, and social pathways that intensify health risks. By synthesizing evidence across environmental health, epidemiology, and public health literature, this review advances an integrated understanding of how changing ecosystems contribute to converging respiratory and infectious disease challenges.

A key insight from the reviewed evidence is the synergistic nature of environmental exposures. Air pollution and climate-related factors simultaneously weaken respiratory defenses and facilitate infectious transmission, thereby increasing disease severity and healthcare utilization. This interaction helps explain why populations exposed to high pollution levels often experience disproportionate morbidity and mortality during respiratory infectious outbreaks. Such findings align with broader environmental health research emphasizing cumulative exposure and multi-hazard risk, rather than single-risk-factor models.

Another important contribution of this review is the emphasis on ecosystem disruption and zoonotic disease emergence. Land-use change, biodiversity loss, and intensified human–wildlife contact continue to drive spillover events that pose long-term global health threats. When combined with climate-driven shifts in vector ecology and compromised water and sanitation systems, these processes create fertile conditions for both novel and re-emerging infectious diseases. The convergence of these drivers underscores the relevance of integrated frameworks that link environmental stewardship with disease prevention.

From a public health perspective, the findings highlight critical gaps in preparedness and governance. Many health systems remain reactive, addressing disease outcomes without adequately tackling upstream environmental determinants. Surveillance systems frequently operate separately from environmental monitoring, limiting their capacity to anticipate climate-sensitive outbreaks. Strengthening cross-sectoral collaboration and integrating environmental data into health decision-making are therefore essential steps toward improving early warning systems and response capacity.

Health equity emerged as a central theme across the reviewed studies. Vulnerable populations—particularly those in low-income settings, densely populated urban areas, and regions experiencing rapid environmental change—bear a disproportionate share of respiratory and infectious disease impacts. Environmental injustice amplifies existing social and health inequities, reinforcing the need for policies that prioritize at-risk communities in environmental protection and health system planning.

Despite its strengths, this review has limitations. As a narrative synthesis, it may be subject to selection bias and variability in study quality. Additionally, the heterogeneity of environmental exposures and disease outcomes limits direct comparison across studies. Future research should prioritize longitudinal, interdisciplinary studies that quantify combined environmental exposures and their long-term health impacts.

Overall, the discussion reinforces that environmental change is not a peripheral concern but a central driver of contemporary respiratory and infectious disease risks. Addressing these intersecting crises requires a paradigm shift toward preventive, ecosystem-informed public health strategies that enhance resilience, promote equity, and safeguard population health in an era of accelerating environmental transformation.

CONCLUSION

This review demonstrates that environmental change is a critical and unifying driver of both respiratory diseases and infectious disease emergence, operating through interconnected ecological, biological, and social pathways. Air pollution, climate variability, ecosystem disruption, and rapid urbanization collectively alter exposure patterns, weaken respiratory defenses, and facilitate pathogen transmission, thereby amplifying disease burden and increasing the frequency and severity of outbreaks. These findings confirm that respiratory and infectious diseases should not be addressed as isolated health challenges but as interconnected outcomes of broader environmental transformations.

The evidence synthesized in this review highlights the importance of adopting integrated, ecosystem-based approaches to disease prevention and health protection. Strategies that reduce environmental pollution, mitigate climate impacts, and preserve ecosystem integrity offer dual benefits by lowering chronic respiratory morbidity and reducing vulnerability to infectious threats. Incorporating environmental and climate data into disease surveillance and early warning systems is essential for improving outbreak preparedness and enabling timely public health responses.

Furthermore, this review underscores the role of health equity in addressing environmental health risks. Vulnerable populations continue to experience disproportionate exposure to environmental hazards and limited access to healthcare resources, resulting in unequal disease impacts. Addressing these disparities requires coordinated policy actions that prioritize environmental justice, strengthen community resilience, and ensure equitable access to preventive and healthcare services.

In conclusion, confronting the intersecting environmental and health crises of the modern era demands a shift from reactive, disease-centered responses toward proactive, preventive, and systems-oriented public health strategies. Strengthening collaboration across environmental, health, and policy sectors is vital to building resilient health systems capable of responding effectively to the evolving challenges posed by environmental change.

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