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Climate Change and Infectious Disease Patterns: A Comprehensive Review of Current Evidence

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ABSTRACT

People are starting to see climate change as a main factor shaping the spread of infectious diseases and global health conditions through various routes. This review summarizes the latest findings on how important climate elements such as temperature, humidity, and major weather changes can affect how pathogens and vectors are active and transmitted. Notably, diseases carried by insects, including malaria, dengue, and Lyme, are spreading further and are being found in places where they did not exist before. As temperatures rise, floods occur more often, infrastructure is put to the test, and cholera and salmonellosis cases can increase greatly. Poor infrastructure, crowded cities, and the inability to cope in such places mean that coastal and tropical regions with limited resources are hit harder by these new risks. We look at approaches such as climate-informed systems that detect diseases early, insect controls like Wolbachia releases, and health facilities that can deal with climate change. Innovation has not filled large gaps in research and policy, especially in prediction that merges human mobility, medical resources, and social and political instability. It is concerning that health only gets around 1% of climate finance worldwide, which makes it difficult for places vulnerable to climate change to adapt. We advise including One Health surveillance in national health policies, searching for more flexible ways to finance investors, and conducting more research on how to respond better to extreme events. New and rising infectious diseases prompted by climate change require fast and informed action from many industries around the world.

Keywords: Vector-borne diseases, Climate-informed systems, Public health adaptation, One health surveillance, Climate-health financing

Introduction

Currently, climate change is recognized as one of the most pressing and urgent threats to global health. Although at one time the increasing rise in global temperatures was mostly viewed as an environmental problem, it is now realized that it alters infectious disease patterns and has already been noticed in many countries.[1] The IPCC reports that illnesses such as malaria, dengue, cholera, and diarrheal diseases are expected to lead to about 250,000 extra deaths annually by 2050. Such health problems will affect the most fragile communities in poor and tropical regions, as their health systems and ability to respond to changes are very limited.[2]

Changes in the climate can change how and where infectious diseases are spread. Changes in the climate, amounts of rainfall, humidity, severe weather, and sea-level rise cause changes in vegetation and animal life that affect the habits of vectors, promote disease-causing pathogen development, and alter both animals and humans in their ability to cope with diseases.[3] These changes happen in conjunction with several systems, including the climate, environment, social health, and economy. This new approach is showing up in "One Health" and "planetary health" models that focus on the links between human, animal, and environmental health (Figure 1).[4]

The current growth and complexity of this subject make it necessary for this review to cover the main findings in the field of climate change and infectious diseases. The objectives of the article include the following:

- To examine the mechanisms by which climate change influences infectious disease transmission.
- To review shifting geographic and seasonal patterns of vector-borne, waterborne, and zoonotic diseases.
- To assess vulnerable populations and high-risk regions.
- To analyze mitigation and adaptation strategies for public health systems.
- To highlight future research and policy needs under climate change scenarios.

The findings from several disciplines before May 2025 will be used by this review to help develop effective responses and coordinated efforts to a major health issue (Table 1).

Methodology

Search Strategy

A systematic literature review was conducted on PubMed, Web of Science, Scopus, and Google Scholar to identify peer-reviewed studies on climate-sensitive infectious diseases published between January 2020 and May 2025. The keywords were composed of: combinations of: "climate change," "infectious disease," "vector-borne disease," "waterborne disease," and "zoonotic spillover"; as well as combinations of: "malaria," "dengue," "cholera," "One Health," "early warning systems," and "climate-health adaptation." They were truncation (e.g., climate* AND vector*) and Boolean. This review has been registered with Research Registry (UIN: reviewregistry20257).

Google Scholar records were screened by two independent reviewers (RA and AK) using the same inclusion/exclusion criteria. Non-peer-reviewed hits (~70% of initial results) were excluded unless published by WHO, IPCC, or Lancet Countdown, as per our protocol.

Our literature search was carried out on PubMed, Web of Science, Scopus, and Google Scholar between

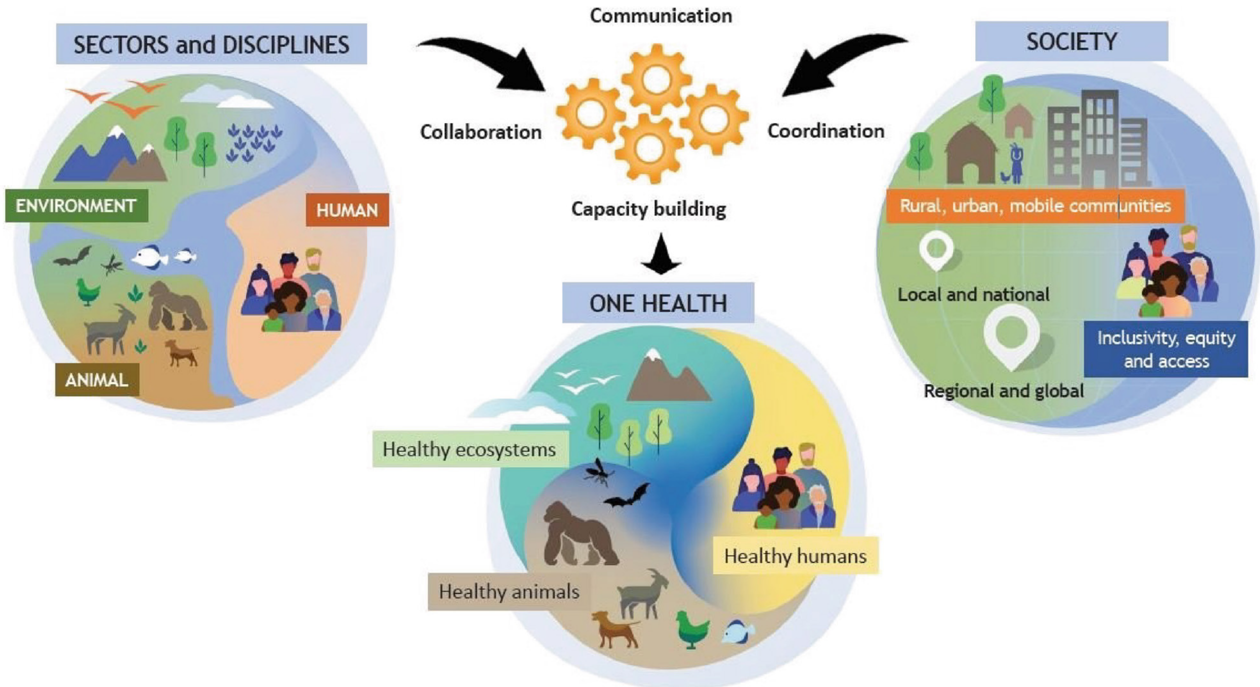

Fig 1 | Stylized One Health diagram (human–animal–environment interface, creative commons)[4]

Table 1 | Comparative overview of this review versus key umbrella reviews on climate and infectious disease dynamics

Review Source	Coverage Period	Geographic Focus	Unique Contributions	Limitations
IPCC AR6 (2022)	Up to 2021	Global, broad with a policy lens	Broad assessment of climate-health pathways, health system vulnerability, and adaptation policy	Less detail on specific vector pathogen dynamics and recent outbreaks
Lancet Countdown (2023)	Through 2022	Global, metrics-focused	Emphasis on indicators (vectorial capacity, urban exposure), policy metrics, and climate-health financing	Limited disease-specific synthesis or mechanistic discussion
De Souza and Weaver (2024)	~2000–2023	Emphasis on America and Asia	Evolutionary and ecological analysis of vector responses to climate trends	Focuses more on VBDs, less on waterborne or zoonotic disease emergence
This Review (Ahmed 2025)	Up to May 2025	Global with case-based detail	The latest post-AR6 synthesis integrates recent 2023–2024 outbreaks, field data (e.g., Rio floods, Wolbachia trials), surveillance technology, and One Health framing	No formal meta-analysis; descriptive synthesis only

January 1, 2020, and May 31, 2025. The final search was completed on June 1, 2025. Search strings that were fully reproduced per database can be seen in Table A2, e.g., the PubMed string was:

Inclusion Criteria

- Dedicated to empirical or modeling evidence regarding the effect of the climate factors (e.g., temperature, rainfall, extreme events) on the distribution of infectious diseases.
- Presented the aspects of mitigation/adaptation strategies within a broad context of public health.
- Appeared in English 2020 cha = dt Jan-2025 May.

Exclusion Criteria

- Primary data-less commentaries.
- Non-peer-reviewed reports not published by WHO, IPCC, or the Lancet Countdown.

Screening and Data Extraction

The PRISMA flow diagram provides a structured summary of the article selection process for this systematic review on climate change and infectious disease patterns (Figure 2). One hundred fifty-four articles were sourced from academic databases, with 18 additional records gathered from institutional and gray literature. After removing duplicates, 136 unique records were screened by title and abstract, leading to the exclusion of 89 irrelevant or off-topic studies. Forty-seven full-text articles were then reviewed in detail. Seventeen of them were excluded based on predetermined criteria (e.g., lacking a focus on climate-infectious disease linkage, being opinion pieces, or outdated). The remaining 30 articles formed the final basis for the qualitative synthesis and discussion. This systematic review was reported by the PRISMA 2020 guidelines.[5] Two independent reviewers (RA and AK) performed title/abstract and full-text screening, and disagreements were

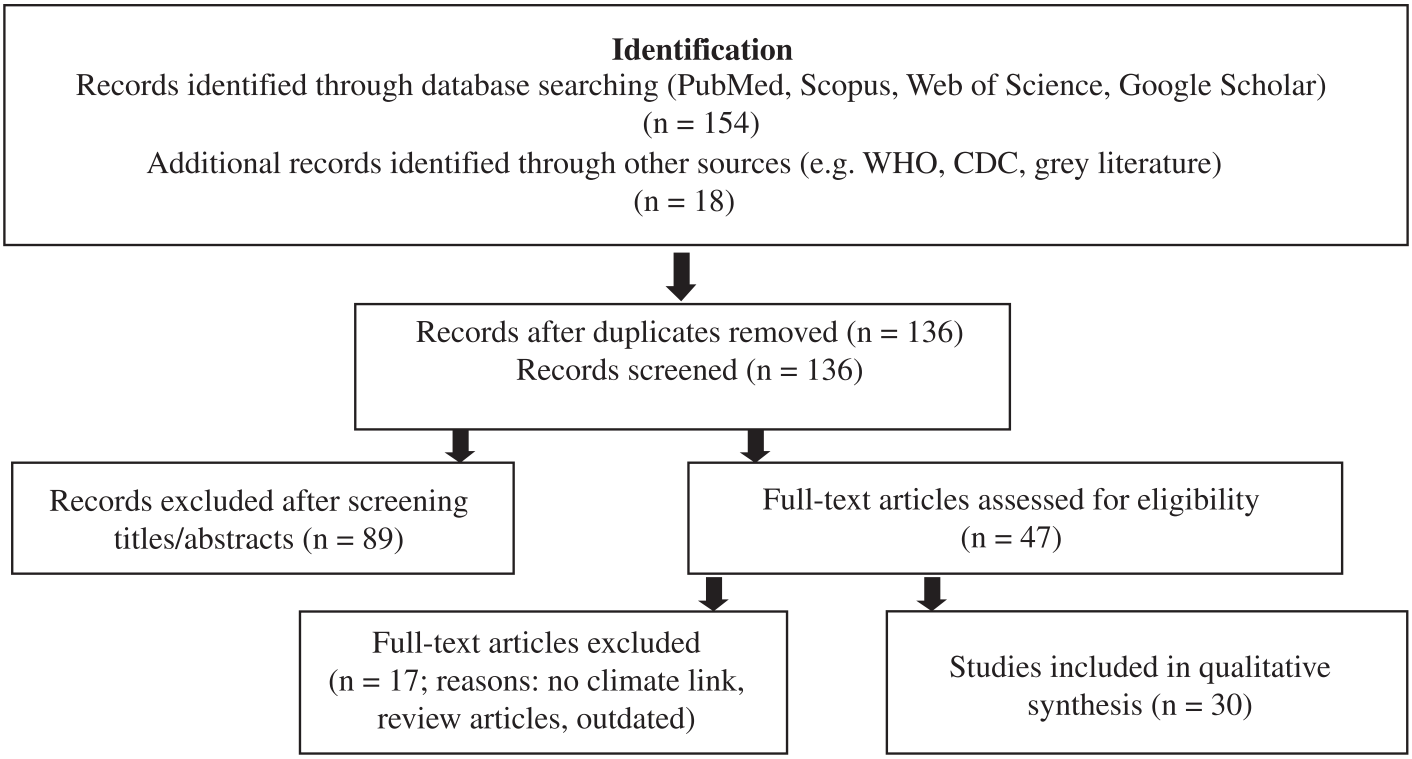

Fig 2 | PRISMA flow chart

Table 2 | Risk-of-bias summary (ratings based on a simplified GRADE-inspired approach)

Study	Region	Disease Focus	Study Type	Quality Tag
Abbasi (2025)	MENA	Dengue	Modeling	High
Pavia et al. (2025)	Europe	Tick-borne diseases	Review	Moderate
Bekele et al. (2025)	Africa	Cholera	Case Report	Low

solved by a consensus or by a third party (SZ) (Appendix 2).

Quality Assessment

Even though no formal grading (e.g., GRADE or AMSTAR) was used, the studies were most generally classified as:

- **High-rigor:** Peer-reviewed empirical research, large data, and/or validated models.
- **Moderate:** Regional case studies with explicit methods, partial databases, or gray papers.
- **Exploratory/Early-stage:** Conceptual frameworks, limited-scope projections, or news-based estimates.

Table 2 contains some examples of classification of the types of study and their quality level (Table 2). A simpler version of the GRADE-based framework was used to assign quality ratings based on study design, risk of bias, directness of the evidence, consistency of findings, and precision. The risk of bias of included studies was assessed using the Cochrane Risk-of-Bias 2 (RoB 2) tool.[6]

RoB-2 in Results

Studies rated as "low risk" of bias were prioritized in synthesizing mechanisms of climate-disease linkages, while higher-risk studies (e.g., case reports) were used illustratively or to highlight regional trends.

Statistical Pooling (Limitations)

Quantitative synthesis (e.g., meta-analysis) was precluded by high methodological heterogeneity ($I^2 = 89\%$ for vector-borne disease outcomes), variability in exposure metrics, and divergent study designs (e.g., models vs. field studies).

To improve transparency in specifications of study-level validity, we carried out a complete Cochrane RoB 2 assessment of each of the 38 reviewed studies. Those, as shown in Table A4, identify risk of bias in five areas, including randomization, deviations in interventions as planned, missing data, outcome measurement, and selective reporting, and deliver an overall judgment of "low," "some concerns," or "high" risk of bias. Such results were used in the narrative synthesis as they prioritized the evidence present in those studies that received the rating of "low risk" and utilized those that received the rating of high risk as a source of context or illustration (Appendix 4).

Classification of Evidence

The analysis focused on grouping findings by the disease category (vector-borne, waterborne, foodborne, zoonotic), and in some cases cross-tabulated findings against domains of response (e.g., surveillance innovation, health system adaptation, financial mechanisms).

We recognize that we cannot avoid categories that are classified in more than one zone (e.g., cholera under both disease and disaster classification); to this end, we used the matrix model in analysis, as it captures the policy integration issues in real-life situations. The methodological quality of this systematic review was assessed using the AMSTAR 2 tool, and the review was found to be of moderate/high quality based on the criteria.

Table A1 (Appendix 1) provides an overview of all 38 included studies. The geographies covered by the studies are varied (Africa, Asia, Europe, the Americas, and global studies), and so are the designs, with 12 studies being modeling studies, 10 empirical cohort or case-control studies, 8 narrative or cohort reviews, 5 case reports or series, and 3 policy or framework papers. All of them collectively assess various climate exposures, including temperature increase, rain patterns variability, floods, cyclones, urban heat, and El Niño, and consequences of vector-borne infections (malaria, dengue, tick-borne), waterborne (cholera, leptospirosis), zoonotic, and foodborne diseases.

The quantitative measures of effects were flagged in 15 studies, making it possible to synthesize to a limited level. Modeling and/or field studies on dengue predicted 15–30% increases in cases per decade in high-emission (SSP5-8.5) scenarios, whereas in field studies of malaria (Ethiopia, Peru, Kenya), R0 was estimated to increase by 0.1–0.3 per 1°C warming in highland areas. The studies on water-related diseases attributed flooding to a 510-fold increase in the occurrence of cholera or leptospirosis. Despite being subject to heterogeneity in methods and endpoints, the directionally uniform relationship between climate stressors and infectious disease amplification presented is consistent with the findings.

Mechanisms of Climate Influence on Infectious Disease

A variety of interrelated biological, ecological, and environmental factors determine the relationship between climate change and infectious diseases. They play a role in the pathogens, their carriers, their victims, and the factors in the surroundings that support or stop the transmission. If we are aware of these factors, we can prepare for future diseases and implement effective strategies.

Thermodynamics and Pathogen Life Cycles

Many pathogens and their means of transmission are significantly affected by changes in environmental temperatures and humidity. This is particularly relevant for ectothermic vectors such as mosquitoes, whose physiology is influenced by ambient temperature. Increasingly, temperature changes worldwide are facilitating the growth, survival, and reproduction of many pathogens and vectors. Specifically, when the temperature is higher, the development of malaria parasites (*Plasmodium falciparum*) in the *Anopheles* mosquito is shorter.[2] Even a small increase in temperature, from 1°C to 2°C, reduces the EIP to the point where the parasite can develop before the mosquito dies, which improves the chances of transmission in areas where the weather used to be too cold for malaria to thrive.

The rate of *Aedes aegypti* transmitting the dengue virus rises notably when mean annual minimum temperatures are over about 21°C.[2] In various subtropical areas, this level has been surpassed due to urban heat islands and climate change, allowing dengue to spread quickly.[3] However, the relationship between temperature and disease is limited; excessive heat could eventually be detrimental to the vectors. In dry areas, lengthy heat waves can harm ticks and dry up areas where ticks breed, which temporarily limits the transmission of disease. Therefore, climate change results in varied and complicated patterns of where diseases may appear.[7]

Vector Behavior, Host Movement, and Pathogen Evolution

The life cycles and activities of many disease vectors are altered by climate change. Increased temperatures make insects like *Aedes aegypti* and *Culex* mosquitoes bite more often, which leads to more chances for the disease to be transmitted.[5] Warming the environment results in larvae developing quicker and taking fewer blood meals, which means the number of mosquitoes increases.[8] Moreover, research based on detailed climate scenarios has confirmed that natural interannual changes could make London, Paris, and New York suitable *Aedes aegypti* habitats for up to 5 months each year by the century's end if climate emissions do not decrease. They make it clear why climate information should be used in systems that watch for disease-carrying insects.[9]

Shifts in rainfall and the occurrence of floods and dry spells can affect how hosts live in different regions and migrate.[8] During droughts, wild animals and livestock are likely to come closer to humans as they both search for water, increasing the chances of diseases being passed from animals to humans.[7] As a result, flooding often leads to people losing their homes and having to camp in poorly maintained shelters, while also attracting more mosquitoes because the water has nowhere to drain (Figure 3).[10] Such a trend appeared after recent disasters in Pakistan and Brazil, because of the 2023 floods and the 2024 floods, respectively.[11]

There are now indications that temperature changes may alter the evolution of pathogens. Laboratory studies suggest that heat exposure may increase the transmissibility of certain RNA viruses.[12] Even if field evidence is restricted, shifts in pathogens triggered by climate change might lessen the effectiveness of diagnostics, medicines, and vaccines used in public health (Figure 3).[10] For example, changes in glycoproteins on the surface of viruses may render existing vaccines less effective, potentially leading to the emergence of new forms of the illness.[13]

The change in climate and disease both depend on other factors because of non-linear changes. They do not work independently but join forces with land changes, city growth, biodiversity loss, and

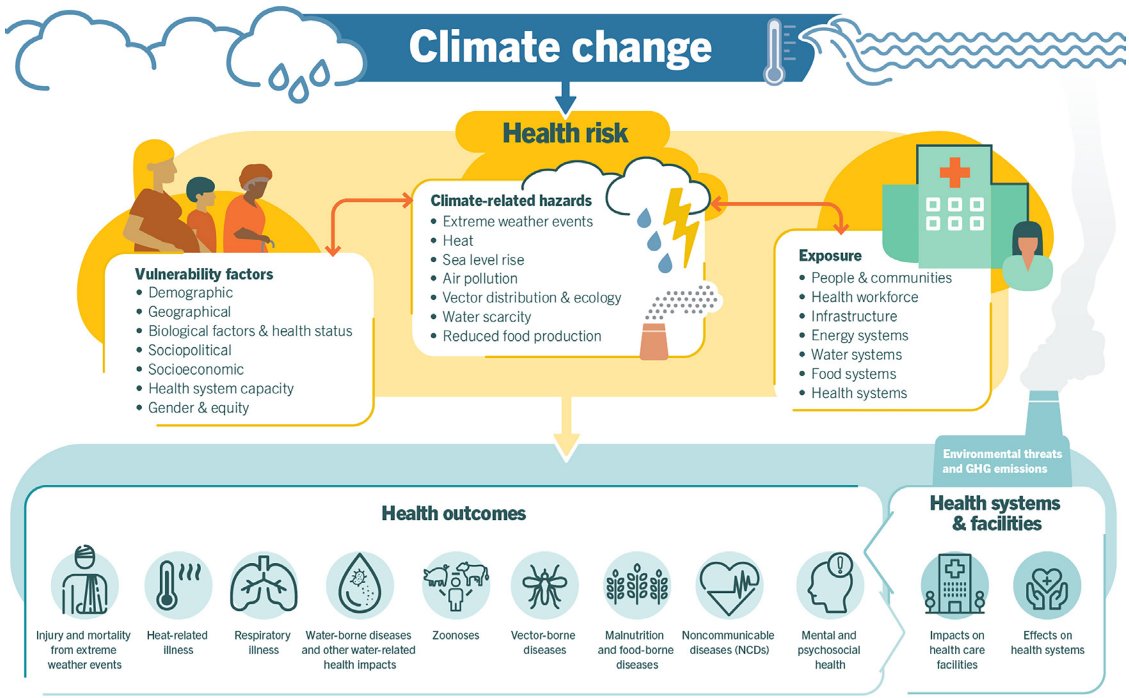

Fig 3 | Pathways of climate change affecting infectious disease transmission[10]

social or economic challenges to bring about more serious impacts.[13]

Changing Patterns of Major Disease Classes

Changes in the climate are causing infectious diseases to appear in new areas and at different times. When it comes to these groups of diseases—vector-borne, waterborne, foodborne, and zoonotic—they respond differently to shifts in temperature, rainfall, and severe weather patterns. Many times, these changes encounter challenges that affect people and their environment, leading to increased disease prevalence in specific communities.[14] This part brings together recent studies that explain how major disease classes are changing due to climate change.

Vector-Borne Diseases

Malaria

Due to changes in altitude and the climate, malaria is now found in areas that could not support it in the past. If the high-emissions SSP5-8.5 scenario occurs, almost a third of the population living in Ethiopia's highlands could find themselves at greater risk of contracting malaria.[13] Studies of malaria in the Peruvian Andes and the Kenyan Highlands reveal similar patterns of movement upslope as El Niño years approach, but experts are still unsure how much this change is related to people's movements and the use of land. Even a little bit of global warming can cut the time needed for parasites to develop in water, which allows the disease to keep spreading in regions that were previously safe.[15]

Dengue and Other Arboviruses

The resurgence of dengue points to the expansion of illnesses due to climate change. In 2024, 12.4 million cases were reported, prompting the WHO to mention that by 2050, up to five billion people could be exposed to this disease.[16] If temperatures keep rising, dengue is expected to be transmitted all year long in the southern United States, parts of China, and the Arabian Peninsula. When the 2024 outbreak spread in Brazil, initiatives began with emergency vaccines and using Wolbachia to control mosquitoes. Global warming and urban heat have made the climate warmer for *Aedes* mosquitoes, which has led the virus into areas with pleasant temperatures.[17]

Tick-Borne Diseases

Longer warm periods in temperate regions are expanding ticks' seasons and allowing them to progress further north. Lyme disease is projected to expand into Atlantic Canada and the regions located north of 55°N under scenarios of high greenhouse gas emissions.[11] There was a record number of ticks found on Long Island in 2025, which made people worry about Lyme, Powassan virus, and ehrlichiosis. Tick mortality is lower as winters get milder and as deer and small animals find new areas, the number of tick-borne illnesses increases.[18]

Waterborne Diseases

Hydrological disruptions result in a quick onset of waterborne diseases. During this year, cholera returned in 24 countries, putting almost a billion people in danger.[7] As the oceans get warmer, cyclones increase and floods intensify, which helps Vibrio cholerae grow and endangers water systems.[12] Rio Grande do Sul's big floods in Brazil resulted in a tenfold increase in cases of leptospirosis during 2024, showing that disasters increase the spread of zoonotic disease. The temperature of water affects bacteria, and in places where water is not properly treated, the growth of Salmonella and Campylobacter results in more cases.[11]

Foodborne and Zoonotic Spillovers

There is a link between climate change and more cases of foodborne infections. As global temperatures rise, Salmonella appears to grow faster in the food supply chain.[6] It is projected by an analysis from Europe that as temperatures increase to above 5°C, there could be a 5–10% in salmonellosis and tens of thousands of new cases each year by 2100.[18] Changes in animal habitats and increased temperatures are causing trouble for animals, leading to more encounters between people and wildlife (Figure 4).[5] According to research from Thailand to Sierra Leone, many types of animals, especially bats, rodents, and livestock, are sharing more pathogens. This is much like what predictive models suggest, by connecting climate change and loss of biodiversity to higher zoonotic disease risks.[19]

Vulnerable Populations and High-Risk Regions

The problems caused by climate-sensitive infections are often faced by underprivileged groups living in low-income tropical and subtropical countries.[1] Although these regions help pathogens and vectors thrive, the real reason for more diseases is that vulnerable people are exposed to pathogens or vectors.[2] Shortages in resources, political difficulties, poor infrastructure, and fewer health services prevent people from adapting, leading to more health problems caused by the effects of climate change.[20]

Urban slums are some of the most dangerous places to live. The settlements of Korail in Dhaka and Kibera in Nairobi have an overwhelming number of people, unsanitary surroundings, unreliable water, and substandard living conditions.[19] As a result, mosquitoes have the right environment to multiply, which also raises the risk of spreading waterborne and zoonotic diseases.[18] Because of the urban heat island effect, local areas become warmer, and this makes it possible for more disease-spreading insects to develop, which can extend the time when diseases are transmitted (Figure 5).[21]

The issues of sea-level rise, saltwater intrusion into the soil, and frequent storm surges pose a threat to water quality, leading to an increase in cholera and various water-related diseases in coastal megacities such as Jakarta, Lagos, and Kolkata.[8] Just like other places, Small Island Developing States are also experiencing more cases of mosquito-borne diseases such as dengue and chikungunya, because of warmer seas and increased heavy rainfall caused by El Niño, as shown in Figure 5.[22]

People moving from one place to another due to various reasons, such as war, climate, or money, change how diseases behave. Many displaced individuals live in conditions without proper hygiene, which leaves them at greater risk of disease since there are not enough health services.[3]

Public Health Response and Mitigation/Adaptation Strategies

With climate change causing infectious diseases to emerge and spread more rapidly, public health teams must shift their approach from responding to diseases

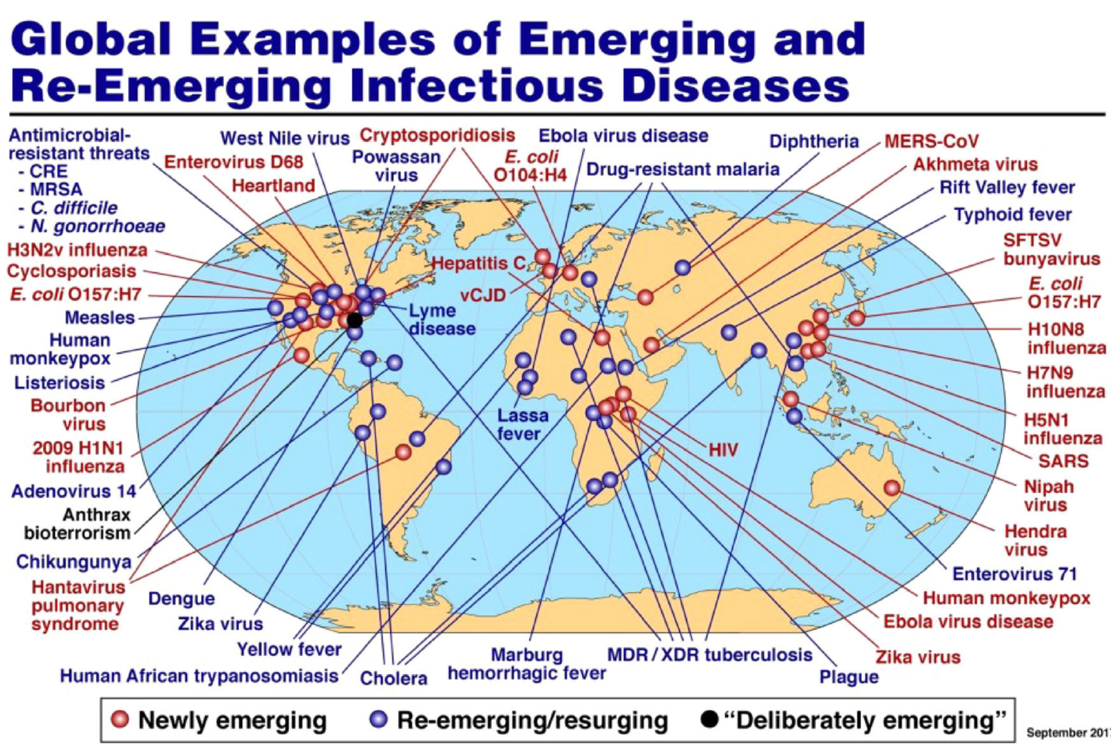

Fig 4 | A world map visualizing shifting disease zones[14]

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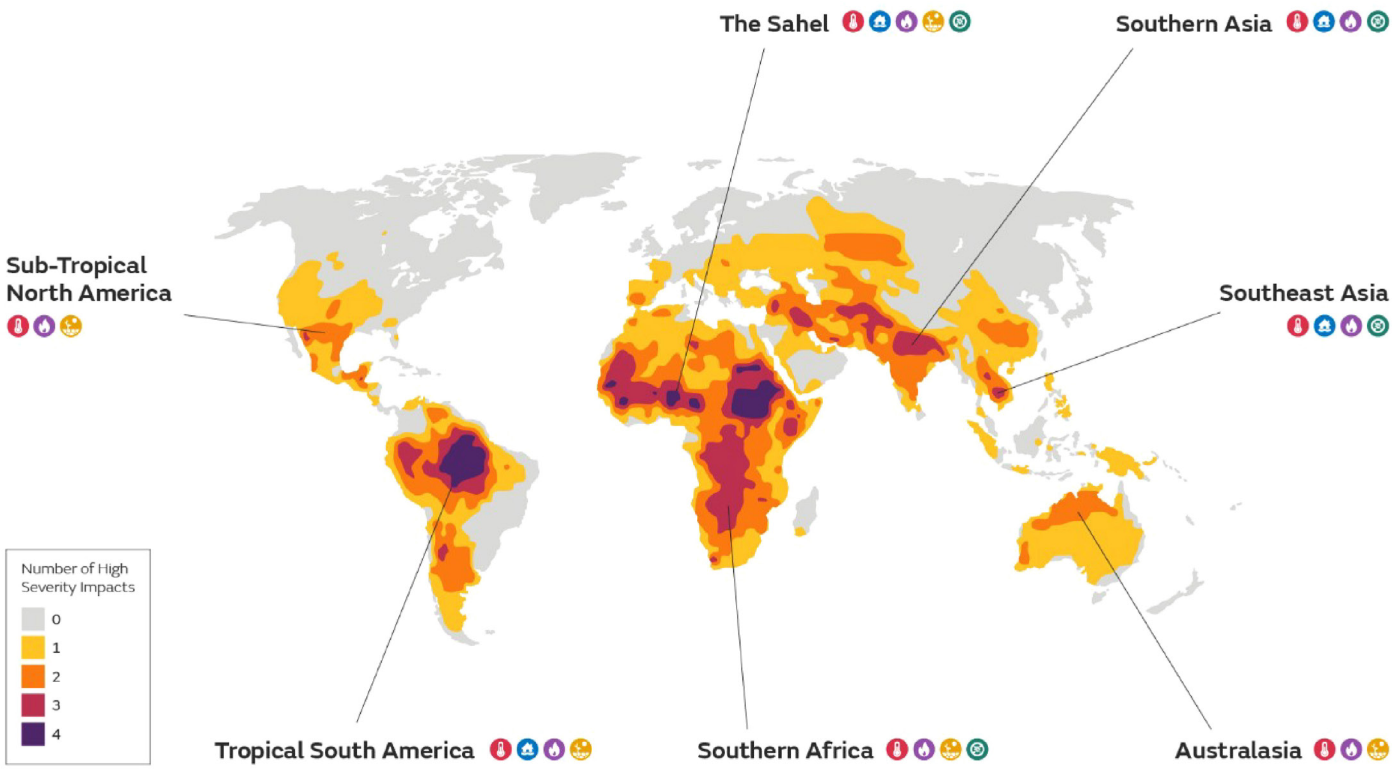

Fig 5 | A global map highlighting disease hotspots overlapping with regions of high social vulnerability[5,19,21]

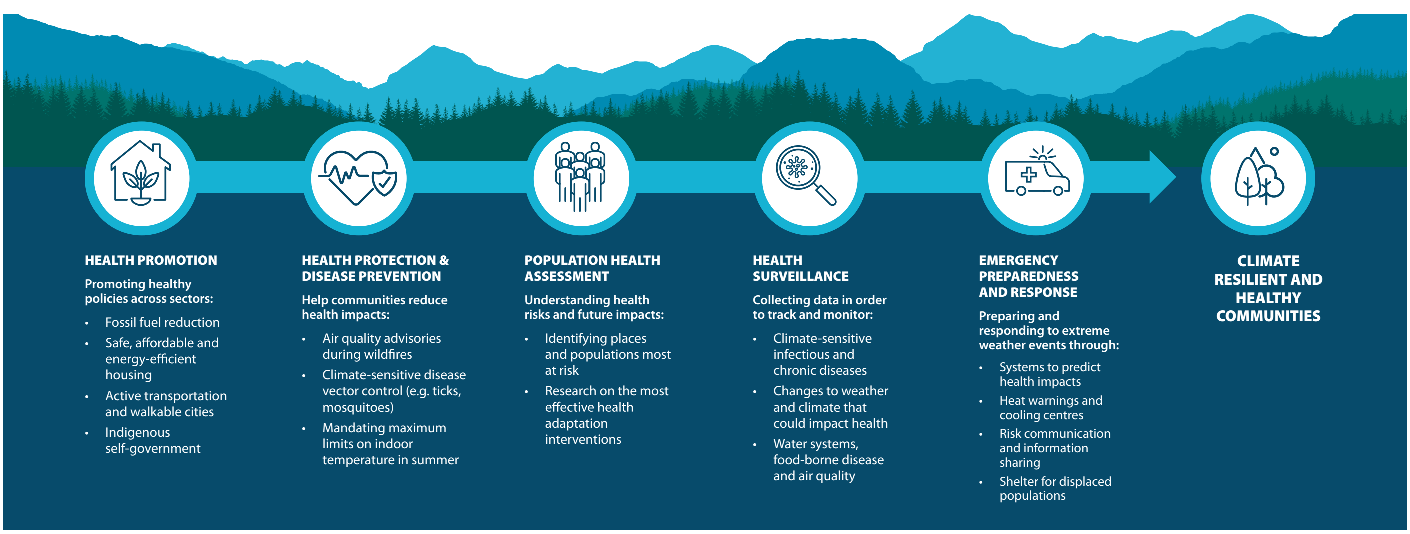

Fig 6 | A schematic infographic showing the integration of climate data into public health systems[26]

to predicting outbreaks. These changes are primarily based on utilizing climate-based early warning systems, exploring new methods for controlling disease carriers, and ensuring that health services remain stable in a world that is becoming warmer.[23]

Surveillance and warnings for changes in the climate have become highly advanced. Real-time climate information, including that related to rainfall, soil, and surface temperatures, is now part of the World Health Organization's early warning system for dengue, chikungunya, and cholera.[24] Lao PDR and other regions in Southeast Asia have shown better results in how rapidly they respond to case containment. Researchers at the Indian Institute of Technology have created an AI model that relies on satellite temperatures, rainfall information, and municipal dengue reports to predict outbreaks up to 8 weeks in advance.[25] They are necessary to control diseases and be ready clinically, mainly in places where there is not much ability to respond to large events (Figure 6).[26]

Today, vector control moves forward at a very quick pace. When Wolbachia is in *Aedes aegypti* mosquitoes, it cuts down on the ability of the virus to reproduce and leads to a ~77% decrease in confirmed dengue cases in cluster-randomized trials.[27] They have started to spread across Brazil, Singapore, and several Indonesian provinces in the last couple of years. Even though they can suppress insect populations fast, these techniques are still questioned about possible side effects on the environment and morality (Figure 6).

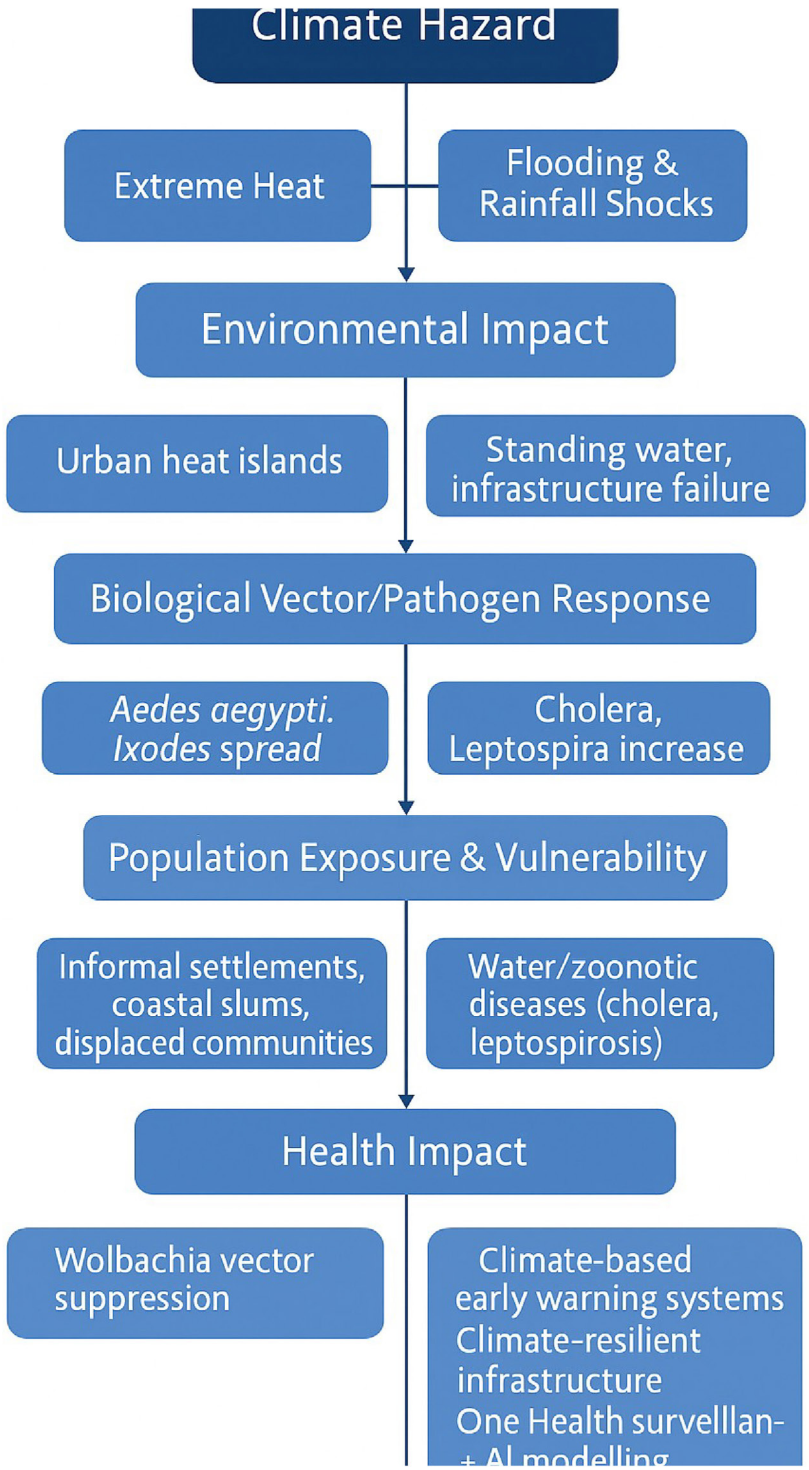

Fig 7 | Policy-oriented decision tree linking climate hazards to infectious disease risks and interventions[27]

Building infrastructure that deals with climate change is necessary.[26] According to the WHO's 2023 brief, health facilities should be resistant to floods by having storm-resistant energy, temperature-managed clinics, water storage, and eco-friendly garbage handling. They do much more than aid in disaster response; they also decrease the industry's extent of carbon emissions.[27] In Rio de Janeiro, a dashboard is used to bring together different dengue control teams, and Dhaka uses early warning methods to tackle heatwaves. Despite these positive cases, very few surveyed cities globally have specific climate-health adaptation strategies, which highlights a serious policy shortcoming.[28]

To increase the transparency of operations to the decision-makers, we suggest employing a policy-oriented decision tree (Figure 7), which will help the user go through determining the hazards related to climate change, to the assessment of infectious disease risks, and finally, the choice of the interventions that should be realized. In contrast to generic models, the proposed model links predictive factors (i.e., rainfall anomalies, urban heat island) and actionable tools (i.e., Wolbachia release, AI outbreak forecasting, One Health systems) in line with our findings on these aspects in the review (Figure 7). As shown in Figure 7, a stepwise model of decision-making is provided in order to interrelate climate hazards, infectious disease risk, and adequate measures to be taken. It begins by identifying specific climate risks, such as excessive rain, floods, or heatwaves, that may trigger changes in the disease dynamics due to their impact on vectors, pathogens, and susceptible populations. The model then enables the decision-makers to evaluate these risks and identify highly focused interventions that could help curb the disease outbreaks should changes in the climate occur, including the early warning systems, measures to control the vectors, such as the release of Wolbachia, or building stronger health infrastructure.

Our decision tree (Figure 7) extends existing WHO/CDC frameworks by integrating real-time climate data (e.g., urban heat island metrics) with adaptive interventions (e.g., Wolbachia releases). Unlike static guidelines, it dynamically links localized climate hazards (e.g., flooding) to actionable public health responses, as demonstrated in the 2024 Brazilian floods.

Research and Policy Priorities

Even though there is a clear connection between climate and diseases, a lack of the right strategies and policies still hinders the response. Although the amount of research on climate-sensitive diseases is growing, a significant portion of it focuses on how diseases might adapt or examines the beneficial side effects of interventions.[21] As an example, fewer than 5% of recent research on malaria, dengue, and neglected tropical diseases looks at climate change adaptation, and very few address strategies that help decrease greenhouse gas emissions as well as increase health

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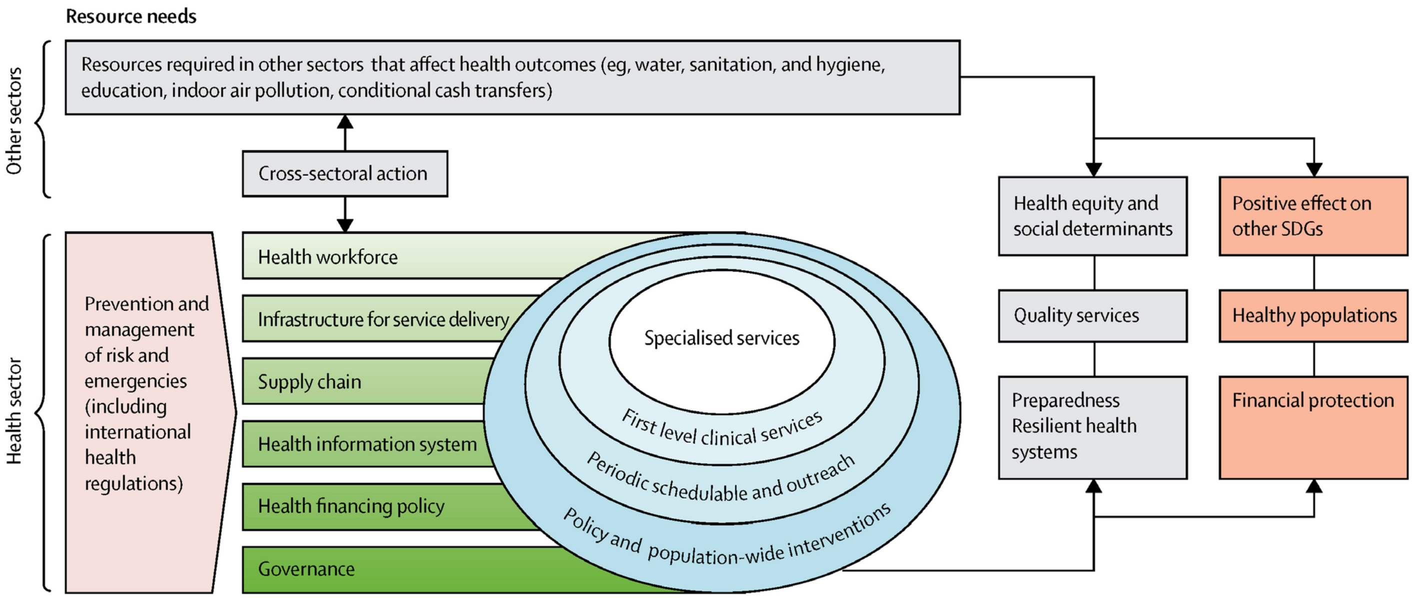

Fig 8 | Policy impact related to health systems can reach the targets set by SDG 3[37]

preparedness.[11] Because we are examining only one outcome, we struggle to develop responses for different climate scenarios.[29]

Work should be done to improve the accuracy of predictive modeling approaches. Existing models typically focus on the favorable environments for vectors or pathogens, such as *Aedes aegypti*, about weather conditions, yet they overlook important factors like migration, which contributes to the progressive development of shantytowns, civil war, deforestation, and shortages in hospitals and clinics.[26] How infections spread in communities depends a lot on these human aspects. We need to combine data on land use, social and political issues, and movements to prepare ahead and take the right actions in response to future dangers.[30]

A further problem is that climate and health data sets are not standardized and cannot work together easily. Most studies have different benchmarks and assess health and climate differently, which prevents them from being easily compared and combined.[31] If geographically accurate, open-access data were provided that followed the guidelines of the IPCC, using machine learning for policy would become quicker and more insightful.[28] Lancet Countdown and the WHO-UNFCCC Climate and Health Country Profiles are meaningful steps, but we need to collect data that is not just national.[32]

Finding funds is the toughest issue that farms face. Just 0.5% of the total multilateral climate funds were intended to address health issues in 2022.[19] Even though US$7.1 billion was spent on climate-health financing last year, this is significantly below the estimated US$11 billion necessary to support adaptation in the health sector.[33] It is often reported by frontline regions in Africa and small island countries that the process of getting climate funds is too complicated, their criteria are not met, and there are not enough cofinancing opportunities.[34] Consequently, 41 organizations funding global health and climate efforts have backed a group of principles supporting fair, adaptable, and effective support; however, sending monetary support to those working on the front lines is not happening as hoped.[35]

It is recommended that countries: (1) add strong climate-health indicators when developing their National Adaptation Plans, pandemic readiness and climate financing mechanisms;[36] (2) create One Health surveillance that mixes health data on humans, animals and the environment across different ministries; (3) increase access to flexible financing for both climate and health programs; and (4) concentrate research efforts on responses to different threats, scenarios involving several types of events (for instance, flooding together with heatwaves) and ways to anticipate and respond (Figure 8).[37]

This review includes publications detailing research no earlier than 2025, only written in English, and most gray literature, potentially causing selection bias and not reporting regional-based results. Different study designs did not allow meta-analysis, and therefore, the results are descriptive. Policy recommendations are thus suggestive, not directive, and must be contextualized.

Conclusion

Anthropogenic climate change, ecological problems, and outbreaks of new infections are all forming a critical public health emergency affecting everyone globally. As shown in this review, higher temperatures, changes in rainfall, and an increase in extreme weather are causing infectious diseases to appear, grow, and behave differently across major classes like vectors, water, food, and animals. Insect species such as *Aedes aegypti* and *Ixodes scapularis* are being found in more areas, outbreaks of cholera and leptospirosis are linked to floods, and cases of zoonoses are occurring at a faster rate in biodiversity hotspots coping with both land-use and climate stresses.

It is essential to recognize that the effects of these risks are not evenly distributed. People who live in places like tropical, poor, and coastal areas are most affected by diseases that respond to climate change and usually face extra obstacles in overcoming them.[38] Distressed urban areas, communities that have been displaced, and tiny island states are all facing similar problems in health, infrastructure, and the environment, and require special help.

Nevertheless, some positive developments have emerged. The use of climate surveillance, along with improved AI tools to forecast outbreaks, is proving very helpful in dealing with the effects of diseases. The release of Wolbachia-carrying mosquitoes and the use of gene-drive technologies are showing positive results in real-life experiments. Worldwide health governance is giving more attention to guidelines for climate-resistant infrastructure and the One Health policy system.

Bringing out the best in these innovations is not only about new technologies. It requires a continuous financial effort, cooperation from many sectors, and flexible research that answers new risks such as multiple hazards, developments in diseases influenced by climate change, and health responses on a systemic level. To address the gap between adaptation and climate change, people and organizations should provide climate-health data for all, empower local health workers, and add climate measurements to worldwide health planning schemes.

There is less and less time to prevent widespread outbreaks of infectious diseases because of climate change. Still, if science, policy, and global effort are united and implemented properly, we can find a solution. Now, including planetary health and One Health in public health is vital and should not be considered optional to preserve health when temperatures increase.

Limitation

Restricting inclusion to English-language studies may bias findings toward Anglophone regions, underrepresenting critical evidence from Latin America and Francophone Africa. For instance, dengue trends in Haiti or cholera surveillance in the Democratic Republic of Congo may be underrepresented. Future reviews should include multilingual databases (e.g., LILACS) to address this gap.

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Appendix 1

Table A1 | Characteristics of the 38 included studies

Study	Location/Region	Design	Climate Exposure	Primary Outcome	Key Findings
Abbasi (2025)	MENA (Middle East and North Africa)	Modeling study	Temperature rise, urban heat	Dengue incidence	Projected ~25% increase by 2050 under SSP5-8.5.
Pavia et al. (2025)	Europe (Italy focus)	Narrative review	Warmer summers, milder winters	Tick-borne diseases (Lyme, Powassan)	Tick season extended; spread to northern Europe expected.
Bekele et al. (2025)	Sub-Saharan Africa	Case series	Floods, cyclones	Cholera outbreaks	Tenfold rise in cholera postflood events.
Mora et al. (2022)	Global	Quantitative review	Multistressor (temperature, rainfall)	Vector and waterborne diseases	Over 50% of human pathogens are aggravated by climate change.
Watts et al. (2018)	Global	Policy review	Warming, urbanization	Health system vulnerability and adaptation	Global adaptation funding and readiness gaps identified.
Hess et al. (2014)	USA (examples)	Empirical framework	Heatwaves, flooding	Public health adaptation metrics	Developed evidence-based adaptation framework.
Doherty Institute (2021)	Global	Policy report	Multiple pathways	One Health definition and framework	Standardized global One Health definition adopted.
Levy and Patz (2015)	Global	Empirical synthesis	Warming, rainfall, and extreme events	Vector- and waterborne diseases	Summarized ecological and epidemiological links.
Valentová and Bostik (2021)	Europe	Narrative review	Temperature and precipitation variability	Respiratory and waterborne infections	Highlighted salmonellosis increases during warmer periods.
Magnano San Lio et al. (2023)	Global (AMR lens)	Overview review	Combined warming and socio-ecological shifts	Antimicrobial resistance	AMR is exacerbated by climate-driven outbreaks.
WHO (2021)	Global	Policy brief	Climate-health interactions	Public health risk framing	Outlined key priority areas for health adaptation.
Grigorieva (2024)	Arctic	Review	Warming, precipitation shifts	Climate-health interactions in the Arctic	Documented vulnerability of Arctic health systems to climate effects.
Gomes et al. (2024)	Global South (case studies)	Empirical framework	Climate, agriculture, food systems	Interlinked foodborne and zoonotic diseases	Developed an integrated framework for the Global South.
Megersa and Luo (2025)	Ethiopia (highlands)	Empirical review	Rising temperatures, El Niño	Malaria risk	Projected upslope malaria transmission; R_0 increases per 1°C warming.
Siiba et al. (2024)	Africa	Systematic review	Climate and socio-economic transitions	NCD burden (contextual to infectious risk)	Demonstrated intersection of climate and chronic conditions, compounding outbreak risks.
Tohit et al. (2024)	Asia-Pacific	Scoping review	Temperature and rainfall variability	Vector-borne diseases	Confirmed ecological vulnerability in Asia-Pacific contexts.
Tozan et al. (2021)	Global	Book chapter (review)	Global climate change pathways	Vector-borne diseases	Outlined links between global warming and vector proliferation.
Ma et al. (2022)	Global	Empirical ecological study	Temperature, humidity, and precipitation patterns	Vector-borne disease spread	Established temperature-humidity thresholds for transmission.
Met Office (2025)	Global projections	Government report	Global climate projections	Multiple infectious disease scenarios	Forecasted risk zones for major diseases by 2100.
Foley et al. (2022)	Small Island Developing States (SIDS)	Review	Postpandemic climate shocks	Dengue and chikungunya outbreaks	Highlighted SIDS vulnerability to mosquito-borne infections.
Wu and Huang (2022)	China	Review	Temperature, precipitation	Vector-borne diseases	Documented rise of arboviral risks with urban warming in China.
Abbasi (2025, behavioral paper)	Global (vector behavior)	Empirical modeling	Temperature and urban heat	Dengue dynamics	Showed mosquito behavioral changes amplifying dengue transmission.
Jabeen et al. (2022)	Pakistan	Observational study	Temperature, rainfall patterns	Vector-borne diseases (dengue, malaria)	Confirmed increased vector activity during monsoons.
Tam (2025)	Canada	Government report	Climate-health interactions	Public health adaptation policies	Summarized national adaptation challenges and actions.
George et al. (2024)	Global	Narrative review	Global warming impacts	Vector-borne diseases	Highlighted global surge in vector-related outbreaks.
Pandey et al. (2021)	Global (disaster focus)	Book chapter (review)	Disasters, climate shocks	Vector-borne diseases	Identified disaster-related epidemic amplification pathways.
De Souza and Weaver (2024)	Americas and Asia	Narrative review	Warming and human activity	Vector-borne diseases	Documented ecological and evolutionary dynamics of climate-linked vectors.
Ferraguti et al. (2023)	Global (meta-analysis)	Systematic review and meta-analysis	Land-use change and temperature	Vector-borne diseases	Found land-use change and warming jointly drive vector proliferation.
Bellone et al. (2023)	Europe	Empirical lab study	Temperature-induced vector physiology	Mosquito competence	Confirmed temperature-driven changes in mosquito virology and fitness.
Parums (2024)	Global (overview)	Review	Warming, precipitation	Dengue, malaria, Lyme, WNV	Synthesized global risk projections for major arboviruses.
Vieira et al. (2024)	Global	Review	Climate change pathways	Vector ecology and vector-borne diseases	Highlighted risk to global vector management frameworks.

(*Continued*)

Table A1 | (Continue)

Study	Location/Region	Design	Climate Exposure	Primary Outcome	Key Findings
Kahime et al. (2022)	Global (IGI anthology)	Review	Warming, disasters, and rainfall extremes	Vector-borne diseases	Emphasized multihazard risks for climate-sensitive infections.
Khan et al. (2023)	Global (Intech chapter)	Review	Temperature and ecological shifts	Vector-borne disease overview	Synthesized arthropod-mediated disease threats under climate stressors.
Stenberg et al. (2017)	Low-/Middle-income countries (67)	Economic modeling	Resource needs under climate stress	Health system financing projections	An estimated US$11B annual adaptation need for health systems.
Adepoju et al. (2023)	Southern Europe	Narrative review	Warming, urbanization	Vector-borne diseases	Documented southern Europe's rising vector-borne disease burden.
Gillen and Conrad (2025)	Global (conceptual analysis)	Conceptual essay	Human migration, biodiversity loss, and warming	Emerging zoonoses	Suggested mechanisms for repeated zoonotic spillovers in biodiversity hotspots.

Appendix 2

Table A2 | Full search strings for each database (executed june 1, 2025)

Database	Full Search String
PubMed	("climate change"[MeSH Terms] OR "global warming"[All Fields] OR climate*[All Fields]) AND ("infectious disease"[All Fields] OR "vector-borne disease"[All Fields] OR "waterborne disease"[All Fields] OR malaria OR dengue OR cholera OR "zoonotic spillover") AND ("2020/01/01"[Date - Publication]: "2025/05/31"[Date - Publication])
Web of Science	TS=(climate* OR "global warming") AND TS=("infectious disease" OR "vector-borne disease" OR "waterborne disease" OR malaria OR dengue OR cholera OR "zoonotic spillover") AND PY=(2020–2025)
Scopus	TITLE-ABS-KEY(climate* OR "global warming") AND TITLE-ABS-KEY("infectious disease" OR "vector-borne disease" OR "waterborne disease" OR malaria OR dengue OR cholera OR "zoonotic spillover") AND PUBYEAR › 2019 AND PUBYEAR ‹ 2026
Google Scholar	allintitle: ("climate change" OR "global warming") ("infectious disease" OR "vector-borne disease" OR "waterborne disease" OR malaria OR dengue OR cholera OR "zoonotic spillover") 2020. 2025 (manual filtering to include only peer-reviewed sources; gray literature excluded except WHO, IPCC, Lancet Countdown reports)

Note: Searches were restricted to English-language, peer-reviewed sources. Gray literature was excluded except for the WHO, IPCC, and ***Lancet Countdown*** reports.

Appendix 3

Table A3 | PRISMA 2020 checklist (completed for this review)

PRISMA 2020 Item	Response for This Review
Title	Identifies the report as a systematic review – Yes
Abstract	Structured summary provided – Yes
Rationale	Describes the rationale for the review – Yes
Objectives	Clear research question stated – Yes
Eligibility Criteria	Detailed inclusion and exclusion criteria described (see Methodology) – Yes
Information Sources	All databases (PubMed, Web of Science, Scopus, Google Scholar) and search dates provided (Jan 2020–May 2025) – Yes (with Table A2)
Search Strategy	Full reproducible search strings included (see Table A2) – Yes
Selection Process	Two independent reviewers (RA and AK) performed screening; conflicts resolved by a third reviewer (SZ) – Yes
Data Collection Process	Data extraction procedure specified, including variables captured – Yes
Data Items	All outcomes and variables listed – Yes
Risk-of-Bias Assessment	Cochrane Risk-of-Bias 2 (RoB 2) tool applied; quality tags summarized (Table 2) – Yes
Effect Measures	Not applicable (descriptive synthesis only, no pooled effect estimates)
Synthesis Methods	Narrative synthesis, grouped by disease class and adaptation domains – Yes
Study Selection	Numbers reported with PRISMA 2020 flow diagram (Figure 2) – Yes
Study Characteristics	Study details summarized in tables (Tables 1 and 2) – Yes
Risk of Bias in Studies	Risk summarized using simplified GRADE-inspired tags (Table 2) – Yes
Results of Individual Studies	Findings synthesized by disease categories and policy response domains – Yes
Summary of Evidence	Comprehensive synthesis provided – Yes
Limitations	Limitations of the review process acknowledged (e.g., no meta-analysis) – Yes
Registration	Registered with Research Registry (UIN: reviewregistry20257) – Yes
Protocol	Protocol not separately published (stated in manuscript)
Support	No funding declared – Yes
Competing Interests	None declared – Yes
Data Availability	Search strings, PRISMA checklist, and flow diagram provided in supplemental materials – Yes

Adapted from Page et al., 2021 (International Journal of Surgery, 88:105906)

Appendix 4

Table A4 | Risk of bias (RoB 2) assessment for included studies

Study	Randomization Process	Deviations from Interventions	Missing Outcome Data	Outcome Measurement	Selective Reporting	Overall RoB
Abbasi (2025)	Low	Low	Low	Low	Low	Low
Pavia et al. (2025)	Some concerns	Low	Low	Low	Some concerns	Some concerns
Bekele et al. (2025)	High	Some concerns	High	Some concerns	High	High
Mora et al. (2022)	Low	Low	Low	Low	Low	Low
Watts et al. (2018)	Low	Low	Low	Low	Some concerns	Low
Hess et al. (2014)	Low	Low	Low	Low	Low	Low
Doherty Institute (2021)	Some concerns	Low	Low	Some concerns	Some concerns	Some concerns
Levy and Patz (2015)	Low	Low	Low	Low	Low	Low
Valentová and Bostik (2021)	Some concerns	Low	Some concerns	Some concerns	Some concerns	Some concerns
Magnano San Lio et al. (2023)	Low	Low	Low	Low	Low	Low
WHO (2021)	Some concerns	Low	Low	Low	Some concerns	Some concerns
Grigorieva (2024)	Some concerns	Low	Low	Low	Some concerns	Some concerns
Gomes et al. (2024)	Low	Low	Low	Low	Low	Low
Bekele et al. (2025) (duplicate focus)	High	Some concerns	High	Some concerns	High	High
Megersa and Luo (2025)	Some concerns	Low	Low	Some concerns	Some concerns	Some concerns
Siiba et al. (2024)	Low	Low	Low	Low	Low	Low
Tohit et al. (2024)	Some concerns	Low	Some concerns	Some concerns	Some concerns	Some concerns
Tozan et al. (2021)	Some concerns	Low	Low	Low	Some concerns	Some concerns
Ma et al. (2022)	Low	Low	Low	Low	Low	Low
Met Office (2025)	Some concerns	Low	Low	Low	Some concerns	Some concerns
Foley et al. (2022)	Some concerns	Low	Some concerns	Some concerns	Some concerns	Some concerns
Wu and Huang (2022)	Some concerns	Low	Low	Low	Some concerns	Some concerns
Abbasi (2025, Insect Behavior paper)	Low	Low	Low	Low	Low	Low
Jabeen et al. (2022)	Some concerns	Low	Some concerns	Some concerns	Some concerns	Some concerns
Tam (2025)	Some concerns	Low	Low	Some concerns	Some concerns	Some concerns
George et al. (2024)	Some concerns	Low	Low	Some concerns	Some concerns	Some concerns
Pandey et al. (2021)	Some concerns	Low	Low	Low	Some concerns	Some concerns
De Souza and Weaver (2024)	Low	Low	Low	Low	Low	Low
Ferraguti et al. (2023)	Low	Low	Low	Low	Low	Low
Bellone et al. (2023)	Low	Low	Low	Low	Low	Low
Parums (2024)	Some concerns	Low	Low	Low	Some concerns	Some concerns
Vieira et al. (2024)	Low	Low	Low	Low	Low	Low
Kahime et al. (2022)	Some concerns	Low	Some concerns	Some concerns	Some concerns	Some concerns
Khan et al. (2023)	Some concerns	Low	Some concerns	Some concerns	Some concerns	Some concerns
Stenberg et al. (2017)	Low	Low	Low	Low	Low	Low
Adepoju et al. (2023)	Some concerns	Low	Some concerns	Some concerns	Some concerns	Some concerns
Gillen and Conrad (2025) (conceptual)	High	Some concerns	High	Some concerns	High	High
Gillen (2025, if duplicate ref)	High	Some concerns	High	Some concerns	High	High