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**Original Research Article**

# A Reviewed Literature on the Effect of Global Warming on Infectious Diseases' Dissemination

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## Abstract

Climate change presents an urgent and impending threat to virtually all global biological systems. In recent years, there has been a surge in research endeavors aimed at investigating the potential relationship between changes in climate patterns and the spread of infectious diseases. This scoping review aims to assess the influence of climate change and global warming on the spread and occurrence of numerous infectious diseases worldwide. It is recommended that there is an urgent need to carry out some educative programs in all countries to combat global warming and then reduce infectious diseases' dissemination. This review followed the PRISMA flowchart that included studies on global warming and infectious diseases from 2019 to 2023, The studies were selected by a systematic search using different electronic databases from Science Direct, EBSCO, PUBMED, BIOMED CENTRAL, CINAHL, and Google Scholar, which were filtered to include only studies that were published after January 2019 using MeSH terms to find from total 980 research articles were found in different databases, only 10 studies were eligible for the review scope and aims, they found that climate change has a remarkable impact on the dissemination and incidence of many infectious diseases, there was a significant correlation between precipitation, temperature, and the transmission of pathogens and arthropods, the potential economic devastation caused by a bacterial infection in rice could escalate significantly in the coming decades, also, the highest temperature was shown to have a strong relationship with the incidence of dengue, leptospirosis, food poisoning, TB, and hand, foot, and mouth infections in addition to several viral infections such as COVID-19. The governmental efforts to educate and counsel people to reduce their habits and some wring manners such as fuel burning to decrease global warming as one of the main factors causing infections dissemination.

**Keywords**: Global warming, climate change, infectious diseases, dissemination, transmission, infections, scoping review.

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## INTRODUCTION

Global warming is commonly defined as the phenomenon characterized by the progressive rise in the average temperature of Earth (Omonaliyevych, 2023). The frequency of disasters such as hurricanes, droughts, and floods is increasing as the Earth's temperature rises (Williams *et al.*, 2021). Global warming is a significant factor in climate change that is linked to human activities (Baker *et al.*, 2022). It has a substantial impact on health and indirectly contributes to the proliferation of infectious diseases (Semenza and Paz, 2021). The early spring temperatures observed in 2018 appear to have played a role in the early and widespread outbreak of the West Nile virus in Europe (Semenza *et al.*, 2022). This particular pathogen is expected to expand its range beyond its current distribution due to the effects of climate change (Baker *et al.*, 2022). Additionally, infectious diseases, also known as transmissible diseases, are characterized by the transmission of pathogenic biological agents to a host organism, resulting in clinically evident illness (Paz *et al.*, 2021). In specific instances, infectious diseases have the potential to exhibit asymptomatic characteristics throughout a significant portion, or even the entirety, of their progression within each host (Coates and Norton, 2021).

Temperature and precipitation are significant environmental factors that play a crucial role in the spread of infectious diseases (Indhumathi and Kumar, 2021). This includes water-borne diseases such as cholera, vector-transmitted infections like malaria

(Misseri *et al.*, 2019), parasitic helminths, fungal diseases associated with global amphibian declines, and marine diseases that impact corals, sea stars (Baker *et al.*, 2022), fisheries, and aquaculture (Howard C and Huston, 2019). Hence, global warming exerts an influence on infectious diseases through its effects on pathogens, hosts, and transmission mechanisms (Semenza *et al.*, 2022). The potential impact of global warming on diseases that necessitate intensive care (Rohr and Cohen, 2020). This extrapolation is based on existing data about the alteration in the transmission of infectious diseases (Bein, 2020). The impact of a warming climate on the global emergence of infectious diseases is significant, as it influences both the geographical distribution and host range of zoonotic pathogens (Dadar *et al.*, 2020).

Every organism has a specific range of temperatures in which it may thrive (Combe *et al.*, 2023), and if the temperature falls outside of this range, the organism's performance decreases or it may even die (Singer, 2020). This physiological concept is the basis of the human body's defence mechanism against infection (Semenza and Paz, 2021). For instance, the purpose of fever in endothermic animals, including humans, is to increase body temperature to a level that is unbearable for invading pathogens. Despite the scientific reasoning behind using ideal temperature ranges to determine the success or failure of infections, there has been a prevailing belief that a warmer world will lead to increased illness. In other words, there was a prevailing anticipation that parasites, diseases, and even biotoxins would gain more advantages from rising temperatures compared to their hosts (Coates and Norton, 2021; Misseri *et al.*, 2019).

Several notable instances followed this pattern, including Vibrio, coral black band disease, and sea star wasting disease (SSWD) (Amari *et al.*, 2021). Nevertheless, if this trend were uniformly valid, it would imply that the majority of infections worldwide reside slightly below their thermal optima, and the elevated temperatures facilitate their transition into optimal conditions (Calleja-Agius *et al.*, 2021). It is more probable that what we observed were specific cases of infections approaching their ideal temperature conditions, whereas we may have overlooked instances when viruses were forced outside of their optimal temperature range and consequently deteriorated (Semenza *et al.*, 2022).

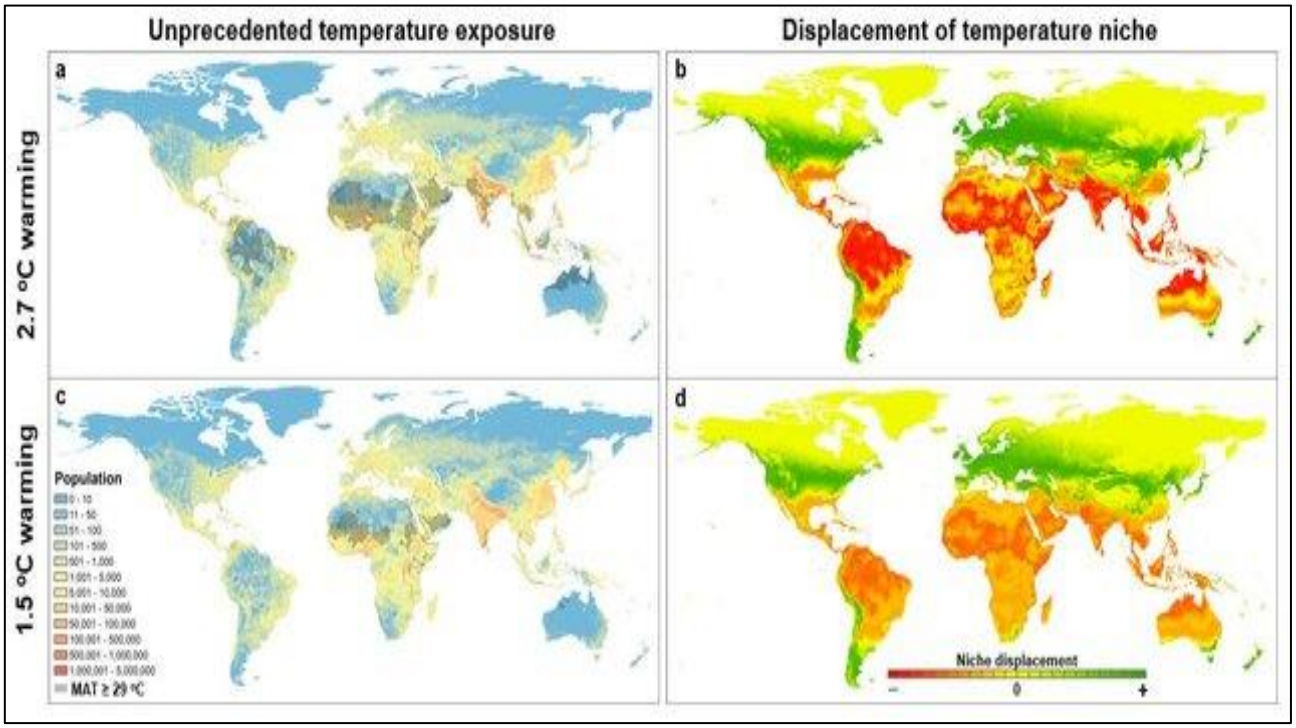


**Figure 1: Global temperature niches undergo significant changes under two scenarios of global warming: a,b. 2.7°C and c,d. 1.5°C. The text shows the areas that will experience a maximum annual temperature (MAT) of 29 °C or higher, together with the population density (number of people per ~100 km2 grid cell), for a projected worldwide population of 9.5 billion in the year 2070 under two scenarios: a. global warming of 2.7°C, and c. global warming of 1.5°C. b,d. The shift in the temperature range (red denotes a drop in appropriateness, green an increase) caused by: b. 2.7°C global warming, d. 1.5°C global warming (Semenza *et al.*, 2022)**

The economic significance of climate change has made it a significant concern for both the general public and governments. There is a widely held belief that climate changes affect the entire world (Nardell *et al.*, 2020). Over the past twenty years, several regions in the Northern Hemisphere have observed a rise in average yearly air temperatures, accompanied by increasingly frequent and severe weather events (Lee *et al.*, 2023).

The consensus among the public, media, and politicians is that the observed warming trends on land are primarily attributed to the rise in atmospheric carbon dioxide levels (Baker *et al.,* 2022). This belief is influenced by a group of climatologists appointed by European governments, known as the Intergovernmental Panel on Climate Change (IPCC), which regularly publishes reports on the extent and causes of this presumed warming (Dadar *et al.,* 2020). Nevertheless, other experts have expressed dissent, pointing out numerous factors that are strongly linked to recent significant shifts in climate, which are unrelated to levels of carbon dioxide. The recent global rise in the average daily temperature on Earth is comparable to that observed on other planets within our solar system **(**Santos-Guzman *et al.,* 2021). Therefore, this review aims to assess the influence of climate change and global warming on the spread and occurrence of numerous infectious diseases worldwide.

## METHODS

The literature review assists in covering and summarizing several studies on the impact of global warming impact on the spread of infectious diseases in the world. The data search was done using the Web of Science, Science Direct, EBSCO, MEDLINE, BIOMED CENTRAL, CINAHL, PubMed, Google Scholar, and Scopus, and only the English language was used. These databases were the most commonly trusted search engines used to investigate the reports regarding this topic with more relevant data, all databases except for Web of Science were used by selecting a few keywords to get all topics related to the review aims, while Web of science was a research engine used by adding a small phrase to get all reports related to the review aim. This search was done using the PRISMA extension for scoping reviews. The research question used to guide the review was; "What is the impact of global warming on the spread of infectious diseases?"

### *Search Terms*

The relevant terms used to search were identified, and then the searches were conducted based on the research question. The specific search terms for the database search are listed in the following:

The following MeSH terms and words were combined to construct systemic searches: ‘global, warming OR warming, global OR global warming OR global OR warming OR climate change OR climate, change, OR climate OR change OR Atmospheric, warming OR atmospheric warming AND ‘effect OR impact OR effects OR result OR results’ AND ‘infectious Diseases OR infectious, diseases OR diseases OR infectious OR communicable diseases OR communicable, diseases OR diseases, communicable OR Communicable’ AND dissemination OR spreading OR transmission AND retrospective cohort OR case-control OR nested-case control OR cross-sectional OR quantitative OR qualitative OR descriptive ’. We also manually searched the reference lists of the included studies and relevant reviews to identify additional records. For specific search strategies, please see Table 1.

**Table 1: Search methods**

| | |
|---|---|
| #1 | Global Warming [Mesh] |
| #2 | ‘Global, warming OR warming, global OR global warming OR global OR warming OR climate change OR climate, change, OR climate OR change OR Atmospheric, warming OR Atmospheric warming |
| #3 | ‘Effect OR impact OR effects OR result OR results’ |
| #4 | ‘Infectious diseases OR infectious, Diseases OR Diseases OR infectious OR communicable diseases OR communicable, diseases OR diseases, communicable OR Communicable’ |
| #5 | dissemination OR spreading OR transmission |
| #6 | retrospective cohort OR case-control OR nested-case control OR cross-sectional OR quantitative OR qualitative OR descriptive |

They were used in the search engines that were identified through a series of brainstorming and searching a thesaurus, the database, and preexisting knowledge on the topic. The thesaurus helped in finding and using the control terms to ensure accurate and high-level coherency among the terms. Furthermore, the thesaurus helped control the narrowing and broadening of the search. If there were no controlled terms, the search strategy entailed using free text searching either alone or with the controlled terms. In the free search, several broader terms were used and acted as a guide for the accuracy of the search to obtain relevant results. Such terms included Impacts of global warming, Viral infections, Bacterial infections, Fungal infections, Parasitic infections, and spread of infectious diseases.

In the controlled terms, there was a systematic search using different electronic databases from Science Direct, EBSCO, PUBMED, BIOMED CENTRAL, CINAHL, and Google Scholar, which were filtered to include only after January 2019. The search was restricted to the English language. Following the studies' selection, some references in the studies were also selected. Subsequently, the results were screened based on the inclusion and exclusion criteria described below. These criteria allowed a broad search to be conducted while keeping the scope as precise as possible. Given that the pandemic occurred recently, the year of publication was not restricted. However, the rationale was used to exclude papers in these spread hits to maintain the chain of evidence.

***Inclusion Criteria***

- Peer-reviewed articles.
- Articles related to search terms that influence the global warming and infectious diseases' incidence.
- Published after January 2019.
- English language papers.

***Exclusion Criteria***

- The papers discussed the strategies to prevent global warming and infectious diseases' dissemination.
- Systematic reviews.
- Papers that do not use a statistical analysis for the infectious diseases' dissemination and transmission.
- Papers are not reporting global warming in their study as main factor for infections' dissemination.

Researchers relied on the databases using the Boolean operators (AND, OR, NOT) which included: 8980 citations; 1220 from Science Direct, 78 from EBSCO, 3174 from PubMed, 1139 from BIOMED CENTRAL, 1123 from CINAHL, and 2246 from Google Scholar, of which 4423 records were excluded after removal of duplicates; 4102 records were excluded following title and abstract screening. A total of 455 studies were included in the full-text screening. An additional 444 studies were then excluded: 210 studies did not meet the research purpose; 125 studies did not meet the study design criteria; 105 reviews did not meet the outcome criterion; and four articles analyzed identical data. One study was excluded after the full-text screening because the author did not respond when asked to provide a critical table that was not listed in the paper. Ultimately, 10 papers met the inclusion criteria and were incorporated in the study (Figure 2).

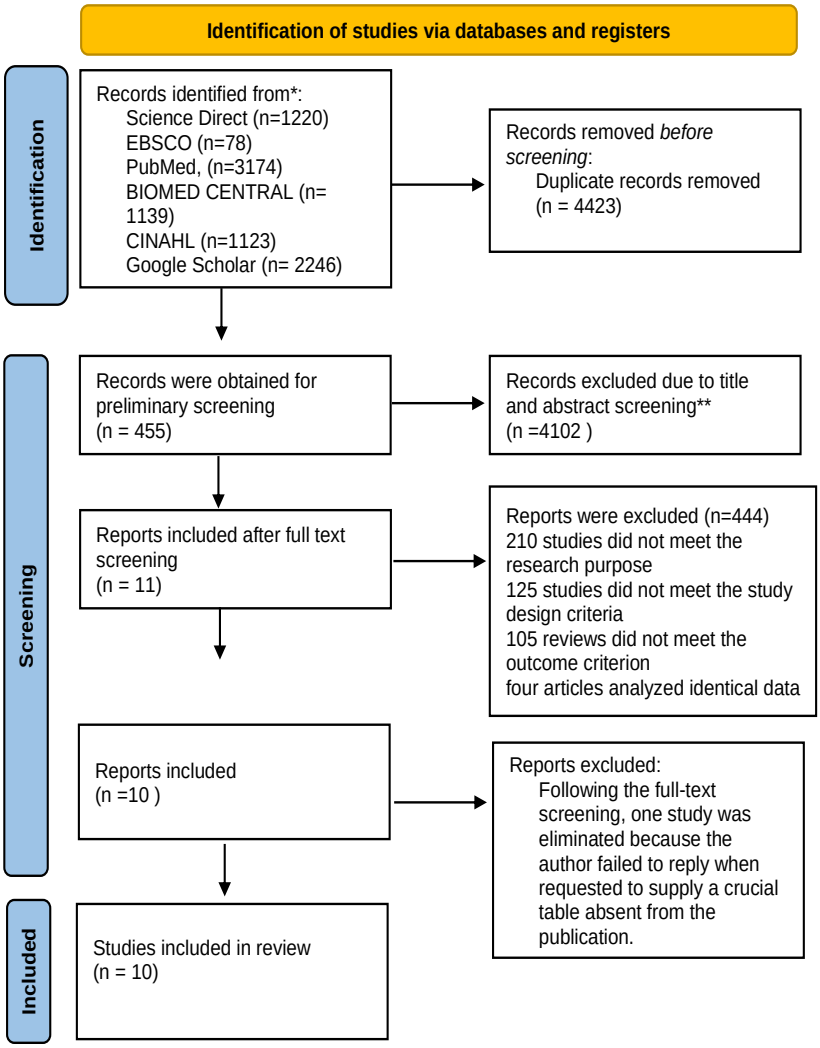


**Figure 2: PRISMA tool chart used and designed in this review**

The citation titles and abstracts were independently screened, and potentially relevant articles were fully reviewed after excluding articles that proved irrelevant. An electronic data charting form was

developed to determine the most appropriate variables to extract from the articles, and the charting form was continuously updated. Some of the data that were extracted included the general data (the names of the author, country of study, and year of publication), the methodological data (study design, to all sample's characteristics of the participants, intervention group, control group, outcome measures. and follow-up) as a study matrix designated as shown in the following table (Table 2).

**The Risk Assessment of the Quality of the Final Selected Articles**

The author utilized the Agency for Healthcare Research and Quality (AHRQ) checklist for RioB assessment in Comparative Effectiveness Reviews. This checklist is employed to acknowledge and consider assumptions and limitations when evaluating validity and generalizability. The question is, what other purposes can this checklist serve? The AHRQ Evidence-based Practice Centers (EPCs) utilize the risk of bias evaluation to assess the quality of research included in Comparative Effectiveness evaluations.

This research assessment encompassed the examination and recommendations put out by authors, comprising a total of 12 items (Title, Abstract, Key findings, Introduction, Objectives, Study design, Statistical methods, Experimental results, Interpretation and scientific implications for results, study limitations, recommendations and future perspectives). The reviewer assigned a rating of either 0 (not reported) or 1 (reported) to each item. The table below displays the checklist for the studies.

**Table 2: The Data Extraction Matrix for this review's studies**

| Author year | Aim of the study | Research design | Study sample | Key finding and implications |
|---|---|---|---|---|
| Shew *et al*., 2019 | To estimate the producer, consumer and environmental impacts of Bacterial Panicle Blight and how those impacts change under warming scenarios. | Retrospective description | 34 rice cultivars, 33 rice-growing counties in Arkansas, 35 parishes in Louisiana, and 18 counties in Mississippi, for a total of 4,382 yield observations. | There are presently no effective chemical solutions available to treat what might become a more widespread and serious rice disease as global warming accelerates. |
| Yu *et al*., 2021 | To examine the effects of three-year simulated field warming on the complexity of soil bacterial communities and predicted functions in a temperate steppe of Inner Mongolia. | Quantitative Experimental design | five soil cores (3cm in diameter, 0–10cm depth). | Warming led to a notable increase in aerobic chemoheterotrophy, ureolysis, and chemoheterotrophy. Warming will collectively modify the structure and potential functions of soil bacterial communities, subsequently impacting crucial functions within grassland belowground ecosystems. |
| Pallarés *et al*., 2019 | To study heat tolerance, accounting for both basal and induced tolerance. | Quantitative experimental study | Four distantly related arthropod species with different evolutionary origins inhabit the same cave. | The underground organisms' heat tolerance is not influenced by their surroundings. Subterranean species may respond differently to global warming, even if they share a comparable climate. |
| Mbouna *et al*., 2022 | To explore the potential effects of global warming on the malaria propagation over Cameroon. | Experimental model | NA | Parasite ratio (PR) and entomological inoculation rate (EIR) show diverse variations throughout the research region as a result of global warming. |
| Miedaner *et al*., 2020 | To discuss three types of shifts caused by climate changes; shift in the importance of already established, fungal pathogens adaptation of | case study | NA | Incorporating many diverse effective resistance resources into breeding programs may be difficult, especially if trade-offs among breeding aims occur. |

| Author year | Aim of the study | Research design | Study sample | Key finding and implications |
|---|---|---|---|---|
| | pathogen species/subspecies to warmer and/or drier conditions resulting in a higher fitness of the better-adapted species/subspecies within a disease complex and shift of the ecological boundaries of thermophilic fungal pathogens. | | | |
| Alhoot *et al*., 2019 | To assess the effect of climate change by measuring the incidence of certain infectious diseases | cross-sectional study | NA | The lowest temperature was strongly linked to dengue, leptospirosis, food poisoning, TB, and hand, foot, and mouth infections. Only malaria is strongly connected with heavy rains. Maximum temperature strongly correlates with Leptospirosis. |
| Dadar *et al*., 2020 | To evaluate the relation between the incidence of brucellosis and climatic parameters in Iran, an important endemic region for brucellosis with diverse climate. | Regression analysis | NA | This study data implies a strong temperature sensitivity for brucellosis in Iran. |
| Nyawanda *et al*., 2023 | To investigate the relative effect of climate variability on malaria incidence after scale-up of interventions in western Kenya. | Retrospective descriptive study | NA | Temperature and rainfall fluctuations affect malaria dynamics. |
| Lian *et al*., 2023 | to elucidate the cause of the increase in COVID-19 cases in the summer of 2022 | statistical dynamics and epidemiological modeling methods | Population mobility data were obtained from Google COVID-19 Community Mobility Reports | Without heat waves, 69.3% of COVID-19 cases this summer may have been averted. The pandemic-heat wave collision was intentional. |
| Carlson *et al*., 2020 | To test the hypothesis that environmental change should alter mammal communities in ways that expose hosts to new viruses, altering the structure of the whole mammal–virus network. | A statistical dynamics | NA | Study results emphasize the necessity to combine viral monitoring and discovery with biodiversity surveys tracking species range alterations, particularly in tropical areas with the highest zoonoses and fast warming. |

## RESULTS

The review included 10 records. A thematic analysis of the content of the selected records yielded six major themes across global warming's impact on spread of infectious diseases. A total of 10 studies were found: Two statistical dynamics and epidemiological modeling methods, 2 quantitative experimental study, 2 retrospective, 1 cross-sectional study, as well as 1 regression model, one experimental and another case study.

The study's findings were presented in terms of themes obtained through the analysis, comparison, and contrast of the information from the studies as follows:

*Theme 1: Global warming impact on bacterial infection*

About 2 studies have assessed global warming's impact on bacterial infection. Shew *et al*., (2019) showed

that the aquaculture Multi-Antibiotic Resistance (MAR) indices exhibit correlations with MAR indices observed among human clinical bacteria, as well as with temperature and the climate vulnerability of countries. Authors have observed that warmer temperatures lead to increased mortality rates in infected aquatic animals. Countries that are highly susceptible to climate change are likely to experience significant risks associated with marine aquaculture resources (MAR). These risks have the potential to adversely affect human health, extending beyond the aquaculture sector. This underscores the pressing need for immediate action also, he argued that it is necessary to implement sustainable strategies in order to reduce antibiotic usage and enhance system resilience.

*Subtheme: The infectious diseases and their impact on rice production*

Yu *et al*., (2021) found that warming led to an increase in the complexity and connectivity of the bacteria community network. However, the variation within the community was only partially explained by soil physicochemical properties and plant biomass, indicating that bacterial interactions may play a significant role in driving the bacterial community network. Warming has led to changes in the structure of bacterial communities and an increase in bacterial decomposition of organic matter. These changes have the potential to create significant feedback effects on the loss of soil carbon and the emissions of greenhouse gases. Additional research is needed to investigate the impact of global warming on soil bacterial community structure and ecosystem function, as well as Climate change is projected to result in elevated temperatures in various global regions. Uncertainty surrounds humidity predictions, but certain regions will experience higher temperatures and humidity, resulting in increased infection pressure of Bacterial Panicle Blight (BPB) in global rice production.

*Theme 2: Global warming impact on viral and parasitic infection*

Different studies have mentioned global warming's impact on viral and parasitic infection, researchers investigated 4 studies. Combe *et al.*, (2023) identified a dearth of data regarding the correlation between temperature and mortality in fish and shellfish. Similar to bacteria, their findings emphasize the significance of understanding the connections between temperature and virus-related mortality. This study demonstrates that a modest temperature rise of 1 °C may result in a 3-6% increase in mortalities. This could have notable implications for food safety in low- and middle-income countries (LMICs) engaged in aquaculture. Researchers have observed that the ecological transition is already occurring, and limiting global warming to below 2°C by the end of the twenty-first century will not necessarily decrease the sharing of viruses in the future. The study emphasizes the importance of integrating viral surveillance and discovery initiatives with biodiversity surveys that monitor species' range shifts, particularly in tropical regions. These areas are known for having a high number of zoonotic diseases and are currently undergoing rapid warming.

Parasites that are not eliminated by higher temperatures may experience an increase in intensity and pathologies. This can be attributed to certain physiological factors, such as the tendency of temperature to enhance the metabolism of ectotherms and induce oxygen stress on hosts. Parasites are integral to ecological communities, and it is important to consider the indirect and secondary effects resulting from climate-induced changes in host-parasite interactions. These effects may not be apparent when studying these interactions in isolation (Byers, 2021). This study investigates the bioclimatic preferences of parasites and their potential response to future climate changes, focusing on broad climate parameters. Specifically, it examines how parasite life cycles, seasonality, and population dynamics may be affected. Regions of New Zealand experiencing warmer and wetter conditions due to climate change are projected to have increased occurrences of flystrike and cattle tick prevalence. Additionally, there may be an increase in biting louse populations, but a decrease in chorioptic mange and flea infestations. Dry and warm regions may have fewer ectoparasites overall, except for flea infestations (Heath, 2021).

*Theme 3: Global warming impact on fungal infection*

Global warming impact on fungal infection. Only a small number of fungal species are pathogenic to humans, as most mammals have a high level of resistance to invasive fungal diseases. In addition to immunological responses, humans possess a "thermal restriction zone" which serves as a protective mechanism against infections. Human activities may be causing climate changes that are leading to the gradual reduction of the thermal restriction zone. This zone refers to the difference between the basal temperature of humans and the temperature of their surroundings. The emergence of *Candida auris* may have been influenced by global warming due to its higher thermotolerance compared to other yeasts. The impact of climatic oscillations on wetlands may have enhanced the suitability of this habitat for non-pathogenic *C. auris* strains by providing thermal and salinity tolerance, although the exact ecological niche has not been determined. The acquisition of virulence factors in *C. auris* may be attributed to the transfer of virulence genes from other pathogenic *Candida* species to *C. auris* strains that have not been previously exposed to them (Williams *et al.*, 2021). Another possible explanation is the occurrence of genetic mutations induced by global warming and UV radiation[2]. The study's model predicts that there will be an expansion of *Cryptococcus gattii* VGI distribution from the Mediterranean basin coasts to inland sub-continental regions in the coming decade. Based on these predictions, there is an anticipated rise in cryptococcosis

cases caused by *C. gattii* VGI in the coming decade. It is essential to continuously monitor the epidemiology of this fungal pathogen as a critical strategy for detecting future outbreaks (Whitehorn *et al.,* 2019).

*Theme 4: Global warming impact on arthropods and vector transmission*

Studies have mentioned the global warming impact on arthropods and vector transmission (Cogliati, 2021; Miedaner and Juroszek, 2021; Pallarés *et al.*, 2019; Mbouna *et al.,* 2023; Khezzani *et al.,* 2023). The geographical range of mosquitoes and mosquito borne diseases (MBD) are therefore profoundly altered by global warming. The present scenario is highly concerning, and it will get considerably more problematic as GW worsens. Thus, health systems in developing nations would face significant challenges in health policy and public health measures to contain the development of MBD. This means that African governments need to step up their efforts to stop MBD (Khezzani *et al.,* 2023), in order to prevent further spread of the disease. Arboviral transmission is successful only when the vector and the virus are exposed to ideal circumstances. Global warming in particular is anticipated to increase the outer boundaries of arboviral transmission. Dengue transmission in the UK summer by 2100 is possible according to model tests using the most severe climatic scenarios (Cogliati, 2021).

*Subtheme: Africa vectors and arthropods dissemination as resultant from Global warming*

Insects will flourish in a warmer environment, likely generating negative direct (feeding, sucking, etc.) and indirect (vectors of infections, feeding wounds establishing gateways for various pathogens, passive transmission of inoculum across maize plants) impacts. There has to be constant fine-tuning of breeding programs for disease resistance. Significant progress is needed in breeding for resistance to insect pests (Miedaner and Juroszek, 2021). Different arthropod groups (Coleoptera, Diplopoda, and Collembola) were studied for their basal heat tolerance and its plasticity. These species have different evolutionary histories but have been subjected to similar selection pressures due to long-term exposure to the same constant environmental conditions. This research disproves the idea that ambient factors control the heat tolerance of underground animals. Pallarés *et al.,* (2019) suggested that animals that spend their lives underground may respond differently to climate change, even if they do so in identical environments.

Under global warming, the research area is characterized by diverse changes, including regional variations in the entomological inoculation rate (EIR) and the parasite ratio (PR). This study was conducted in Africa to learn more about the impacts of global warming on the spread of malaria throughout Cameroon. The rate of change in PR and EIR is more pronounced over time as radiative forcing levels rise (Mbouna *et al.,* 2023).

*Theme 5: Global warming impact on the incidence of infectious diseases*

*Subtheme: COVID-19 dissemination and global warming*

Studies have investigated global warming's impact on the incidence of infectious diseases. The chosen climate-sensitive communicable illnesses had the strongest correlations with precipitation and temperature. Dengue, malaria, and cholera cases were predicted to rise in a climate change scenario simulation because of regional climatic reactions. The occurrence of communicable illnesses that are particularly vulnerable to changes in climate is affected by both precipitation and temperature (Baharom *et al.,* 2021). Lian *et al.,* (2023) found that if there weren't any heat waves this summer, almost 69.3 percent of COVID-19 cases may have been prevented. There is no coincidence that the epidemic and heat waves are occurring at the same time. Future control initiatives should take into account climate-based malaria early warning systems and maintain the declining trend in malaria incidence, as shown by this research (Nyawanda *et al.,* 2019). Also, there is a statistically significant inverse correlation between the average outdoor temperature and the occurrence of brucellosis. Dadar's discovery paves the way for more research into how environmental factors and climatic shifts affect the regional distributions and seasonal/annual cycle of this zoonotic virus across the globe (Dadar *et al.,* 2020). The highest temperature was shown to have a strong relationship with the incidence of dengue, leptospirosis, food poisoning, TB, and hand, foot, and mouth infections, according to data analysis from the research by Alhoot *et al*. (2019), Malaria transmission seems to be strongly associated with heavy rains.

## DISCUSSION

In this scoping review, it was found many variations, similarities, and differences between the selected studies regarding the effect of global warming on the spread and dissemination of infectious diseases. There is no doubt that the incidence of infectious diseases as a result of climate change must be discussed and reported with a potential need to combat this disaster. It ended with Lian *et al*., (2023) who reported a high percentage of infectious diseases' incidence in Europe and USA. This statistical data can predict the incidence of other infectious diseases in the whole world when they reported that amidst the ongoing pandemic, it is imperative to prioritize the issue of climate change, as it is currently giving rise to a difficult new epoch for the dissemination of infectious diseases. This phenomenon has increased outbreaks' prevalence and severity, presenting substantial and abrupt hazards. The alteration of environmental conditions is amplifying the propensity for pathogen transmission and the potential for viral transmission across different species, which is also correlated with the COVID-19 pandemic, as well as, Nyawanda *et al*., (2023), Dada *et al.,* (2020), and Alhoot *et al*., (2019), they discussed the incidence of the

infectious diseases and their relationship to the climate change and high temperature in both Asia and Europe countries, to report that the multiplication of mosquito vectors and subsequent transmission of dengue viruses to humans is facilitated by the elevation of ambient temperature and increased precipitation, as these conditions create optimal circumstances (Cogliati, 2021; Baharom *et al.,* 2021).

It was noted that Pallarés *et al*., (2019) and Miedaner and Juroszek (2021), who reported that the main correlation between global warming and arthropods-borne disorders is essential to be reported and studied when they discussed the effect of global warming in different countries of Europe besides Africa where there is a high rate of arthropods-borne diseases, many countries are significantly susceptible to the impacts of global warming (Heath, 2021). The passage of time plays a significant role in mitigating the imminent hazards associated with global warming on marine biodiversity dynamics. Considering this matter, it would be advantageous to proactively address the impending climate scenario by adequately equipping human communities through various available methods and approaches, besides the temperature change and its impacts on increasing the number of mosquitos and other arthropods transmission and dissemination (Khezzani *et al.,* 2023).

Bacterial infection has the greatest and most frequent type of infection, which must be controlled because of its widespread and variable pathogens that may cause the infectious stages and may affect the infection control strategy in the countries, besides microbial resistance, which may occur due to several factors which the increasing in temperature is one of this factors as it is likely that nations that are particularly susceptible to climate change will encounter elevated risks of antimicrobial resistance (AMR), which will have adverse effects on public health beyond the aquaculture industry, besides, Yu *et al*., (2021) and Shew *et al*., (2019) reported that the potential economic devastation caused by a bacterial infection in rice could escalate significantly in the coming decades, alongside the global warming phenomenon. The present investigation has revealed that heightened occurrences of bacterial infection can result in significant economic, environmental, and food security implications. This underscores the importance of prioritizing rice breeding endeavours to enhance resistance against bacterial pathogens (Whitehorn and Yacoub, 2019).

There is an essential role of climate not only in increasing the pathogen's ability to grow and multiply but also in its effect on increasing their transmission; two main studies, Mbouna *et al*., (2022) and Carlson *et al*., (2022), discussed the mode of transmission and its rates as a resultant from climate change, as there exists a significant correlation between precipitation, temperature, and the transmission of pathogens. The relationship between temperature and the evolution of certain infectious diseases has been well-established in academic literature. Additionally, the influence of seasonality on various metrics that control disease transmission has been emphasized. The analysis of future climate scenarios demonstrates that alterations in temperature and rainfall have a regulating impact on variations in malaria transmission. However, it is important to consider additional factors, such as population mobility and effective intervention strategies against infectious diseases, as they will likely enhance outcomes.

There are many public health policies used to combat the infectious diseases' dissemination such as the infection control (Salah *et al.,* 2021a) and prevention disciplines in addition to protective personnel equipment to decrease the incidence of infections in addition to the governmental efforts to educate and counsel people to reduce their habits and some wring manners such as fuel burning to decrease the global warming as one of the main factors causing infections dissemination. Some intervention strategies such as governmental and ministry regulations to prevent any wrong habits may be attributed to global warming and any causes for infection transmission such as bad hygiene and misuse of antibiotics (Salah *et al.,* 2021b).

**Limitations**

There are many limitations observed in the selected reports such as the restricted areas of study and the narrow period for the experiments with no evidence of infectious diseases' dissemination strategies Also there are no reports for other reasons of dissemination of these infections that may be not attributed to global warming. Also, few studies reported the global warming impact on the infection’s transmission in the African regions and developed countries in addition to low-income countries where the causative habits of global warming and infection dissemination are widely spread.

**Future Perspectives**

- Other studies must be implemented to discuss and report the strategies used to combat and prevent global warming and then disseminate them in countries worldwide.
- More Experimental designs may be carried out to detect other reasons for the dissemination and spread of infections rather than global warming.
- Specifying the type of infections with causative organisms which are disseminated due to global warming must be investigated too.

## CONCLUSION

The phenomenon of climate change has a significant influence on the spread and occurrence of numerous infectious diseases. It has been observed to contribute to the development of microbial resistance and potentially elevate the prevalence of arthropod-borne

diseases. However, its impact on fungal infections appears to be less pronounced. Furthermore, low to middle-income countries may experience a greater susceptibility to these harmful pathogens compared to other nations. Consequently, this study emphasizes the necessity for future research in the realm of climate change and infectious diseases to encompass a comprehensive analysis of disease transmission, encompassing both direct and indirect modes of transmission.

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**Author Contributions:** (I) Conception and design: AAM, and ANS conceived the idea and designed the review. (II) Administrative support: ANS. (III) Provision of study materials for patients: AAM. (IV) Collection and assembly of data: AO and HAA. selected the articles relevant for the review. (V) Data analysis and interpretation: ANS and AO. (VI) Manuscript writing: ANS and AAM. (VII) Final approval of manuscript: All authors.

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