Review

Analysis of a Reviewed Literature on the Effect of Global Warming on Infectious Diseases' Dissemination: A Scoping Review

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Abstract: The 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 included studies on global warming and infectious diseases from 2019 to 2023, The studies included in this research were obtained from reputable academic databases such as Web of Science and google scholar. A systematic keyword search was conducted to identify relevant studies, and a predefined set of inclusion criteria was applied to review and select the appropriate studies for analysis. This review found that climate change has a remarkable impact on the dissemination and incidence of many infectious diseases, it increases microbial resistance and may increase the prevalence the arthropods-borne diseases with mild effect on fungal infections, also, the low to middle income countries may be affected more than other countries from these virulent pathogens, this study concluded that a future research in the field of climate change and infectious diseases should involve a thorough examination of the transmission of diseases, considering both direct and indirect modes of transmission.

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Key findings

Climate change has a remarkable impact on the dissemination and incidence of many infectious diseases.

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It increases microbial resistance and may increase the prevalence the arthropods-borne diseases with mild effect on fungal infections, also, the low to middle income countries may be affected more than other countries from these virulent pathogens.

What it is known & What it is new

Global warming and climate change has a potential impact on the transmission and increasing incidence of infectious diseases.

Bacterial and viral infections get increased with more virulence due to climate changes and may affect the general public health state.

This review adds more knowledge about the most recent incidence rates of infectious diseases in Africa and Europe due to climate change.

What is the implication

It shed the light into the importance of studying this change and its impact trying to combat these infectious diseases' transmission and spread.

Introduction

Global warming is commonly defined as the phenomenon characterized by the progressive rise in the average temperature of the Earth. The frequency of disasters such as hurricanes, droughts, and floods are increasing as the Earth's temperature rises. Global warming is a significant factor in climate change that is linked to human activities[1]. It has a substantial impact on health and indirectly contributes to the proliferation of infectious diseases[2]. The early spring temperatures observed in 2018 appear to have played a role in the early and widespread outbreak of West Nile virus in Europe. This particular pathogen is expected to expand its range beyond its current distribution due to the effects of climate change[3-4]. 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. 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 individual host[5].

Temperature and precipitation are significant environmental factors that play a crucial role in the spread of infectious diseases. This includes water-borne diseases such as cholera, vector-transmitted infections like malaria, parasitic helminths, fungal diseases associated with global amphibian declines, and marine diseases that impact corals, sea stars, fisheries, and aquaculture[6]. Hence, global warming exerts an influence on infectious diseases through its effects on pathogens, hosts, and transmission mechanisms. It has been extrapolated the potential impact of global warming on diseases that necessitate intensive care. This extrapolation is based on existing data pertaining to the alteration in the transmission of infectious diseases[7]. 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[8]. Therefore, the objective of this scoping review is to examine the primary strategies employed in the reviewed literature regarding the influence of global warming on the spread and occurrence of diverse infectious diseases.

Methods

The literature review assists in covering and summarizing several studies on the impact of global warming impact on spread of infectious diseases in world. The data search was done using the Web of Science, Science Direct, EBSCO, MEDLINE, BIOMED CENTRAL, CINAHL, Google Scholar, and Scopus, and only the English language was used. And this search was done using the PRISMA extension for scoping reviews. The research question used to guide the review was;

"What the impact of global warming on 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:

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Global Warming; Heat; Heating; Global heat; Climate change of heat; climate change; Climate change infection; Impact; effect; Spread; Incidence; rate; Infectious Diseases; Infection; Parasites; Viruses; Bacteria; strategies; peer reviewed;

They were used in the search engines 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 the 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 article
- Articles related to search terms
- Published after January 2019
- No restrictions on the area of study
- English language

Researchers relied on the databases using the Boolean operators (AND, OR, NOT) which included: 980 citations; 220 from Science Direct, 78 from EBSCO, 174 from PubMed, 139 from BIOMED CENTRAL, 123 from CINAHL, and 246 from Google Scholar.

By screening the results, papers other than English and duplicates, and other exclusion criteria were removed and revealed that 800 of these retrieved studies had been neglected duo to not coherent titles, with filter of date 88 studies were excluded. 42 papers retained for eligibility observation. 23 excluded as not explicit refers to strategies, and 2 records additionally identified via full text records. A total of 19 articles were reviewed for relevance after being narrowed down to those with titles that most closely resembled the original search term, as showing in the following PRISMA chart.

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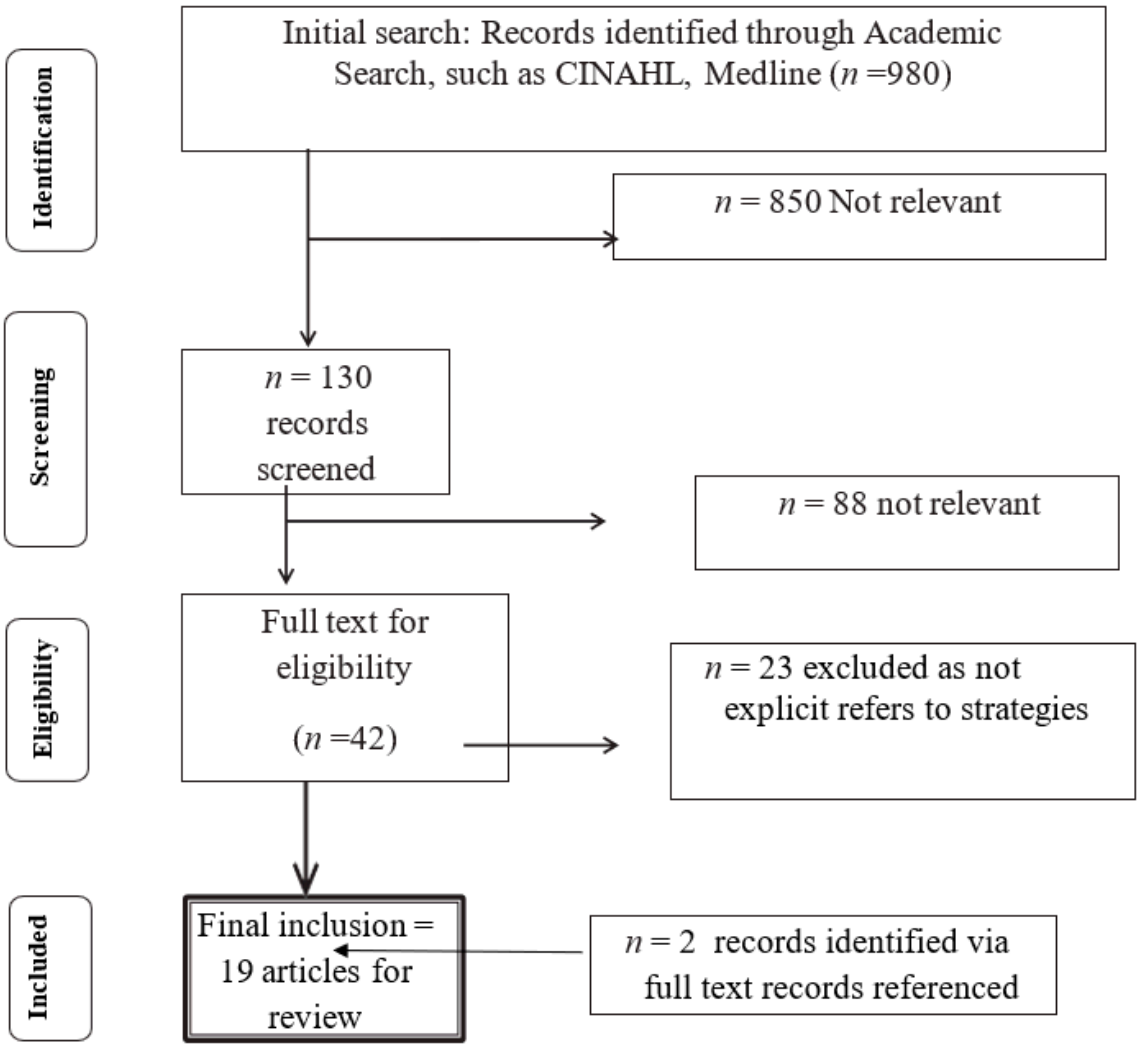

Figure 1. PRISMA tool chart used and designed in this review.

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. 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 1).

Table 1. 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.	Breeding for BPB resistance would be the first line of defence since there are presently no effective chemical solutions available to treat what might become a more widespread and serious rice disease as global warming accelerates.
Reverter *et al.*, 2020	To explore how global warming and antimicrobial resistance (AMR) impact aquaculture.	Double meta-analysis	All peer-reviewed journal articles using Web of Science and Google scholar up to 1 March 2019.	Countries that are highly susceptible to climate change are likely to experience significant risks of antimicrobial resistance, which will have adverse effects on human health beyond just the aquaculture sector. This underscores the urgent need for immediate action.
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. This suggests that warming enhanced the capacity of bacteria to decompose organic matter and release greenhouse gases, including CO2 and CH4. Warming will collectively modify the structure and potential functions of soil bacterial communities, subsequently impacting crucial functions within grassland belowground ecosystems.
Whitehorn& Yacoub, 2019	To consider the impact of climate change on three arboviruses with particular consideration of the effect on Europe.	Literature review	N/A	Climate change is expected to contribute to the expansion of arboviral transmission. Climate change is expected to cause a notable increase in the displacement of people, commonly referred to as 'climate refugees'.
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 that inhabit the same cave.	The results of this research show that 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.
Khezzani *et al.*, 2023	To examine impact of Global warming and mosquito-borne diseases in Africa.	literature review (Narrative review)	97 peer-reviewed references were included for final review.	According to a review of the academic literature, the incidence of illnesses spread by mosquitoes has been on the rise as global warming has gained attention.

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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 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.	case study	NA	Combining numerous disease and insect resistance into maize cultivars is necessary, however incorporating many diverse effective resistance resources into breeding programs may be difficult, especially if trade-offs among breeding aims occur.
Cogliati, 2021	to analyze how geographical distribution of C. gattii VGI in Europe and the Mediterranean area has evolved in the last four decades based on the climatic changes and we tried to predict the scenario for the next decade.	Literature review	NA	The research concluded that c. Gattii vgi-related cryptococcosis cases would rise over the next decade, and that tracking the spread of this fungus will be essential for preventing further pandemics.
Misseri, *et al.*, 2019	To identify how Global warming "heating up" the ICU through Candida auris infections by using the climate changes theory.	Review	NA	Although it is tempting to attribute the increase of C. auris to global warming, other explanations cannot be ruled out. It is possible that C. auris' survival and development of antifungal resistance have been facilitated by factors such as high population density, poor hygiene, migrations, international travel, and pollution. More research is required to determine its evolutionary reserves and verify the climatic changes hypothesis.
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

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				Leptospirosis. The lowest temperature was the most important predictor of climate change since it was the only variable with a significant result of 36% for all infectious illnesses in Malaysia.
Baharom *et al.*, 2021	To review scientific studies on the relationship between meteorological factors and the occurrence of dengue, malaria, cholera, and leptospirosis, and synthesized the key findings on communicable disease projection in the event of global warming.	systematic review	A total of 38 studies were included in the review.	Climate-sensitive communicable illnesses are affected by precipitation and temperature.
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	The mean ambient air temperature was negatively correlated with brucellosis incidence. Frosty days were positively associated with brucellosis incidence. Other metrological characteristics did not affect human brucellosis. Although our data imply 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	Despite high bed net usage in this portion of Kenya, this research demonstrated that 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. Climate change is causing more harsh weather and infectious illnesses, endangering human health and life.
Combe *et al.*, 2023	To investigate the influence of global warming on mortality due to viral infections in farmed aquatic animals.	meta-analysis study	all peer-reviewed journal articles that studied cultured aquatic animal mortalities due to viral infections	A positive tendency between rising temperature and viral virulence, with a rise in water temperature of 1 _C increasing oyster mortality by 1.47–8.33%, CyHV-3 carp mortality by 2.55–6.98%, and NVV fish mortality by 2.18–5.37%. Global warming may increase aquaculture viral disease outbreaks and threaten global food security, according to research.
Byers, 2021	to examine thermal performance curves (TPCs) as a promising first-	Review	NA	Higher temperatures diminish dissolved oxygen levels, increasing oxygen stress and host sensitivity, and expand

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	step approach to predict the effects of changing temperature on parasites and disease.			transmission windows because high-latitude hosts and multi-host parasite life cycles prolong seasonal residence and activity.
Heath, 2021	This paper examines the on- and off-host responses to potential changes in temperature and humidity of a representative selection of arthropod ectoparasites (sheep chewing louse, Bovicola ovis; sheep blowflies, Lucilla spp., Calliphora stygia, and Chrysomya rufifacies; cattle tick, Haemaphysalis longicornis; scrotal mange mite, Chorioptes bovis; cat flea, Ctenocephalides felis; and dog flea, Ctenocephalides canis) that occur in New Zealand and in many other countries, and how these environmental factors can be perturbed by host manipulation..	Review	NA	Warmer climates may have fewer ectoparasites, excluding fleas. Economic impacts of ectoparasite prevalence rises, utilizing estimated dipping costs as a model, and exotic arthropod parasites that may infect New Zealand under climate change are briefly discussed.
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.	Review	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.

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Results

The review included 19 records. A thematic analysis of the content of the selected records yielded six major themes across global warming impact on spread of infectious diseases. A total of 19 studies were found: 2 meta-analysis, 8 literature review, 1 narrative review, 1 statistical dynamics and epidemiological modeling methods, 2 quantitative experimental study, 3 retrospective, 1 cross-sectional study, and 1 systematic review. The geographical areas of these studies were as follows: 4 studies world widely, 5 in Europe, 3 in Africa, 2 in the United States, 2 in China, and 1 study each in Newzeland, Malysia, Iran). The distribution of these studies was then mapped according to the data extraction table 1.

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

There are 3 studies have assessed global warming impact on bacterial infection[9-10-11]. Reverter *et al*. (2020)[11] 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.

Yu *et al*. (2021)[9] 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[10].

Theme 2: Global warming impact on viral and parasitic infection

Different studies have mentioned global warming impact on viral and parasitic infection, researchers investigated 4 studies[12-13-14-15]. Combe *et al*. (2023)[12] 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[13].

 doi:10.20944/preprints202401.1058.v1

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[14]. 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[15].

Theme 3: Global warming impact on fungal infection

Only 2 studies stated Global warming impact on fungal infection[2-16]. 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. 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[16].

Theme 4: Global warming impact on arthropods and vector transmission

There are 5 studies have mentioned the global warming impact on arthropods and vector transmission[17-18-19-20-21]. The geographical range of mosquitoes and mosquitoes 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[21], 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[17].

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[18]. 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

 doi:10.20944/preprints202401.1058.v1

constant environmental conditions. This research disproves the idea that ambient factors control the heat tolerance of underground animals. Pallarés *et al*. (2019)[19] 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 with the goal of learning 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[20].

Theme 5: Global warming impact on incidence of infectious diseases

There are 5 studies have investigated global warming impact on incidence of infectious diseases[22-23-24-8-25]. 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 are affected by both precipitation and temperature[22]. Lian *et al*. (2023)[24] 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 heatwave 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[23]. 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 the ways in which environmental factors and climatic shifts affect the regional distributions and seasonal/annual cycle of this zoonotic virus across the globe[8]. The lowest 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)[25], Malaria transmission seems to be strongly associated with heavy rains. Leptospirosis is strongly associated with high temperatures.

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 the 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) and Baharom *et al*. (2021)[22-24] 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 Furthermore, 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)[23-8-25], 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.

It was noted that Khezzani *et al*. (2022), Pallarés *et al*. (2019), Heath (2021), and Miedaner and Juroszek (2021)[21-19-15-18], 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

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warming.. 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 mosquitos and other arthropods transmission and dissemination.

Bacterial infection has the greatest and most abundant 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 be occurred due to several factors which the increasing in temperature is one of this factors as reported by Reverter *et al*. (2020)[11] 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)[9-10] reported that The potential economic devastation caused by 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 endeavors to enhance resistance against bacterial pathogens.

In addition, both Combe *et al*. (2023), Whitehorn and Yacoub (2019)[12-16] reported the relationship between viral infection and climate change with its effect on increasing viral infections among people, specifically when it was reported that The significance of characterizing the associations between mortality related to viruses and temperature. It has been demonstrated that a modest temperature rises of 1 ◦C has the potential to result in a 3-6% increase in mortalities which is particularly noteworthy in the context of aquaculture in low- and middle-income countries (LMICs), as it could have a substantial effect on food safety. This study aims to increase awareness regarding the pressing need to develop strategies to ensure aquaculture's sustainability in low- and middle-income countries (LMICs) as a viable source of protein for rapidly growing populations. These strategies include temperature mitigation, stock selection, and health management.

Besides the parasitic infections, which had been discussed by Byers (2020)[14], when it was discussed that the impact of climate change on parasites and their hosts is expected to exhibit variability, influenced by the species' tolerances and potentially even the genotypes at play. Nevertheless, the growing focus on observation and experimentation regarding this matter has facilitated the understanding of potential patterns in anticipated reactions and the identification of valuable research methodologies. A potentially effective method for studying the impact of rising temperatures on host-parasite systems is the development of thermal performance curves (TPCs) for both the host and parasite. In the case of parasites that do not exceed their optimal thermal conditions, as determined by thermal performance curves (TPCs), it is plausible to anticipate heightened intensity and pathology. Parasites' accelerated feeding and increased intensity on their hosts, except for marine mammals and seabirds, in response to elevated temperatures, primarily because these parasites and their hosts are ectothermic.

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)[20-13], 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.

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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References

1. Omonaliyevych. Causes of global warming on earth, factors of global warming, consequences in the ocean, effects in the atmosphere. *Научный Фокус*. 2023; 1(1), 141-147.
2. Misseri G, Ippolito M, and Cortegiani A. Global warming "heating up" the ICU through Candida auris infections: The climate changes theory. *Critical Care.* 2019; 23, 1-2.
3. Semenza JC, Rocklöv J, and Ebi KL. Climate change and cascading risks from infectious disease. *Infectious Diseases and Therapy*. 2022; 11(4), 1371-1390.
4. Howard C and Huston P. The health effects of climate change: Know the risks and become part of the solutions. Canada communicable disease report. *Releve des maladies transmissibles au Canada*. 2019; 45(5), 114–118.
5. Baker RE, Mahmud AS, Miller IF., *et al*. Infectious disease in an era of global change. *Nature Reviews Microbiology*. 2022; 20(4), 193-205.
6. Rohr J R, and Cohen J M. Understanding how temperature shifts could impact infectious disease. *PLoS biology*. 2020; 18(11), e3000938.
7. Bein T, Karagiannidis C, and Quintel M. Climate change, global warming, and intensive care. *Intensive care medicine.* 2020; 46, 485-487.
8. Dadar M, Shahali Y, and Fakhri Y. A primary investigation of the relation between the incidence of brucellosis and climatic factors in Iran. *Microbial pathogenesis*. 2020; 139, 103858.
9. Yu Y, Liu L, Wang J, Zhang Y, & Xiao. Effects of warming on the bacterial community and its function in a temperate steppe. *Science of the Total Environment*. 2021; *792*, 148409.
10. Shew AM, Durand-Morat A, Nalley LL, Zhou, XG, Rojas C, and Thoma G. Warming increases Bacterial Panicle Blight (Burkholderia glumae) occurrences and impacts on USA rice production. *PLoS One.* 2019; 14(7), e0219199.
11. Reverter M, Sarter S, Caruso, *et al*. Aquaculture at the crossroads of global warming and antimicrobial resistance. *Nature communications*. 2020; *11*(1), 1870.
12. Combe M, Reverter M, Caruso D, Pepey E, and Gozlan RE. Impact of Global Warming on the Severity of Viral Diseases: A Potentially Alarming Threat to Sustainable Aquaculture Worldwide. *Microorganisms*. 2023; *11*(4), 1049.
13. Carlson CJ, Albery GF, Merow C, *et al*.. Climate change increases cross-species viral transmission risk. *Nature*. 2022; 607(7919), 555-562.
14. Byers JE. Marine parasites and disease in the era of global climate change. *Annual Review of Marine Science.* 2021; 13, 397-420.
15. Heath ACG. Climate change and its potential for altering the phenology and ecology of some common and widespread arthropod parasites in New Zealand. *New Zealand veterinary journal*. 2021; 69(1), 5-19.

16. Whitehorn J, and Yacoub S. Global warming and arboviral infections. *Clinical Medicine*. 2019; 19(2), 149.
17. Cogliati M. Global warming impact on the expansion of fundamental niche of Cryptococcus gattii VGI in Europe. *Environmental Microbiology Reports*. 2021; 13(3), 375-383.
18. Miedaner T & Juroszek P. Global warming and increasing maize cultivation demand comprehensive efforts in disease and insect resistance breeding in north-western Europe. *Plant Pathology*. 2021; 70(5), 1032-1046.
19. Pallarés S, Colado R, Pérez-Fernández T, Wesener T, Ribera I, and Sánchez-Fernández D. Heat tolerance and acclimation capacity in subterranean arthropods living under common and stable thermal conditions. *Ecology and Evolution*. 2019; 9(24), 13731-13739.
20. Mbouna AD, Tamoffo AT, Asare EO, Lenouo A, and Tchawoua C. Malaria metrics distribution under global warming: assessment of the VECTRI malaria model over Cameroon. *International Journal of Biometeorology*. 2023; 67(1), 93-105.
21. Khezzani B, Baymakova M, Khechekhouche EA, and Tsachev I. Global warming and mosquito-borne diseases in Africa: a narrative review. *The Pan African Medical Journal*. 2023; 44.
22. Baharom M, Ahmad N, Hod R, Arsad FS, and Tangang F. The impact of meteorological factors on communicable disease incidence and its projection: a systematic review. *International Journal of Environmental Research and Public Health*. 2021; 18(21), 11117.
23. Nyawanda BO, Beloconi A, Khagayi S, *et al*. The relative effect of climate variability on malaria incidence after scale-up of interventions in western Kenya: A time-series analysis of monthly incidence data from 2008 to 2019. *Parasite Epidemiology and Control*. 2023; 21, e00297.
24. Lian X, Huang J, Li H, *et al*.. Heat waves accelerate the spread of infectious diseases. *Environmental Research*. 2023; 231, 116090.
25. Alhoot MA, Nagarajan R, Abdulmajid MS, *et al*. Effects of global warming on the incidence of infectious diseases in Malaysia. *International Journal of Medical Toxicology & Legal Medicine*. 2019; *22*(1and2), 111-117.