Review Article

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Global Warming and Parasitic Infection in Urban Communities: A Systematic Review

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ABSTRACT

Global climate change is an important global issue; it influences not only the environment but also human health. Parasitic infection is one of the most recognized infectious diseases generally observed in rural areas of developing countries in tropical and subtropical zones of all continents. Interestingly, there are few reports on parasitic infections in the temperate zone; however, climate change provides a wide warming area optimal for the survival of several parasites. This situation leads to the spread of parasitic pathogens and their vectors in other zones around the world that they lack access to optimal healthcare. Moreover, the urban community shares a lot of the population in several developed and developing countries, which generally have a better sanitary system when compared with rural areas. Furthermore, there could have been a slight chance of parasitic infections in the past in these urban communities. For several reasons, the association between climate change and parasitic infection in urban areas has caught research interest. Hence, this systematic review proves the increased prevalence of parasitic infections in urban areas worldwide in the last decade. The most prevalent parasites were vector-borne parasites, which directly suggests their relationship with climate change. Our findings can benefit healthcare providers and governors who must address this situation. In conclusion, parasitic infections in urban areas should be an increasing concern given their increased likelihood because of climate change.

KEYWORDS: climate change, parasitic infection, urban communities

INTRODUCTION

Global climate change, particularly global warming, refers to the most recent emergency crisis worldwide because of the widespread impact effects of several social elements and not only the environment. El Niño and La Niña, which form heatwaves, storms, and melting polar ice, represent the enormous impacts of climate change on humans[1]. Several organizations have been collaborating to halt or at least delay climate change. The recent COP28 UN climate change conference released the United Arab Emirates consensus on agreement signals, "beginning of the end of the fossil fuel era" at the end of 2023 to accelerate climate action through reduction in fossil fuel usage and levels of greenhouse gases[2]. This action is a crucial step that must be considered by communities around the world.

Regarding the health impact, the direct effects of an increase in ground temperature include discomfort and occasional death caused by heatwaves; moreover, the increment in global temperature can lead to changes in infectious environments, which can only expand from limited areas[1,3]. Vector-borne diseases are the best example of this alteration in global temperature.

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Global warming has expanded the geographic distribution of mosquito vectors from tropical to temperate zones. This spread in geographic distribution has increased the likelihood of mosquito-borne diseases, such as malaria, dengue, and yellow fever, in regions that have never experienced such a situation before, which leads to endemic expansion[4-5].

Parasitic infection poses a most concerning health issue worldwide, especially in rural areas of low- and middle-income countries in tropical zones[6]. The World Health Organization and previous studies estimated that > 3.5 billion people are at risk of parasitic infections, including those caused by helminths, protozoa, and ectopic parasites, worldwide[6-8]. Although most endemic areas remain in the same regions, global climate change can increase the prevalence of parasitic infections worldwide[9-10]. In this review, we focused on the reports on parasitic infections in urban areas, where sound sanitary systems and good waste management are not only found in developing countries but also in developed countries around the world. The parasitic infection in the urban areas can be referred to the effects of global climate change on the infectious diseases due to it change the habitat of the organisms, which will be the sign for anxious situation in the future.

SEARCH STRATEGY AND DATABASES

This systematic review followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 guideline for systematic review and meta-analysis[11]. All procedures were conducted in accordance with the checklist and applied at all stages of this study. The search keywords were "parasite infection" OR "parasitic infection" OR "parasite-infection" OR "parasitic-infection", "urban community" OR "urban communities" OR "urban", and "climate change" OR "global warming". Three investigators used these keywords to search three databases, including PubMed, Scopus, and Google Scholar, until January 11, 2024.

ELIGIBILITY CRITERIA

The PICO method (P: population, I: intervention, C: comparators, O: outcome) was used to identify studies that met the inclusion criteria: Data on each part were as follows: P: data on parasitic infection in urban communities coupled with climate change; I: none; C: data on parasitic infection in urban communities without climate change evidence; O: the prevalence or proportion of parasitic infection in urban communities under climate change conditions. This work included all studies published in English and reported parasitic infection in urban areas related to climate change, including case reports and series. However, the following types of research were excluded: (1) those that did not report parasitic pathogens, (2) those that reported parasitic infections in rural areas, (3) those that reported parasitic infections without evidence of climate change, (4) review articles, and (5) conference abstracts.

IDENTIFICATION OF KEYWORDS

Parasitic infection refers to infectious diseases caused by parasitic organisms, including protozoa and helminths (nematodes, trematodes, cestodes, and acanthocephalan). Furthermore, infections caused by ectopic parasites, including acari and insects, are considered parasitic infections. The urban area relates to the community characteristics that form a town or city. The climate change discussed in this review refers to long-term shifts in temperatures and weather patterns[12].

DATA SELECTION AND EXTRACTION

This study considered publications that met the criteria and were published in the last 20 years (2004–2023). Duplicate publications, publications generated from automation, and those published in unreliable journals were removed. Published articles were screening thoroughly. Non-research articles were withdrawn at this step, and only retrieved articles were included. Research on nonparasitic pathogens, noninvolvement of urban communities, and climate change were filtered out at the final screening step. All stages of data extraction were performed using EndNote version 20 (Stanford, CT, USA).

QUALITY ASSESSMENT AND BIAS REDUCTION

This review focused on studies with several research designs, including prevalence, retrospective cross-sectional, comprehensive, spatiotemporal modeling, and intercomparison modeling studies and case reports. Given the different natures of study designs, comparison of the quality of articles was impossible. Therefore, no quality assessment was performed in this systematic review. Three independent searches by different searchers reduced the selection bias. All included articles were pooled, decisions on selected publications were discussed, and a final consensus decision was made.

EXPLANATION OF FINDINGS

In the first stage, 307 articles were obtained from all databases by limiting the search. In total, 61 duplicate articles were removed, and the other 213 were removed for different reasons, such as those generated by automation tools, published in unreliable journals or databases, and nonrelevant research. Then, 96 articles were included in the screening step, and 41 review articles were removed afterward. Attempts were made to retrieve the full texts of 55 research articles from the databases. Four articles could not be retrieved. In the final step of screening, 13 articles were removed as they were concerned with research on other pathogens, e.g., viruses and bacteria. Next, 8 nonrelevant articles on urban communities were removed, and another 14 were removed for the lack of direct involvement with climate change. Figure 1 illustrates the study flow diagram, and Table 1 shows all the studies included in this review.

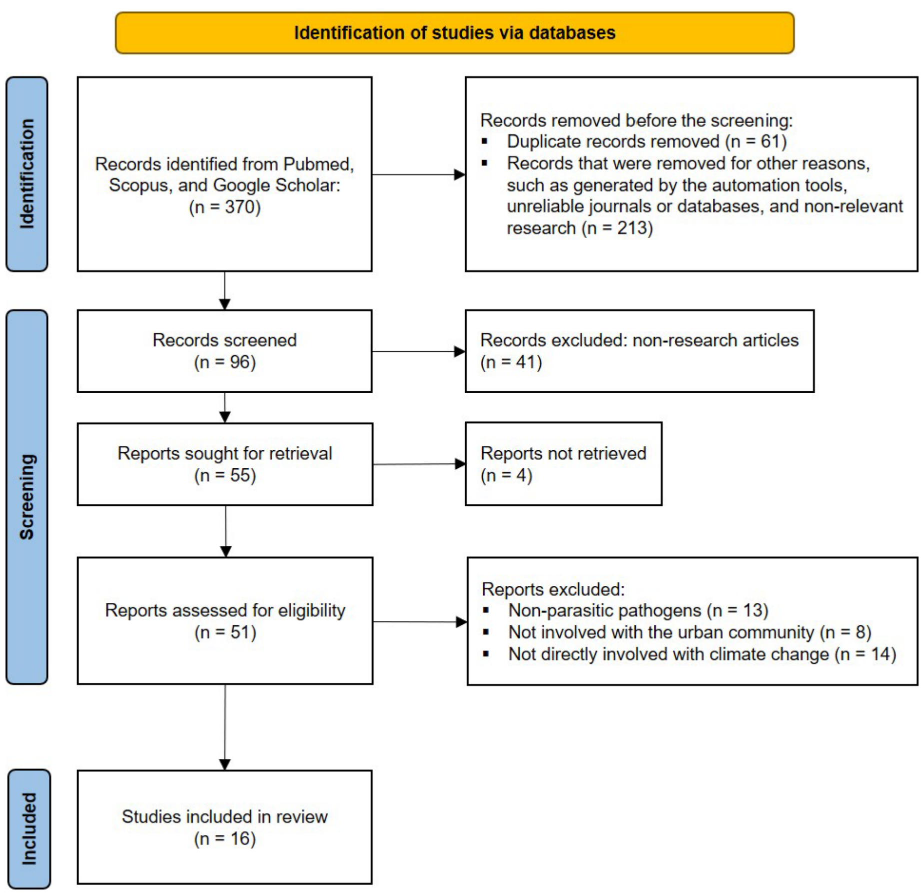

Figure 1 PRISMA flowchart diagram of systematic review process used in this study

Table 1 The publications included in this systematic review at the final selection step

No.	Title	Authors	Journal	Parasite	Country/ Continent	Year
1	Quantifying climatic and socioeconomic drivers of urban malaria in Surat, India: a statistical spatiotemporal modelling study	Santos-Vega M, et al.[33]	Lancet Planet Health	Malaria	India	2023
2	*Toxoplasma gondii* in small mammals in Romania: the influence of host, season and sampling location	Kalmár Z, et al.[21]	BMC Vet Res	*Toxoplasma gondii*	Romania	2023
3	Climate change and cutaneous leishmaniasis in the province of Ghardaïa in Algeria: a model-based approach to predict disease outbreaks	Saadene Y, et al.[36]	Ann Saudi Med	cutaneous leishmaniasis	Algeria	2023
4	Identification of a triatomine infected with *Trypanosoma cruzi* in an urban area of the state of Veracruz, Mexico: a comprehensive study	Ochoa-Martínez P, et al.[28]	Zoonoses Public Health	*Trypanosoma cruzi*	Mexico	2023
5	Data-driven predictions of potential *Leishmania* vectors in the Americas	Vadmal GM, et al.[29]	PLoS Negl Trop Dis	*Leishmania* vectors	Americas	2023
6	Molecular epidemiological study of *Trichomonas gallinae* focusing on central and southeastern Europe	Tuska-Szalay B, et al.[22]	Front Vet Sci	*Trichomonas gallinae*	Europe	2022
7	Synergies between environmental degradation and climate variation on malaria re-emergence in southern Venezuela: a spatiotemporal modelling study	Fletcher IK, et al.[30]	Lancet Planet Health	Malaria	Venezuela	2022
8	The neglected role of relative humidity in the interannual variability of urban malaria in Indian cities	Santos-Vega M, et al.[34]	Nat Commun	Malaria	India	2022
9	A comparative spatial and climate analysis of human granulocytic anaplasmosis and human babesiosis in New York state (2013-2018)	O'Connor C, et al.[31]	J Med Entomol	*Anaplasma Babesia*	USA	2021
10	One Health approach to zoonotic parasites: molecular detection of intestinal protozoans in an urban population of Norway rats, *Rattus norvegicus*, in Barcelona, Spain	Galán-Puchades MT, et al.[23]	Pathogens	Intestinal parasites	Norway	2021
11	Effects of climate change and heterogeneity of local climates on the development of malaria parasite (*Plasmodium vivax*) in Moscow megacity region	Mironova V, et al.[24]	Int J Environ Res Public Health	Malaria	Russia	2019
12	Risk factors for schistosomiasis in an urban area in northern Côte d'Ivoire	M'Bra RK, et al.[37]	Infect Dis Poverty	*Schistosoma*	Côte d'Ivoire	2018
13	Phleboviruses detection in Phlebotomus perniciosus from a human leishmaniasis focus in South-West Madrid region, Spain	Remoli ME, et al.[25]	Parasit Vectors	*Leishmania*	Spain	2016
14	The increase of exotic zoonotic helminth infections: the impact of urbanization, climate change and globalization	Gordon CA, et al.[38]	Adv Parasitol	Helminths	Global	2016
15	*Angiostrongylus cantonensis* infection in molluscs in the municipality of São Gonçalo, a metropolitan area of Rio de Janeiro, Brazil: role of the invasive species *Achatina fulica* in parasite transmission dynamics	Oliveira AP, et al.[32]	Mem Inst Oswaldo Cruz	*Angiostrongylus cantonensis*	Brazil	2015
16	Visceral leishmaniasis-associated mortality in Bangladesh: a retrospective cross-sectional study	Huda MM, et al.[35]	BMJ Open	*Leishmania*	Bangladesh	2014

The number of publications in the last 20 years has increased. Our review demonstrated that most included articles were published in 2019–2023 (11 articles, 68.75%), followed by those published in 2014–2018 (5 articles, 31.25%), whereas no publications in 2004–2013 were included (table 2 and figure 2A). Notably, most of the published articles were conducted in Europe and America (5 articles, 31.25% for each continent), followed by those in Asia (3 articles, 18.75%) and Africa (2 articles, 12.50%), and 1 article that was conducted at the global scale (6.25%) (table 2). Among infective parasites, *Plasmodium* spp. (malaria) and *Leishmania* spp. were the two most prevalent (4 articles, 25.00% for each parasite). The other parasites, including *Toxoplasma* spp., *Schistosoma* spp., *Trypanosoma* spp., *Angiostrongylus* spp., *Trichomonas* spp., intestinal parasites, helminths (unclassified), and other protozoa, were observed at the same proportions (1 article, 6.25% for each parasite) (table 2 and figure 2B). The model-based approach was the most used study procedure (7 articles, 43.75%), followed by comprehensive and epidemiological (3 articles, 18.75% for each study method), spatiotemporal modeling (2 articles, 12.50%), and cross-sectional (1 article, 6.25%) (table 2) studies.

Table 2 The data analysis from all publications used in this systematic review

Parameters	No. of study	Percentage (%)
Published year		
2004 – 2008	0	0.00
2009 – 2013	0	0.00
2014 – 2018	5	31.25
2019 – 2023	11	68.75
Study area		
Global	1	6.25
America	5	31.25
Europe	5	31.25
Asia	3	18.75
Africa	2	12.50
Parasite		
Malaria	4	25.00
Leishmania	4	25.00
Toxoplasma	1	6.25
Schistosoma	1	6.25
Trypanosoma	1	6.25
Angiostrongylus	1	6.25
Trichomonas	1	6.25
Intestinal parasites	1	6.25
Helminth (unclassified)	1	6.25
Other protozoa	1	6.25
Study method		
spatiotemporal modelling study	2	12.50
model-based approach	7	43.75
comprehensive study	3	18.75
epidemiological study	3	18.75
cross-sectional study	1	6.25

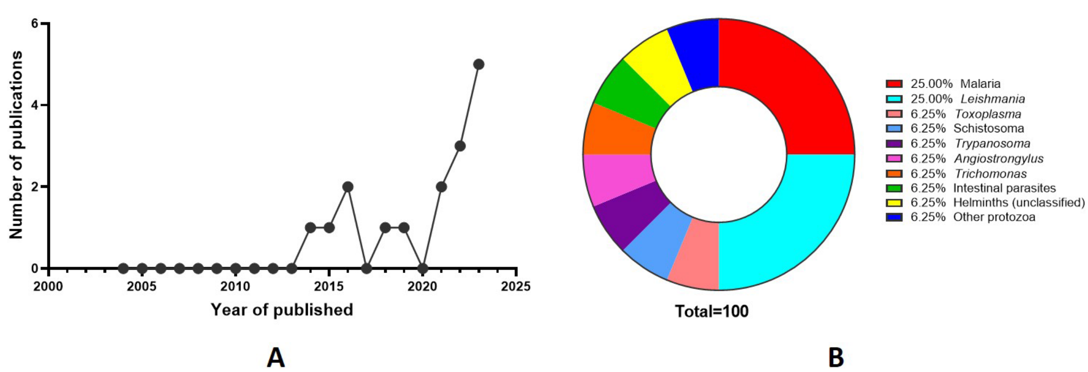

Figure 2 (A) The trend of publications in the parasitic infection in urban areas related to climate change, (B) The proportion of parasites found in this review during 2004 – 2023.

CONSIDERATION OF FINDINGS

This systematic review demonstrated the trends of parasitic infection in urban communities involved with global climate change published in the last 20 years. Our results reveal the increment in published articles, which reached up to twofold of the previous period (2004–2013), especially in the past decade (2014–2023). This finding suggests the effects of climate change on parasitic infection in urban areas of several countries. Furthermore, this result agrees with those of several previous reviews and reports that indicated the association between climate change and increased likelihood of parasitic infections[13-17]. Comparably, this trend is the same as that observed for other pathogenic organisms, which are increasingly reported in relation to climate change[18-20].

Our review revealed that the highest prevalence of parasitic infection was observed in Europe and the Americas. In Europe, where high sanitary standards are implemented, the reported parasites were *Toxoplasma gondii*, *Trichomonas gallinae*, intestinal protozoans, malaria parasites, and *Leishmania*, which were reported from Romania, Spain, Russia, and central and southeastern Europe[21-25]. *Toxoplasma gondii*, *Trichomonas gallinae*, and intestinal protozoans can spread through direct contact and consumption of contaminated foods and beverages; however, a supportive solid evidence of their association with climate change is lacking. In contrast, malaria and *Leishmania* were vector-borne parasites. This result indicates that the vectors of these parasites, namely, *Anopheles* mosquitoes and sandflies, can be increasingly found in Europe. This situation directly affects climate change because the normal habitat of these insects includes the tropical and subtropical zones[26-27]. In the Americas, the reported parasites included *Trypanosoma cruzi*, *Leishmania* spp., malaria parasites, *Anaplasma* spp., *Babesia* spp., and *Angiostrongylus cantonensis*, which were noted from the urban areas of USA, Mexico, Brazil, and Venezuela[28-32]. Publications from the Latin Americas were obtained because these countries are in tropical and subtropical zones; however, *Anaplasma* spp. and *Babesia* spp. were unexpectedly observed in New York City[31]. In general, these parasites are rarely observed in humans. Still, an article suggested an association between parasites and climate change via a comparative spatial analysis; the results revealed that the spread of parasites was indirectly associated with house locations, which were neither close nor far from forests[31]. Asia and Africa have fewer reports of parasitic infections in urban areas. These areas have a high number of parasitic cases, and reports focusing on climate change are very few. Regarding Asia, our review included two reports from India and one from Bangladesh[33-35]. Malaria and *Leishmania* were parasites that have been reported along with the burden involved with climate change. However, humidity was the only specific reason for the increase in malaria cases[34]. Two reports from Africa included in our review demonstrated that climate change promoted cutaneous leishmaniasis and schistosomiasis in urban areas[36-37]. These studies indicate that the inflation risk of these parasites is related to climate change worldwide[38]. However, more investigation is still required for a definite conclusion when getting more reports in the future.

CONCLUSION

This systematic review provided a specific discussion topic focusing on climate change, which can affect human life by increasing the chance of parasitic infections. Our study revealed the increased trend of parasitic infections in urban areas, where sanitary conditions are better than those in other communities reported worldwide. The most reported parasites were malaria parasites and *Leishmania*, which can be considered effects of climate change owing to the biology of their vectors. In conclusion, climate change can be associated with parasitic infection in urban areas. This finding can be used for further prevention and precautionary campaigns.

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