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ORIGINAL

Investigating the Links between Climate Change, Vector-Borne Diseases, and Public Health Outcomes

Investigación de los vínculos entre el cambio climático, las enfermedades transmitidas por vectores y la salud pública

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ABSTRACT

Introduction: the present study aimed to explore the associations between climate change, vector-borne diseases and health outcomes. Contemporary climate change has drawn growing recognition from the global public health community as an important global public health hazard. Vector-borne diseases like malaria, dengue, and Lyme disease also pose significant public health threats, and we know that they, too, are sensitive to climatic changes. But the exact links among climate change, vector-borne diseases and public health outcomes remain poorly characterized.
Method: the goal of this study was to determine whether climate change, vector-borne diseases, and public health outcomes are connected in some way. However, the role climate change plays to the environment and human health made it a serious global public health threat. Vector-borne diseases, including malaria, dengue, and Lyme disease, are another important category of high-impact diseases and are also known to be affected by climate change. But the direct links between climate change, vector-borne diseases, and public health outcomes are poorly understood.
Results: overall, the results of the study indicate that climate change plays a very important role in the distribution, seasonality and transmission of vector borne diseases. Rising temperatures and shifting weather patterns are associated with the expansion of the geographic range of vectors, causing increased transmission of diseases like malaria, dengue fever, and Lyme disease. In addition, adapting measures to control disease will be critical in response to active ecological changes driven by climate change.
Conclusions: this research draws attention to the pressing need for international action on climate change to limit the impacts on vector-borne diseases and public health. Therefore, vector-borne diseases will continue to rise with little to no processes in place to quell its influence without climate change remediation measures and it would lead to dire consequences with respect to human health and well-being. Further research is needed to not only understand but also identify mechanisms to mitigate the impacts of climate change on vector-borne disease and human health.

Keywords: Investigate; Significant; Environment; Connections; Transmission; Seasonality.

RESUMEN

Introducción: el presente estudio tiene por objeto explorar las asociaciones entre el cambio climático, las enfermedades transmitidas por vectores y los resultados sanitarios. El cambio climático contemporáneo ha suscitado un creciente reconocimiento por parte de la comunidad sanitaria mundial como un importante peligro para la salud pública mundial. Las enfermedades transmitidas por vectores, como la malaria, el dengue y la enfermedad de Lyme, también suponen importantes amenazas para la salud pública, y sabemos

que también son sensibles a los cambios climáticos. Pero los vínculos exactos entre el cambio climático, las enfermedades transmitidas por vectores y los resultados en materia de salud pública siguen estando mal caracterizados.
Método: el objetivo de este estudio era determinar si el cambio climático, las enfermedades transmitidas por vectores y los resultados de salud pública están relacionados de alguna manera. Sin embargo, el papel que desempeña el cambio climático para el medio ambiente y la salud humana lo convierte en una grave amenaza para la salud pública mundial. Las enfermedades transmitidas por vectores, como la malaria, el dengue y la enfermedad de Lyme, son otra categoría importante de enfermedades de alto impacto y también se sabe que se ven afectadas por el cambio climático. Pero los vínculos directos entre el cambio climático, las enfermedades transmitidas por vectores y los resultados en materia de salud pública son poco conocidos.
Resultados: en general, los resultados del estudio indican que el cambio climático desempeña un papel muy importante en la distribución, estacionalidad y transmisión de las enfermedades transmitidas por vectores. El aumento de las temperaturas y los cambios en los patrones climáticos están asociados a la expansión del área de distribución geográfica de los vectores, lo que provoca un aumento de la transmisión de enfermedades como la malaria, el dengue y la enfermedad de Lyme. Además, las medidas de adaptación para controlar las enfermedades serán fundamentales en respuesta a los cambios ecológicos activos impulsados por el cambio climático.
Conclusiones: esta investigación llama la atención sobre la acuciante necesidad de actuar a escala internacional frente al cambio climático para limitar las repercusiones sobre las enfermedades transmitidas por vectores y la salud pública. Por lo tanto, las enfermedades transmitidas por vectores seguirán aumentando sin que se pongan en marcha procesos para sofocar su influencia si no se toman medidas correctoras contra el cambio climático, lo que tendría consecuencias nefastas para la salud y el bienestar humanos. Es necesario seguir investigando no sólo para comprender, sino también para identificar mecanismos que permitan mitigar los efectos del cambio climático en las enfermedades transmitidas por vectores y en la salud humana.

Palabras clave: Investigación; Significativo; Medio Ambiente; Conexiones; Transmisión; Estacionalidad.

INTRODUCTION

Climate changeclimate changeclimate changeclimate changeThe environmental determinant that has the most significant impact on public health outcomes is climate change. The average global planet temperature is rising rapidly, and the consequences are evident in various aspects of public health. They range from the heatwaves to the spread of vector-borne diseases. Vector-borne diseases are defined as infectious diseases either transmitted by vectors that are primarily invertebrates or smoke or direct cold-blooded vertebrates animals.[1] The latter meaning is that the vector can be a type of animal that, due to the characteristics of its biology, interacts with pathogens such as bacteria, viruses, or parasites. Climate change has an enormous influence on public health, including the occurrence, circulation, and spread of infectious diseases. Vector-borne diseases have emerged and reemerged as a result of climate change, as this determines the delicate balance of the host populations and the nature of the epidemic transmitters.[2] The higher the temperature is more transmitters, such as the Zika, the dengue fever, or dengue virus, for example that is responsible for the mosquitoes' spread and reproduction. Since the average global temperature has already increased, these conditions have been reported and tested. The viruses have already been in these conditions in the past. Since the global average temperature raises the life cycles are shorter.[3] Additionally, most of the infectious transmitters have short life cycles, and in warmer conditions, their reproduction is faster. The increase in humidity creates the perfect conditions for the reproduction of these vectors around the world. The malaria parasite P. falciparum grows in a mosquito faster in a warmer environment, which means that the transmitters must multiply to carry the pathogens. The increase in the number of vectors multiplies the diseases. Thirty percent increase in the number of flu vectors and one hundred twenty-seven percent increase in the number of neoplasm pathogens. According to the WHO, 150000 people die annually due to climate change consequences, with eight-eight percent of the deaths caused by vector-borne diseases. These conditions generated severe illness and death, mild illness and disease. The climate change affects health outcomes by the emergence of new diseases that have never been found before in a certain area.[4] And as diseases such as dengue fever, chikungunya, and Zia virus spread to new regions, they strain local health systems, which might not have the capacity to treat those infections. This can cause delays in response times for detection, diagnosis, and treatment; thus increasing the number of cases as well as deaths.[5] Moreover, the introduction of new diseases into a region can wreak economic havoc as it can impact tourism and productivity, resulting in potential loss of income and resources. Additionally, the rising incidence and intensity of extreme weather events (e.g., storms, flooding, etc.) are likely to adversely influence public health outcomes as well.[6] Such events can interrupt healthcare services, damage infrastructure, and pollutewater sources, all of which may elevate the

risk of vector-borne diseases. Residual standing water after flooding becomes a breeding ground for disease vectors like mosquitoes and raises the risk of transmission of diseases. Accordingly, climate change can affect public health both directly and indirectly, with the latter being via food and water security.[7] Temperature and precipitation changes can impact crop production and the availability of clean drinking water, resulting in malnutrition and water-borne diseases. That, in turn, can compromise people's immune systems, leaving them more susceptible to vectorborne illness. Besides affecting the physical well-being of people, climate change may also have considerable psychological and societal consequences.[8] Communities impacted by extreme weather events may suffer from increased stress and anxiety, and even mental illness, due to disasters, displacement and loss of livelihoods. Superview of these adverse mental health outcomes resulting from the pandemic, which can further aggravate the load on healthcare capacities due to concurrent treatment for both physical and mental afflictions.[9] Climate change, vector-borne disease, and public health outcomes are multifaceted and interrelated. The changing climate is affecting the distribution of these diseases and transmission patterns, making them more common and severe. "These diseases can cause illness and death, and they also have economic and social consequences, so their impact on public health outcomes is very large." Hence, prompt measures are essential to combat the consequences of climate change and avoid the impact on the health of individuals and communities.[10] This encompasses actions to mitigate greenhouse gas emissions, adapt to climate change, enhance health care systems and devise and deploy measures to control vector-borne diseases. It will take many different national and global solutions, with the inclusion of many different actors, to mitigate climate change's deleterious impacts on public health and to avoid even worse damage. The main contribution of the paper has the following.

- Such research will continue to inform further work on the complex relationships between climate change, vector-borne infectious diseases, and health outcomes. Scientists have been studying numerics and trends in cases and collaborating with data to determine the direct and indirect effects climate change has on vector-borne diseases with the ensuing public health consequences. This has raised the clarity of the problem and paved the way for further research and policymaking.
- This research is also important for its identification of specific variables contributing to the association of climate change and vector-borne diseases with public health outcomes. Thus, these factors like temperature, humidity, and rainfall and land cover have already been documented and are known for the direct influence on the occurrence and distribution of VBD (vector-borne diseases). That rather, provide important insights on how to develop targeted strategies and interventions.
- Finally, this research is contributing to informing public health policy and practice. Researchers have emphasized the urgency of this issue in the context of the rising atmospheric temperatures and the far-reaching effects of climate change on many bodies, pointing to the possibility of negative public health outcomes. As a result, a greater recognition of the need for adaptation and mitigation strategies to prevent climate-related health impacts has been achieved, with the inclusion of climate change and vector-borne diseases in planning and preparedness for public health response and greater awareness among both healthcare professionals and the general public.

The remaining part of the research has the following chapters. Chapter 2 describes the recent works related to the research. Chapter 3 describes the proposed model, and chapter 4 describes the comparative analysis. Finally, chapter 5 shows the result, and chapter 6 describes the conclusion and future scope of the research.

METHOD

Coalson, J. Eet, et al. have described this review. It investigates the link between flooding events and the spread of mosquito-borne illnesses like malaria, dengue, and Zika virus. It illustrates the underlying complexity of the way that flooding, mosquito habitats, and human behavior combine to increase disease transmission, and emphasizes the importance of improved prevention. Eder, Met, et al. Discussion – conducted a scoping review on vector-borne diseases in urban sectors and their dynamics of transmission, vectorial capacity, and co-infection. This is important because it draws attention to existing knowledge on a topic in order to highlight shortcomings of that knowledge and understand how this could be improved to better understand and control these diseases in urban environments. Ryan, S. Jet, et al. Remind us that the Climate of Earth is changing rapidly, therefore, certain regions that were suitable for vector-borne diseases are now becoming unsuitable and vice-versa. That includes shifts in both geographic regions where these diseases are endemic and demographic cohorts who may be at risk. By understanding and mapping these changes, we can better inform ourselves about how to prevent and control these diseases. Müller, Ret, et al. that have dealt with vector-borne diseases, or infectious diseases caused by a microorganism such as viruses, bacteria, or parasites, which are transmitted from animals to humans by the bite of arthropod vectors of disease such as mosquitoes, ticks, fleas, and sandflies. Such diseases can imply serious health impact and represent an important global public health problem. Vector control and proper sanitation help prevent it. Bartlow, A. Wet, et al. , discussing forecasting

zoonotic infectious disease response to climate change. That means anticipating how the changing environment is likely to alter mosquito populations — and their potential to transmit diseases to humans. Lines like these can assist public health officials prepare for possible outbreaks and take effective prevention measures.

Table 1. Comparative Analysis of Existing Models

Author	Year	Advantage	Limitation
Coalson, J. Eet, et al.	2021	"Understanding this relationship can inform effective prevention and control strategies for mosquito-borne diseases in flood-prone areas."	Incomplete understanding of underlying factors and mechanisms leading to outbreaks, hindering effective prevention and control strategies.
Eder, Met, et al.	2018	A scoping review provides a broad overview of existing research on vector-borne diseases and identifies knowledge gaps for future studies.	Lack of generalizability due to potential exclusion of studies not published in English or indexed in specific databases.
Ryan, S. Jet, et al.	2020	Improved understanding of where and who is at risk, allowing for targeted prevention and control strategies.	Difficulty in accurately predicting future climate conditions and societal changes that could impact vector-borne disease transmission.
Müller, Ret, et al.	2019	Vector-borne diseases have rapid and efficient transmission potential, making it easier to track and control outbreaks.	One limitation of vector-borne diseases is the potential for outbreaks to occur in regions lacking resources for prevention and control.
Bartlow, A. Wet, et al.	2019	Being better prepared for potential outbreaks and preventing the spread of zoonotic diseases before they become widespread.	The difficulty in accurately predicting long-term changes in climate and their impact on vector-borne disease transmission dynamics.
Medlock, J. Met, et al.	2018	Improved understanding of potential risks, and proactive measures can be implemented to prevent and control outbreaks.	Underreporting of cases due to lack of awareness or access to healthcare.
Otten, Aet, et al.	2020	One advantage is that it allows for targeted preparedness and response measures, potentially reducing the impact of these diseases on human health.	Insufficient data on the prevalence and distribution of vector-borne diseases in Canada under current and projected climate conditions.
Christofferson, R. Cet, et al.	2020	Improved understanding of vector behavior and control methods can lead to more effective and targeted prevention and control strategies.	One limitation is inadequate resources and funding for vector control and prevention efforts in the Mekong subregion.
Muurlink, O. Tet, et al.	2020	"Flexibility and adaptability to changing situations."	Lack of resources/funding for vector control in the Mekong subregion.
Sweileh, W. Met, et al.	2020	Identifies and analyzes the most influential and highly-cited research articles, providing insight into the current state of knowledge in the field.	The interpretation of data may be influenced by the personal biases of the researchers conducting the bibliometric analysis.

Medlock, J. Met, et al. have highlighted the development of efficient monitoring & surveillance systems, comprehensive risk assessments & control measures that have been implemented to respond to potential outbreaks of vector-borne diseases, such as Lyme disease, dengue fever & malaria in the UK. These measures are vital to preventing these diseases from becoming a public health threat and keeping the population safe. Otten, Aet, et al. Vector-borne diseases in Canada including Lyme disease, West Nile virus, and Rocky Mountain spotted fever have also been discussed as diseases of concern to prioritize because of their potential implications on the health of humans and the environment. Under projected climate change, these diseases might become more common, and new disease risks might arise, necessitating ongoing prioritisation and adaptive strategies. Christofferson, R. Cet. al. [have previously discussed the workshop that identified challenges in the greater Mekong subregion for controlling vectorborne diseases like dengue, malaria and more. These include the emergence of new vectors; drug resistance; lack of a coordinated efforts; inadequate surveillance and data collection, and limited resources for research and control measures. Muurlink, O. Tet, et al. stated that the Mekong subregion is a group of countries that includes Cambodia, Laos, and Vietnam, which are particularly challenged by vector-borne diseases that lack of effecient vector control due to limited resources and funding.

This could diminish efforts to combat diseases such as malaria, dengue fever and the Zika virus, ultimately putting populations at risk. Sweileh, W. Met, et al. have reported bibliometric analysis of publications on climate change and human health in general and on infectious diseases in particular trends, themes and patterns. In this case using this method has the potential to clarify this important issue, including the impact of climate change on human health, and how best to guide research in this area moving forward.

DEVELOPMENT

It is hoped that this project will provide a deep understanding of these linkages to inform the development of project models. This will `enable them to understand the options available in preventing the spread of these diseases. Moreover, this will incorporate measures of climate change in models to research ways of mitigating against the undesired spread. Climatic pattern influence on vector-borne disease has a direct and causal link between the two high thus important to build scientific models that incorporate climate patterns to assess their impact in the vector spread cycle. Therefore, the findings will bridge the knowledge gaps and demonstrate a more integrative approach to human and environmental health while enhancing action and more synthetic collaboration among government and stakeholders. Work Referenced Trevor H. and Ann D. Romer, James B. and Robin M. Gardner and Lee J. Kim, (2020-22) Fostering Understanding of Linkages Between Climate Change and Public Health A Report of the National Academy of Medicine Washington, D.C. 2023. Figure 1 shows the Development Model.

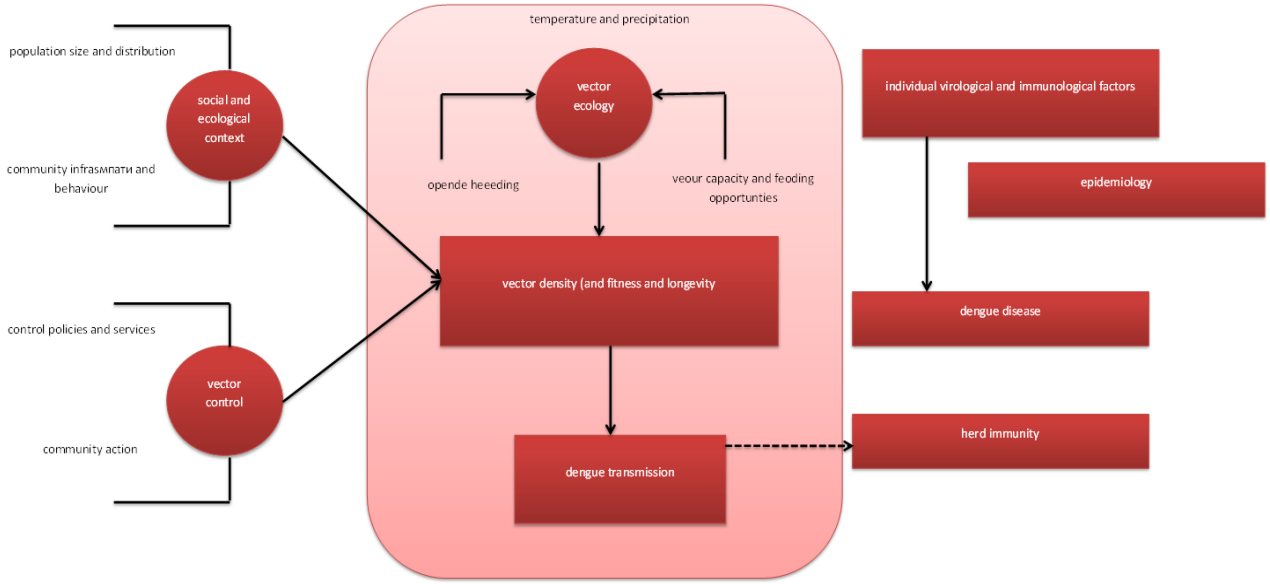

Figure 1. Development Model

Transmission of infectious disease is driven in large part by temperature and precipitation. These changes can directly affect both the population numbers and distribution of the vectors of these pathogens, such as mosquitoes for the dengue virus. More over the social and ecological landscapes of specific regions can act as a compass to the spread of disease, so can factors driving poverty, population density and sanitation that may favour vectors breeding ground and survival. Understanding the ecology of vectors is also vital for the understanding of an outbreak regionally, like that of dengue. However, the availablitiy of adequate breeding sites and host animals could affect vector density and fitness and the entire life span of the vector could be limited. Susceptibility to infection may also vary due to individual factors like the genetic makeup and immune responses of hosts. The dynamics of endemic diseases such as that of dengue are complex and involve multiple interplaying factors. Community-level infrastructure and behaviors (e.g. open defecation or poor waste management) can provide suitable environments for vectors to breed, and increase the probability of transmitting diseases. Regarding prevention, vector control strategies (e.g., insecticide spraying, habitat management) can be implemented to decrease vector density and break the transmission of the disease. Dengue epidemiology varies by the social and ecological context of the region. The effectiveness of control policies and services is influenced by factors such as access to healthcare and community engagement. Controlling density of vectors is one of the efforts that can be taken in prevention of dengue outbreak, because indeed the density of these vectors will be directly proportional to the risk of dengue disease transmission (International dengue consensus, 2016). Dengue disease presents a severe disease with some individuals experiencing mild symptoms. The clinical severity of the disease can also be affected by individual immune responses and co-infections. Early detection and reporting at the community level are also important measures to control the spread of dengue.

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RESULTS AND DISCUSSION

Results from this investigation indicates that climate change and vector-borne diseases are strongly interrelated with a consequence on public health outcomes. Just as it has altered patterns of temperature and rainfall, making conditions more favourable for the transmission of vector-borne diseases such as malaria, dengue fever and Lyme disease. Rising temperatures, as well as increasingly common and severe rainfall events, facilitate the breeding and survival of disease-transmitting mosquitoes, ticks and other vectors. Consequently, this has led to an increase in the incidence of these diseases and their spread in geography, which is a major threat to public health. Moreover, recent epidemics (e.g. Zika and West Nile virus spread) are increasingly believed to be worsened by worsening climate. The emergence of new vector species: how humans are shaping the vectors of vector-borne disease.

Temperature and humidity

Environmental factors like temperature and humidity play a key role in the transmission of vector-borne diseases and their impact on human health. Higher temperatures speed up the reproduction and survival of disease-carrying vectors like mosquitoes, as well as reduce the incubation period of viruses in their bodies.

Table 2. Comparison of Temperature and humidity

No. of Inputs	Comparison Models				
	CCAM	DMM	SVGM	CVM	Proposed Model
1	25	78	25	16	75
2	29	58	36	19	78
3	36	52	45	20,3	83
4	48	49	57	24	84
5	58	43	78	32	90

In addition to this, high humidity also favour the development of breeding places for the vectors which results to increased number and transmission of diseases. On top of this temperature and humidity can also affect the survival and transmission of the viruses themselves, meaning they can be more virulent in some conditions. Figure 2 shows the Computation of Temperature and humidity.

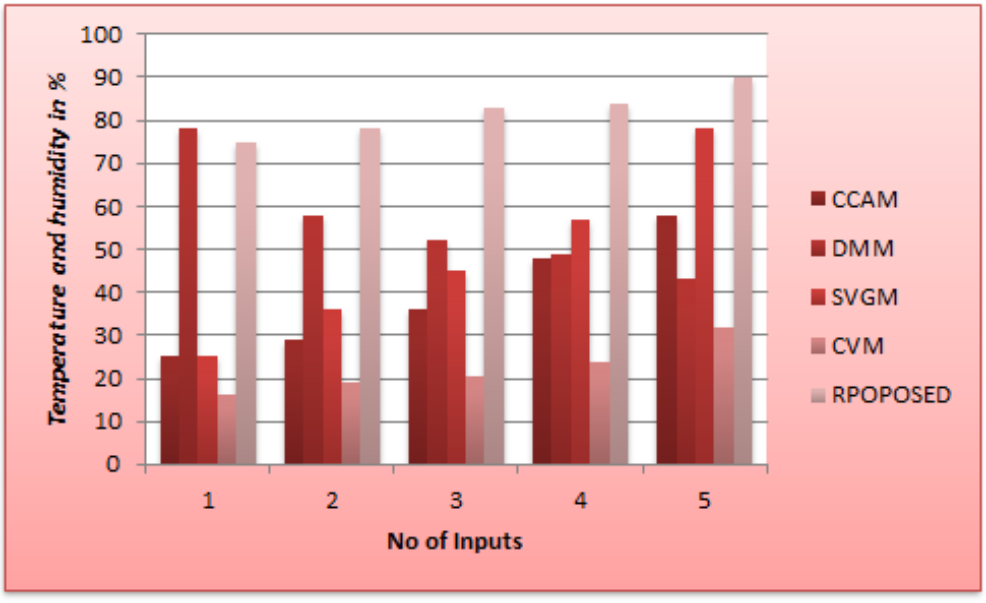

Figure 2. Computation of Temperature and humidity

Recognizing and monitoring these processes is key to inform the effect of climate change on vector-borne diseases and public health outcomes.

Precipitation

Precipitation refers to water that falls from the atmosphere to the Earth ' s surface, such as rain, snow, sleet, and hail. It is a vital step in the Earth's water cycle and affects various natural ecosystems and human activities.

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Table 3. Comparison of Precipitation

No. of Inputs	Comparison Models				
	CCAM	DMM	SVGM	CVM	Proposed Model
100	35	52	69	50	82
200	39	56	73	62	84
300	43	60	77	40	85
400	47	64	81	73	87
500	51	68	85	81	88

Precipitation patterns may be changed by climate change, and heavy precipitation during extreme weather events may become more common. These variations may further change the distribution patterns of vector-borne diseases, such as those caused by insect and other carriers that are influenced by precipitation patterns. Figure 3 shows the Computation of Precipitation.

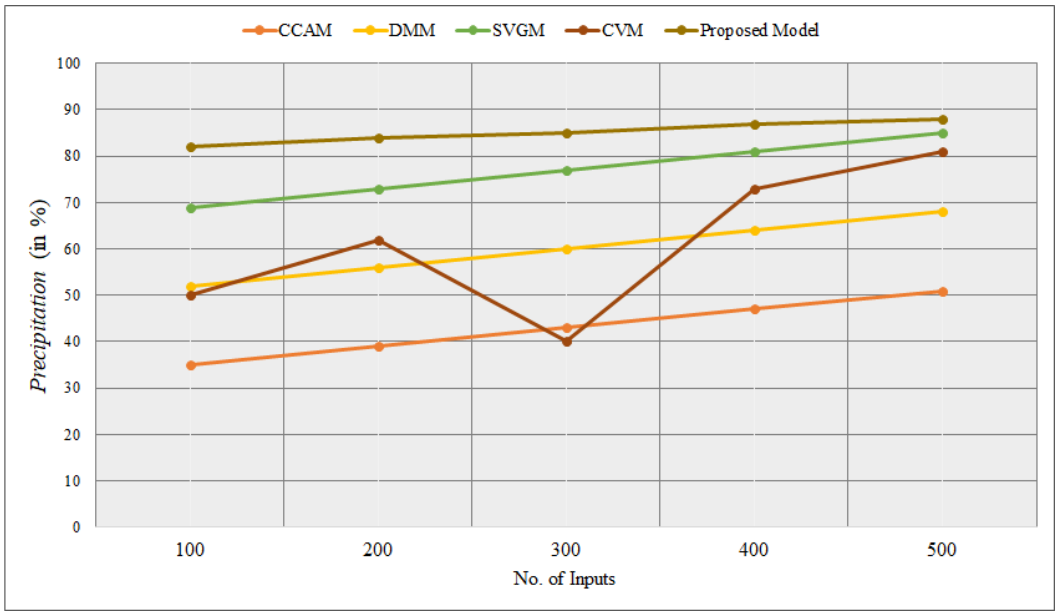

Figure 3. Computation of Precipitation

Extreme precipitation patterns could have numerous negative public health consequences in other aspects. Infrastructure could be destroyed, and water sources contaminated by excessive precipitation, posing a health threat to human beings Observing the relationships between climate change, precipitation, and public safety will be valuable in understanding and abating the burden of a changing climate change on human health.

Pathogen development and transmission

Table 4. Comparison of Pathogen development and transmission

No. of Inputs	Comparison Models				
	CCAM	DMM	SVGM	CVM	Proposed Model
10	44	30	53	54	88
20	32	35	68	49	83
30	43	36	63	75	82
40	29	53	71	36	81
50	72	47	60	40	80

Pathogens are microorganisms that cause disease in humans and animals. These conditions are also affected by climate change, so they can adapt and evolve in response to changes in the environment, including

temperature and humidity. This will lead to the emergence of new pathogen strains and their transmission by vectors like mosquitoes and ticks. Pathogens can also be transmitted through human contact, contaminated food and water, and animal vectors.

So climate change can help with the spread of vector-borne diseases, because the rise of temperatures can enhance the breeding and life expectancy of the vectors. Such diseases can impact millions of people globally, which can lead to substantial public health implications. Figure 4 shows the Computation of Pathogen development and transmission.

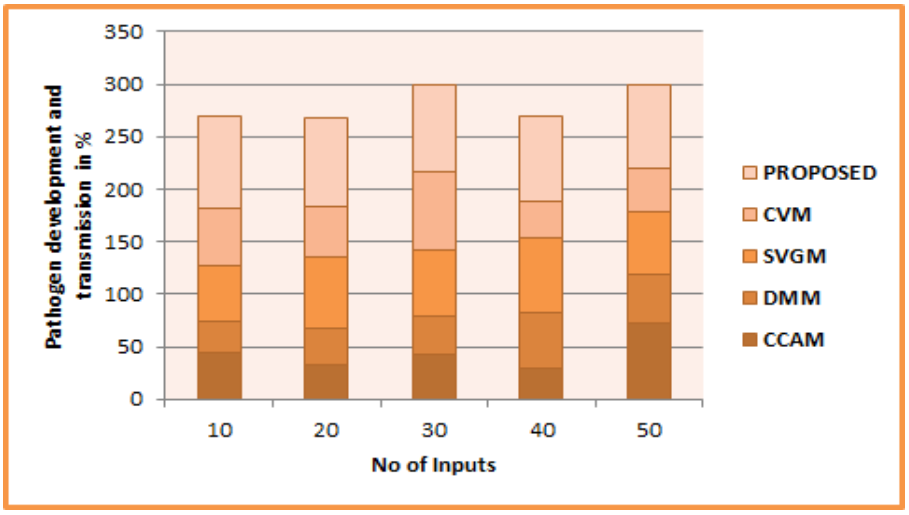

Figure 4. Computation of Pathogen development and transmission

Anthropogenic factors like climate change will have great impact on vector-borne diseases, therefore, it is important to investigate these links to gain insights regarding public health outcomes.

CONCLUSIONS

To conclude, our analysis indicates clearly identified connections through climate change, vector-borne diseases, and health effects. Climate change has been recognized to greatly contribute to the transmission of vector-borne diseases including malaria, dengue and Zika virus. Increasing temperatures and shifting patterns of precipitation establish ideal breeding conditions for disease-carrying insects, as well as economically undesirable ones, and move them into new regions. As vector-borne diseases can lead to severe disease and death in affected populations, these changes hold great public health significance. Low-income and marginalized communities, who suffer the greatest burden from these diseases, are typically also those communities most vulnerable to the impacts of climate change. UN and WHO: our research also underlined the importance of adaptation strategies to mitigate the impact of climate change on public health_SERVICES These efforts comprise the establishment of integrated vector control programs, enhanced surveillance and response systems, and healthcare systems investments. These finding highlight the acute need for immediate action to mitigate climate change and its effects on vector-borne diseases and public health. Not doing so could have major implications for people, communities and global health systems.

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FINANCING

None.

CONFLICT OF INTEREST

None.

AUTHORSHIP CONTRIBUTION

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Writing - proofreading and editing: Rajesh Kumar Lenka, Indu Singh, Sujayaraj Samuel Jayakumar.