Journal of Energy and Safety Technology

JEST

RESEARCH ARTICLE Open Access

Climate Change Effects on Dengue Transmission in Malaysia: A Review

Siti Marwanis Anua[1], Noor Artika Hassan[2]*, Ahmad Idlan Mohd Fauzi[2], Ahmad Muhaimin Kamaludin[2], Asif Fikri Azmi[2], Muhammad Luqman Haqim Mohd Yazid[2]

[1] Interdisciplinary Health Sciences Unit, School of Health Sciences, Health Campus, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan
[2] Department of Community Medicine, Kulliyyah of Medicine, International Islamic University Malaysia, 25200 Kuantan, Pahang, Malaysia

**Corresponding author: noor_artika@iium.edu.my*

Article History

Received:	Received in revised form:	Accepted:	Published Online:
January 20, 2023	August 20, 2023	August 20, 2023	Deccmber 15, 2023

Abstract

Climate change remains a pressing global issue, with vast magnitude and detrimental effects on various aspects, including public health. Among the consequences of climate change, dengue fever is one of the vector-borne diseases projected to witness an increase in incidence due to alterations in transmission dynamics. This review aims to delve into the current understanding of how climate change impacts dengue transmission in Malaysia. The methodology involved the identification of relevant studies from three databases (PubMed, Scopus, and EBSCO) spanning the years 2013 to 2023, followed by a screening process based on predetermined inclusion and exclusion criteria. Ultimately, nine studies were included in the review, with temperature, precipitation, and humidity emerging as the three most extensively studied climatic variables, all of which demonstrated a significant correlation with dengue incidence. Given the evidence presented in numerous articles, it is imperative for policymakers to undertake essential policy revisions to confront this global challenge effectively and to demonstrate resolute and dedicated action in addressing this matter.

Keywords: Climate change; Temperature; Precipitation; Dengue; Malaysia

1.0 INTRODUCTION

Climate change as described by the United Nations Framework Convention on Climate Change (UNFCCC), refers to a shift in the climate that can be directly or indirectly attributed to human actions, resulting in alterations to the composition of the Earth's atmosphere [1]. This change is in addition to the natural climate variations observed over similar a time frame. In Malaysia, climate change presents itself in various forms. One of the common forms of climate change is the increasing temperatures, resulting in occurrences of heatwaves and higher temperatures in urban regions. Furthermore, there is a change in rainfall patterns, involving alteration in the duration, intensity and distribution of rainfall. Some regions of the country may experience more intense rainfall, while others may experience reduced rainfall. Climate change can influence various aspects of the nation, such as health, agriculture, tourism and ecosystem. One of the concerns is health-related issues, such as vector-borne diseases, which can be influenced by climate change.

Malaysia experiences endemic vector-borne diseases, with dengue fever being particularly prevalent. Dengue fever is caused by dengue viruses that are transmitted to humans by Aedes mosquitoes. The Aedes species responsible for transmitting dengue viruses are *Aedes aegypti* and *Aedes albopictus*. Individuals infected with dengue may exhibit typical symptoms such as fever, rash, and body aches, and in more severe cases, they can experience symptoms like vomiting, abdominal pain, and bleeding from the nose or gums. Based on data from iDengue, the total number of dengue cases in Malaysia from January 1, 2023, to December 1, 2023, was 110,354 cases with 73 deaths. The highest number of cases was reported in Selangor (54,325), followed by Wilayah Persekutuan (12,737), and Johor (9,621) [2]. The transmission of dengue is influenced by a range of risk factors, including host immunity, vector competence, the prevalence of circulating dengue viruses, weather conditions, the effectiveness of dengue control measures, and patterns

of population movement. In the study by Morin et al. [3], it was noted that climate change will alter dengue viruses ecology, vector's flying range, increase the period of vector activity and also decrease extrinsic incubation period.
Numerous systematic literature reviews have explored the relationship between climate change and dengue on a global scale in recent years. However, it's worth noting that a review specifically focused on local studies was only conducted by Hii et al. in 2016 [4], which encompassed literature published between 1990 and 2015. Importantly, this particular study examined the impact of "climate" as an independent variable rather than addressing "climate change" explicitly. Given the significant and concerning increase in dengue outbreaks in recent years and the emergence of new research on the intersection of climate change and dengue, there is a compelling need for further investigation. Consequently, the objective of this review is to explore the current understanding of the effects of climate change as experienced in Malaysia on the local transmission of dengue.

2.0 METHODOLOGY

2.1 Search Strategy

The literature search was conducted in May 2023 using three electronic databases, namely PubMed, Scopus, and EBSCO. Keywords used to search the literature are "climate change", "dengue", and "Malaysia" using the Boolean operator "AND" to narrow the scope of literature search. The search results were then identified and screened through title and abstract assessment based on the inclusion and exclusion criteria. Three authors performed the selection of relevant articles from the literature search using the same search string. Further disagreement of inclusion between the authors was discussed between all members to resolve the issue and reach a consensus.

2.2 Inclusion and exclusion criteria

The inclusion criteria set were: (1) article published from 2013 to 2023; (2) full original article in a journal; (3) published in English; (4) related to climate change or climatic variables, and dengue incidence. The exclusion criteria were: (1) non-original articles such as systematic reviews, meta-analyses, and reports; (2) dengue incidence is not a study outcome; (3) study location is not in Malaysia.

2.3 Study selection

The selection process of articles includes identification, screening, and eligibility as illustrated in Figure 1. A number of 56 records were retrieved from the three databases (PubMed (n=12), Scopus (n=29), EBSCO (n=13)), out of which 16 duplicates were removed from the records. The remaining 38 records were then screened by three authors by assessing the titles and abstracts. After title and abstract screening, 26 records were removed and only 12 articles were left for further evaluation of the full text. However, after assessing for the eligibility criteria, three records were excluded because they are systematic reviews and meta-analysis, leaving nine articles to be discussed in this review.

2.4 Data extraction

Data and information retrieved from the articles included in the study are: (1) title; (2) author(s); (3) location of study; (4) study period; (5) climatic variables; and (6) main result(s) of the study.

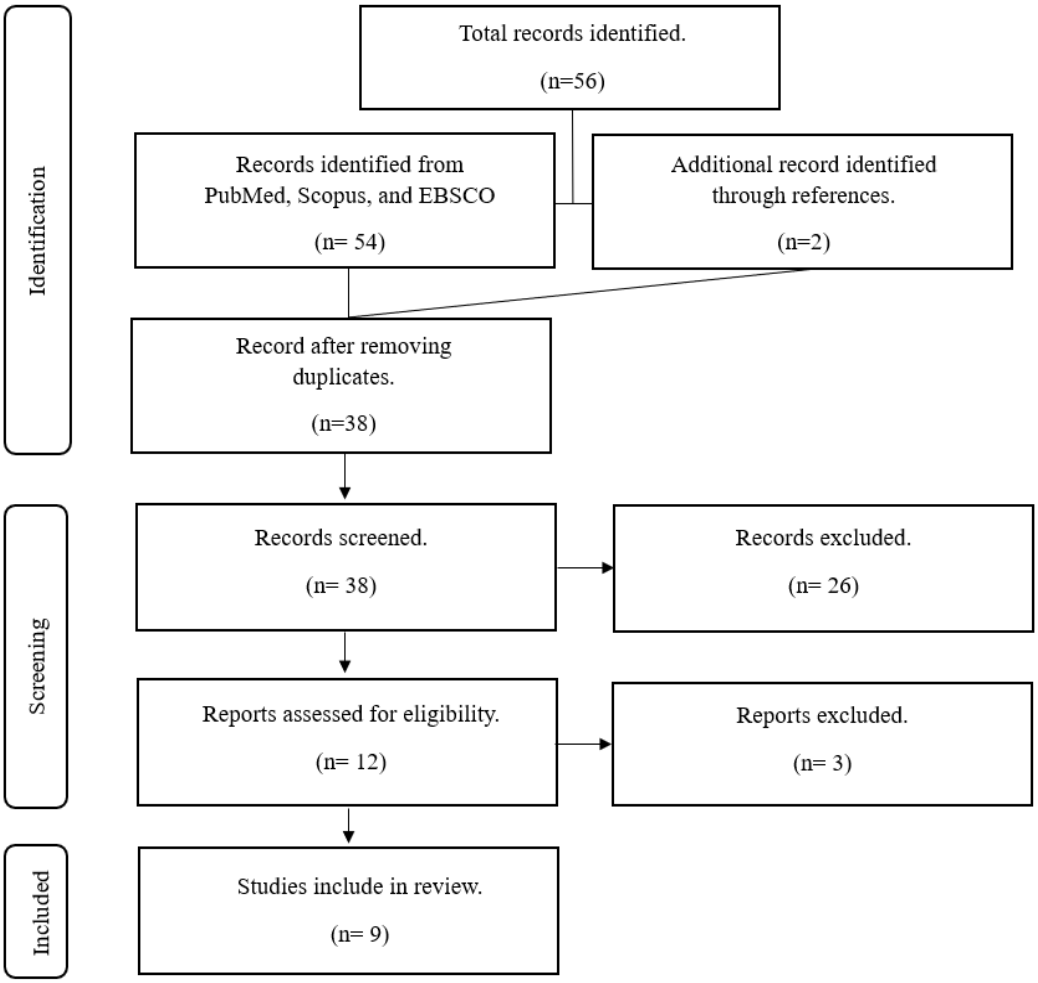

Figure I Flowchart of article selection process

3.0 RESULTS AND DISCUSSION

3.1 Background of included studies

Altogether, there are nine articles included in this review. Majority of the studies covered the Central Peninsular region (n=7, 77.8%), followed by Northern Peninsular, Sabah, and Sarawak (n=4, 44.4% respectively), and Southern and East Coast of Peninsular Malaysia (n=3, 33.3%, respectively). More than half of the studies were published within the year 2014 to 2018 (n=5, 55.6%). In terms of the study time frame, five studies conducted their study in a five-year period or less, the other in a seven and 20-year period, respectively. Table 1 shows the descriptive summary of the included studies.

Table 1 Descriptive summary of included studies (n=9)

Characteristics	Frequency, n (%)
Geographical region	
Northern (Peninsular)	4 (44.4)
Central (Peninsular)	7 (77.8)
Southern (Peninsular)	3 (33.3)
East Coast (Peninsular)	3 (33.3)
Sabah	4 (44.4)
Sarawak	4 (44.4)
Publication year	
2009-2013	1 (11.1)
2014-2018	5 (55.6)
2019-2023	3 (33.3)

Study time frame	
≤ 5 years	5 (55.6)
6-10 years	1 (11.1)
> 10 years	1 (11.1)
Climatic variables	
Temperature	9 (100)
Precipitation	7 (77.8)
Humidity	5 (55.6)
Rainy days	2 (22.2)
Wind speed	1 (11.1)
Sea level	1 (11.1)
Floods	1 (11.1)

3.2 Association between climatic variables and dengue transmission

Temperature was the focal point of investigation in all nine studies [5-13], although there were discrepancies in how temperature was defined and measured across these studies. This encompassed variables like mean, maximum, and minimum temperature readings [7] as well as surface temperature [11]. Precipitation or rainfall came as the second most studied climatic variable (77.8%), followed by humidity (55.6%), rainy days (22.2%), wind speed (11.1%), and sea level (11.1%) (Table 1). Table 2 shows the summary findings of extracted data from the nine selected studies.

Table 2 Summary of climatic variables and dengue transmission in Malaysia from 2013-2022

ID	Author	Title	Location	Study period	Climatic variables	Findings
1.	Tan et al., 2022 [5]	Assessing the Environmental Effects on Dengue Fever and Malaysian Economic Growth	Kota Kinabalu, Kuching, Malacca, Kuantan and Subang/Kuala Lumpur	January 2014 to December 2020	Temperature, sea level pressure, humidity, rainfall, rainy days, and floods	Temperature, humidity, sea level pressure and rainfall revealed a positive correlation with dengue fever cases. Rainy days and floods showed negative correlations.
2.	Majid et al., 2021 [6]	Impact of climate change on dengue incidence in Bandar Baru Bangi, Selangor, Malaysia	Bandar Baru Bangi, Selangor	2014 to 2018	Temperature, rainfall, and rain days	Rainfall and rainy days are positively correlated with dengue cases. Temperature is negatively correlated with dengue cases.
3.	Alhoot et al., 2019 [7]	Effects of global warming on the incidence of infectious diseases in Malaysia	Central Peninsular, East Peninsular, North Peninsular, South Peninsular, Sabah, Sarawak and Cameron Highlands	1996 to 2016	Minimum temperature, maximum temperature, humidity, and rainfall	Maximum temperature, humidity and rainfall are not significantly associated with dengue but minimum temperature is associated
4.	Azman & Abdul Karim 2018 [8]	Assessing Climate Factors on Dengue Spreading in State of Perak	Perak	2014	Rainfall, humidity and temperature	All the variables are significantly correlated with dengue cases
5.	Alhoot et al. 2016 [9]	Climate change and health: The Malaysia scenario	Malaysia	Not stated	Temperature, rainfall time, and humidity	All the variables are significantly correlated with dengue cases
6.	Rozilawati et al. 2016 [10]	Effect of temperature on the immature development of *Aedes Albopictus skuse*.	Keramat, Kuala Lumpur	Not stated	Temperature	There is significantly decreasing trend of developmental period with increasing temperature
7.	Paul et al. 2015 [11]	Interrelation between Climate and Dengue in Malaysia	Setiawan, Kuching and Sandakan	January 2014 to December 2014	Average surface temperature, and average precipitation	All the variables are negatively correlated with dengue case
8.	Williams et al 2015 [12]	Testing the impact of virus importation rates and future climate change on dengue activity in Malaysia using a mechanistic entomology and disease model.	Petaling, Selangor	2010 to 2012	Temperature	Rise in temperature is negatively correlated with dengue

9.	Cheong et al. 2013 [13]	Assessing weather effects on dengue disease in Malaysia	Subang, Kuala Lumpur	2007 to 2010	Temperature, cumulative bi-weekly rainfall, relative humidity, and wind speed	All the variables are positively correlated with dengue case except wind speed which is negatively correlated

Table 3 provides a summary of the correlations observed between the analyzed climatic variables and dengue incidence. Among the nine studies, 55.6% of them indicated a positive correlation between dengue incidence and temperature. In the case of precipitation as a variable, five out of seven studies (71.4%) revealed a significant association with dengue incidence. Concerning humidity, 80% of the five studies reported a significant correlation with dengue incidence. Additionally, half of the studies examining rainy days found a significantly positive correlation with dengue incidence. Notably, the sole study that considered sea level noted a significant correlation, while studies on wind speed and floods both demonstrated a negative correlation with dengue incidence.

Table 3 Correlation of climatic variables with dengue incidence

Climatic Variable	Significant correlation		Non-significant correlation
	Positive	Negative	
Temperature	[5, 7, 8, 9, 13]	[6, 10, 11, 12]	[7*]
Rainfall/Precipitation	[5, 6, 8, 9, 13]	[11]	[7]
Humidity	[3, 8, 9, 13]	-	[7]
Rainy days	[6]	[5]	-
Wind speed	-	[13]	-
Sea level	[5]	-	-
Floods	-	[5]	-

Note: The numbers in the table refer to the citation reference.

* Minimum temperature was significantly correlated while maximum temperature was not significantly associated.

Malaysia, situated in Southeast Asia, is characterized by its tropical nature, encompassing a variety of land cover and topography across Peninsular Malaysia and East Malaysia. Due to its equatorial location, Malaysia experiences a hot and humid climate throughout the entire year. The country observes two distinct monsoon seasons annually, with the Southwest Monsoon occurring approximately from April to September, and the Northeast Monsoon spanning from around October to March. Malaysia's annual average temperature stands at 25.4°C, with an annual precipitation of approximately 3085.5 mm.

This review has revealed that the majority of studies have identified a significant association between average temperature, humidity, and rainfall precipitation with dengue incidence. Moreover, between 1970 and 2013, there has been a noticeable increase in surface mean temperatures, ranging from approximately 0.14°C to 0.25°C over a span of 10 years in Peninsular Malaysia, Sabah, and Sarawak regions [14]. This temperature trend extends to surface maximum temperatures, which have shown an increase of around 0.17°C to 0.22°C during the same timeframe, while surface minimum temperatures have risen by approximately 0.20°C to 0.32°C. Future projections indicate a significant rise in annual temperatures in Malaysia, with an estimated increase of 3.4°C by the year 2090.

The precise mechanisms underlying the relationship between temperature and humidity are not fully understood, although various hypotheses have been proposed in several studies. Firstly, it has been suggested that favorable temperature and humidity conditions can enhance the survival rate of the *Aedes aegypti* vector. Additionally, optimal environmental conditions can influence the vector's behavior, leading to a higher frequency of biting and increased competence, thereby elevating its potential for disease transmission. A higher annual temperature can also lead to a reduction in the extrinsic incubation period required for the agent to be transmitted through mosquito bites [15]. Consequently, sustained high minimal surface temperatures over an extended period can further increase the potential for dengue transmission from mosquitoes to humans. Moreover, previous laboratory investigations have also reported instances where *Aedes aegypti* failed to acquire the Dengue virus from the salivary gland when maintained at a temperature of 20°C, as well as the inability of larvae to develop into adult mosquitoes when exposed to temperatures below 14°C. Next, higher annual temperature will also shorten the extrinsic incubation period for the agent to be transmitted through mosquito bite [16]. So, a high minimal surface temperature that was sustained for a longer duration will also risen the potential of dengue transmission from mosquito to human.

3.3 Limitation of review process

A major limitation encountered upon performing the review process was the lack of resources identified through the databases for reasons as follow: (1) The number of databases used, three in our case, provided not more than 200 results

once limits were imposed; (2) The number of recent local studies (after 2015) related to our objective did not add much when compared to the previous study by Hii et al. [4].

4.0 CONCLUSION

The impacts of climate change on transmission of dengue are not confined by geographical boundaries and will persist on a global scale. Climate-sensitive infectious diseases such as dengue are expected to increase in prevalence due to climate-related changes. Within the Malaysian context, temperature, precipitation, and humidity are the primary factors influenced by climate change, and they have a substantial impact on the spread of dengue fever. With numerous pieces of evidence published in various articles, it is incumbent upon policymakers to make necessary revisions to policies aimed at addressing this global challenge and to take significant and committed action in tackling this issue.

Acknowledgement

This paper and the research behind it would not have been possible without the exceptional support of my supervisor, colleagues and family.

References

[1] United Nations Framework Convention on Climate Change (UNFCC). 2023. Retrieved October 6, 2023 from https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/united-nations-framework-convention-on-climate-change
[2] Ministry of Health. 2023. idengue version 3.0 for community. Retrieved from https://idengue.mysa.gov.my/ide_v3/index.php
[3] Morin, C. W., Comrie, A. C., Ernst, K. 2013. Climate and dengue transmission: evidence and implications. *Environ Health Perspect*. 121:1264–72.
[4] Hii, Y. L., Ahmad Zaki, R., Agharnohammadi, N., Roclov, J. 2016. *Curr Environ Health Rep*. 3: 81–90. doi: 10.1007/s40572-016-0078-z
[5] Tan, C. H., Lee, S. N., Ho, S. B. 2022. Assessing the environmental effects on dengue fever and Malaysian economic growth. International Journal of Environmental Science and Development, 13 (2): 49–56). EJournal Publishing. https://doi.org/10.18178/ijesd.2022.13.2.1371
[6] Majid, N. A., Mohamed, A. F., Ghani Aziz, S. A. A., Rainis, R., Sahani, M., Ismail, S. M., & Nazi, N. M. (2021). Impact of climate change on dengue incidence in Bandar Baru Bangi, Selangor, Malaysia. *Malayan Nature Journal*, 73(2), 163-175.
[7] Alhoot, M. A., Nagarajan, R., Abdulmajid, M. S., Alabed, A. A. A., Al-Majeed, L. R. A., Bisri, N. M., & Al-Maleki, A. R. (2019). Effects of global warming on the incidence of infectious diseases in Malaysia. In International Journal of Medical Toxicology & Legal Medicine (Vol. 22, Issue 1and2, p. 111). Diva Enterprises Private Limited. https://doi.org/10.5958/0974-4614.2019.00026.3
[8] Azman, N. N., & Abdul Karim, S. A. B. (2018). Assessing Climate Factors on Dengue Spreading in State of Perak. In Journal of Physics: Conference Series (Vol. 1123, p. 012026). IOP Publishing. https://doi.org/10.1088/1742-6596/1123/1/012026Hii, Y. L., Zaki, R. A., Aghamohammadi, N., & Rocklöv, J. (2016). Research on climate and dengue in Malaysia: A systematic review. Current Environmental Health Reports, 3(1), 81–90. https://doi.org/10.1007/s40572-016-0078-z
[9] Alhoot, M. A., Tong, W. T., Low, W. Y., & Sekaran, S. D. (2016). Climate Change and Health: The Malaysia Scenario. In Climate Change and Human Health Scenario in South and Southeast Asia (pp. 243–268). Springer International Publishing. https://doi.org/10.1007/978-3-319-23684-1_15
[10] Rozilawati, H., Mohd Masri, S., Tanaselvi, K., Zairi, J., Nazni, W. A., & Lee, H. L. (2016). Effect of temperature on the immature development of aedes albopictus skuse. Southeast Asian Journal of Tropical Medicine and Public Health, 47(4), 731-746.
[11] Paul, B., Tham, W. L. 2015. Interrelation between climate and dengue in Malaysia. *Health*, 7, 672-678. http://dx.doi.org/10.4236/health.2015.76080
[12] Williams, C., Gill, B., Mincham, G., et al (2015). Testing the impact of virus importation rates and future climate change on dengue activity in Malaysia using a mechanistic entomology and disease model. Epidemiology & Infection, 143(13), 2856-2864. doi:10.1017/S095026881400380X
[13] Cheong, Y. L., Burkart, K., Leitão, P. J., Lakes, T. 2013. Assessing weather effects on dengue disease in Malaysia. *Int J Environ Res Publ Health*. 10:6319–34. doi: 10.3390/ijerph10126319
[14] Climate Risk Country Profile: Malaysia. 2021. The World Bank Group and the Asian Development Bank. Available from https://climateknowledgeportal.worldbank.org/sites/default/files/2021-08/15868-WB_Malaysia%20Country%20Profile-WEB.pdf
[15] Campbell, L. P., Luther, C., Moo-Llanes, D., Ramsey, J. M., Danis-Lozano, R., Peterson, A. T. 2015. Climate change influences on global distributions of dengue and chikungunya virus vectors. *Philos Trans R Soc Lond B Biol Sci*. 370(1665):20140135. doi: 10.1098/rstb.2014.0135.
[16] Reinhold, J.M., Lazzari, C.R., Lahondère, C. 2018. Effects of the environmental temperature on *Aedes aegypti* and *Aedes albopictus* Mosquitoes: A Review. *Insects*, 9, 158. https://doi.org/10.3390/insects9040158