



Impacts of climate variability on mosquito-borne diseases: A focus on dengue fever in disaster management and community resilience perspectives

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ABSTRACT

Background: Climate change can modify infectious disease patterns and raise the risk of transmission, particularly in the case of dengue fever. Human communities are at risk because of this fever. The effects of changes in ambient temperatures and precipitation levels on mosquito populations are crucial for understanding the consequences of the danger of mosquito-borne disease epidemics as the world's climate changes. This study aims to determine how the risk of mosquito-borne infectious disease especially dengue fever outbreaks relates to temperature, humidity, precipitation, and population density. **Methods:** The first stage was a literature review using Mendeley, Google Scholar, and the World Health Organization (WHO) website. Then data was collected and processed to find out the relationship among the variables and the outbreak. **Finding:** Warmer temperatures accelerate vector and pathogen metabolism, allowing for faster replication and dissemination, while erratic rainfall patterns may increase the number of suitable breeding sites. **Conclusion:** The result revealed that climate change has a significant impact on dengue fever outbreaks by influencing the proliferation of Aedes mosquitos, which is influenced by temperature, humidity, precipitation, and population density.

KEYWORDS: climate change; dengue fever; humidity; precipitation; temperature.

1. Introduction

Climate change is frequently characterized as changes in temperature and long-term meteorological conditions as a result of global warming. In reality, the Earth's surface temperature was 0.99 [0.84–1.10]°C higher in the first 20 years of the twenty-first century (2001-2020) than it was in 1850-1900 (IPCC, 2021). Climate change may produce variations in rainfall, temperature, humidity, and wind direction, all of which can influence the ecosystem on land and in the oceans. Droughts, floods, storms, coastal floods, wildfires, agricultural production, natural water supplies, landslides, heat waves, and the spread of microorganisms and pathogens by arthropods, vector-borne diseases, are just some of the ways that climate change is wreaking havoc on people's health (Ligsay et al., 2021). It is already influencing the transmission and spread of vector-borne diseases, and the impacts are likely to get worse (Rocklöv & Dubrow, 2020), such as allowing them to reproduce quickly, as well as permitting the introduction and survival of new vectors (Valentová & Bostik, 2021).

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Dengue fever, one of the well-known mosquito-borne diseases, is caused by 4 distinct serotypes of the Flavivirus genus (DEN-1, DEN-2, DEN-3, and DEN-4). Female mosquitos, mostly *Aedes aegypti* and, to a lesser extent, *Aedes albopictus*, carry the disease. *Aedes aegypti* can be found in many tropics and subtropics and has adapted well to urban settings, but *Aedes albopictus* has expanded its territory to temperate zones and is more usually encountered in rustic and peri-urban areas (Rocklöv & Tozan, 2019). Although both *Aedes* species seem capable of transmitting dengue disease, *Aedes aegypti* is the primary vector and has been linked to global outbreaks.

Dengue fever has grown more widespread in recent decades across the world, with significant and recurring epidemics in endemic places, breakouts in immunologically naïve populations, and reemergence in formerly uninfected areas. It affects about 3.9 billion people in 128 countries (Xu et al., 2020). For example, there has been an increase in mosquito-borne diseases in South and Southeast Asia (Servadio et al., 2018). Dengue cases climbed by 46% in the Southeast Asia Region by 2019, from 451,442 cases in 2015 to 658,301 cases in 2019, but fatalities declined by 2%, from 1,584 in 2015 to 1,555 in 2019, resulting in a fall in the case-fatality rate (CFR) from 0.35 per cent to 0.24 per cent (World Health Organization, 2020). Tuuk et al. (2021) discovered a link between dengue disease incidence and climatic variability, such as air temperature and humidity. This study attempts to analyze how all of these variables are linked to the dengue fever global outbreak.

2. Methods

As shown in Figure 1, this paper has been carried out in two stages. The first stage was a literature review using Mendeley, Google Scholar, and the World Health Organization (WHO) website. Relevant literature was identified using inclusion and exclusion criteria, i.e., the relevance of material to the subject field was determined using keywords. The publishing years 2018-2021 were given priority. The following keywords were used to narrow down the results: climate change, vector-borne illness, mosquito-borne disease, dengue fever, climate change effects dengue, temperature, humidity, precipitation, population density, and climate change affects mosquito-borne disease. In this stage, all the literature was reviewed to know how climate change affects mosquito-borne diseases, especially dengue. To acknowledge earlier studies, the literature was reviewed and properly cited. The second stage was data collection. Data was freely collected and downloaded from the World Health Organization (WHO) website, Google, and Mendeley. All the data then was processed in Microsoft Excel.

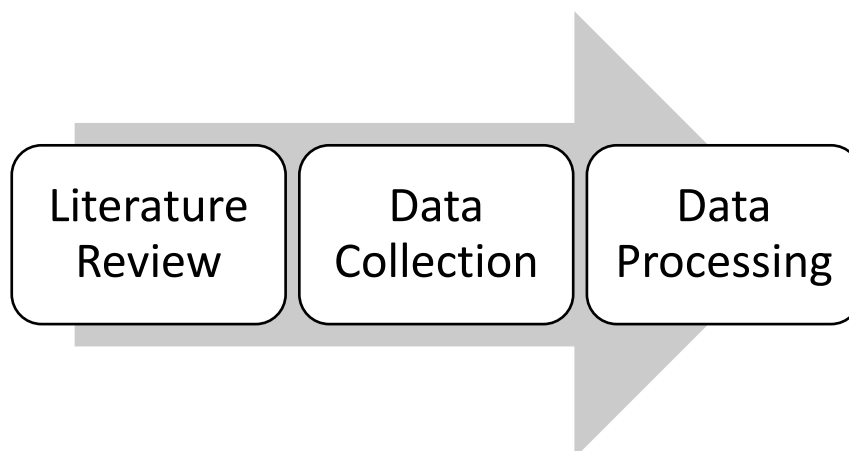


Fig 1. Paper method flowchart

3. Results and Discussion

A high association has been observed between local climatological circumstances and the likelihood of disease outbreaks spread by vectors in several studies. Increased minimum temperatures and excessive rainfall, for example, have been linked to an increased risk of dengue outbreaks (Chowell et al., 2019). The life cycle of mosquitos and the strength of mosquito suction are both affected by climate change. This is because mosquitos are ectothermic, i.e. body temperature depends on the ambient temperature (Novita, 2019). Warmer temperatures accelerate vector and pathogen metabolism, allowing for faster replication and spreading, while irregular rainfall patterns may increase the number of suitable breeding sites (Filho et al., 2019). Warming climates enhance the risk of dengue transmission because mosquito growth and development are heavily influenced by temperature and humidity (see Table 1, Figure 2, and Figure 3).

Table 1. Number of patients and deaths due to dengue fever in Semarang, Indonesia

Year	Patient	Death
2018	175	2
2019	458	1
2020	167	2

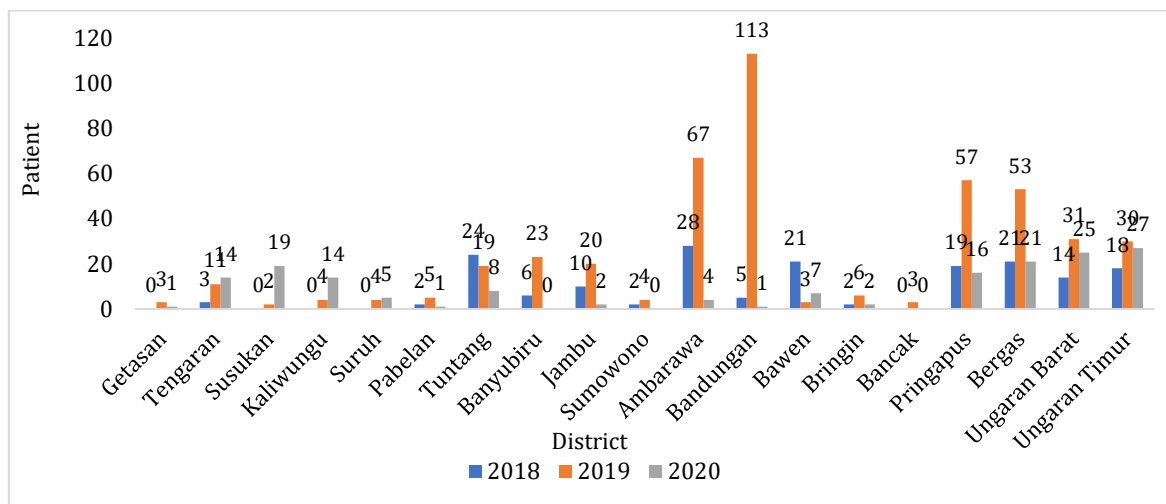


Fig 2. Dengue fever patients in Semarang, Indonesia from 2018-2020.

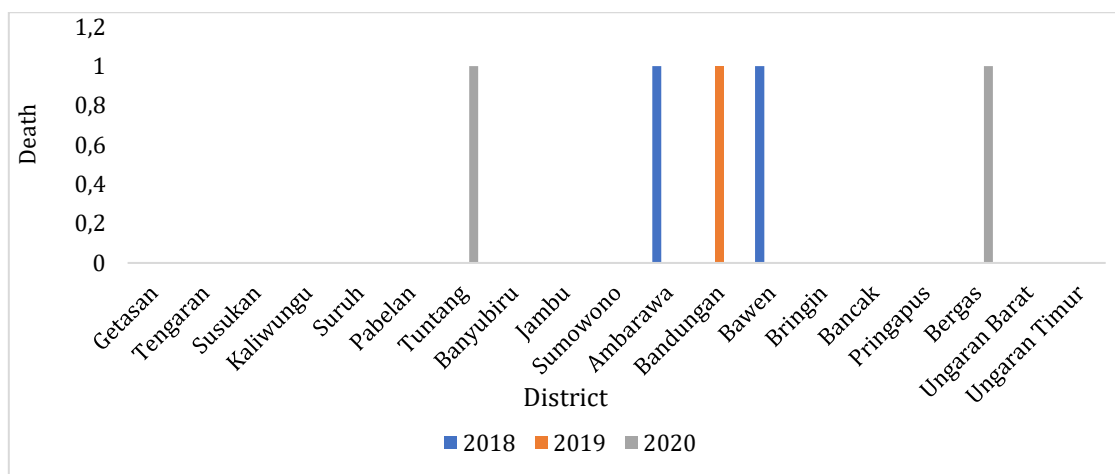


Fig 3. Death due to dengue fever in Semarang, Indonesia from 2018-2020

3.1 Temperature

The geographical spread and expansion of *Aedes* mosquitoes are constrained by climatic factors, notably temperature. The association between water temperature and development rate, which is equivalent to the interaction between eggs, larvae, and pupae of insects, was described by the researchers. The higher metabolism of mosquitoes is connected to an increase in ambient temperature. Because of an accelerated rate of pupation, blood feeding, and a shorter extrinsic incubation time, mosquito-borne illness transmission is at its peak at warmer temperatures (Chowell, 2019). Yet, at temperatures that prevent mosquito or pathogen survival, growth, reproduction, or metabolism, transmission is impossible. The nonlinear impact of temperature on mosquito and pathogen features influences the amount of transmission within a range of acceptable temperatures (Mordecai et al., 2019).

The climate reliance of the two dengue vectors, on the other hand, differs greatly, with the most notable difference being *Aedes albopictus*' capacity to diapause (hibernate), which is absent in *Aedes aegypti*. This ability may be attributed to *Aedes albopictus* colonists in non-tropical Asia, and it is currently found in many subtropical and temperate places throughout the globe (Rocklöv & Tozan, 2019). According to seasonal day length and temperature trends, diapausing permits the vector to lay eggs that will survive the chilly winter months and hatch in the spring. Temperature has the greatest influence on the survival and lifespan of mature vectors. The growth of mosquito larvae is also aided by increasing ambient temperature, which allows for rapid maturation. With a rise in external temperature, viral replication in mosquitoes increases even faster, resulting in a shorter extrinsic incubation time.

3.2 Humidity

Humidity can also have a significant impact on the propagation of vector-borne diseases. The degree of disease transmission is determined by mosquitoes' dispersal, which is partly influenced by relative humidity. The high surface area to volume ratio of mosquitos exposes them to desiccation, hence humidity is favourably related to mosquito survival. High humidity is required and influences mosquito respiration. Mosquitos breathe using tracheal tubes known as spiracles, which have no settings at the time due to low humidity. Low humidity causes water to evaporate from mosquitoes' bodies, allowing their bodily fluids to escape (Putri et al., 2020). Mosquitoes' age is affected by humidity; a humidity level of 60% is the lowest at which mosquitoes may survive. Because virus transmission from the stomach to the salivary glands takes too long when the humidity is less than 60%, the mosquito's lifetime is limited and it cannot become a vector. When humidity is less than 60%, mosquitos have a short lifetime and cannot become carriers because virus transmission from the stomach to the salivary glands takes too long (Ridha et al., 2019).

3.3 Precipitation

Precipitation has direct implications for infectious disease epidemics. Increased precipitation increases vector incidence by increasing the size of current larval habitats and creating new breeding grounds. Precipitation is rain that falls to the earth and forms puddles of water. This water puddle is needed for the stages of mosquito development associated with humidity. This affects the resistance of mosquitoes. The higher the rainfall and rainy days, the breeding places expand their existence, and the cases of dengue fever increase. Moderate rainfall but for a long time will increase breeding places so that there is a risk of increasing vector populations (Susilawati, 2021).

An increase in precipitation enhances the opportunity for mosquitoes to lay eggs and larvae in the environment (Ludwig et al., 2019). The link is frequently non-linear, with above-average rainfall typically boosting mosquito numbers by increasing the amount of standing water, although severe or violent precipitation can act as a leaching agent,

destroying eggs and flushing larvae from some habitats. Increased precipitation may offer more vector breeding sites; conversely, dryness may give more breeding sites as a result of an increase in the usage of rainwater collecting and storage containers, which are good breeding sites for *Aedes aegypti* (Rocklöv & Dubrow, 2020). Ecosystem change (of which climate change is a factor) might affect vector abundance by degrading or improving vector habitats and species competition, as well as increasing or decreasing the presence of vector predators or vector diseases.

3.4 Population density

Mosquitoes have evolved to deposit their eggs in stagnant water, which includes areas with waterlogging, urbanized catchment ditches, and built-in containers near homes. Because mosquito breeding areas are near human urban populations, unusually high numbers of cases can be created on a relatively local scale (Ligsay et al., 2021). Population density and urbanization, in addition to climatic variables, are regarded as key driving factors for dengue spread. According to (Tran et al., 2020), population density has a positive and substantial effect on the number of reported dengue cases in most Taiwanese counties. Fast population development in tropical metropolitan settings typically creates excellent ecological circumstances for the spread of *Aedes aegypti*. Wherever *Aedes* populations are plentiful, the likelihood of autochthonous disease transmission within the human population is increased (Johnson et al., 2018).

4. Conclusions

As climate change progresses, the population exposed to locations with a conducive environment for dengue transmission may shift. According to impact studies done using anticipated climate change scenarios, in many endemic and non-endemic places, dengue fever's infectiousness is predicted to rise; however, these estimates are vulnerable to changes in future greenhouse gases. It is crucial to note that the influence of climate on mosquito-borne disease is complicated by several factors other than temperature, including precipitation, humidity, and population density. Furthermore, outbreak sizes may rise rather than decrease in various nations with differing climates or geographies. Future studies should go further into and explain these patterns to better understand not just the variability of dengue fever, but also its epidemic potential and spatial patterns. Furthermore, more research is needed to discover how the vectorial capacity characteristics are affected by temperature and how sensitive they are to diurnal changes, as well as to build on present research.

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