

# Why climate change is bad for our health



Mosquitoes on stagnant water in Dhaka, Bangladesh

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The Earth's climate has changed throughout history. Human activities have intensified these changes to our global environment. A particular concern is how climate conditions influence our interactions with disease-transmitting insects. Virologist Claire Donald looks at why climate change may increase the risk of mosquito-transmitted disease

## EXAM LINKS

**AQA** Biodiversity within a community; Energy and ecosystems; Nutrient cycles; Populations in ecosystems

**OCR A** Malaria

**OCR B** Pathogenic microorganisms; The impact of population increase

**Pearson Edexcel A** On the wild side

**Pearson Edexcel B** The malarial parasite; Ecosystems

**WJEC/Eduqas** Human impact on the environment

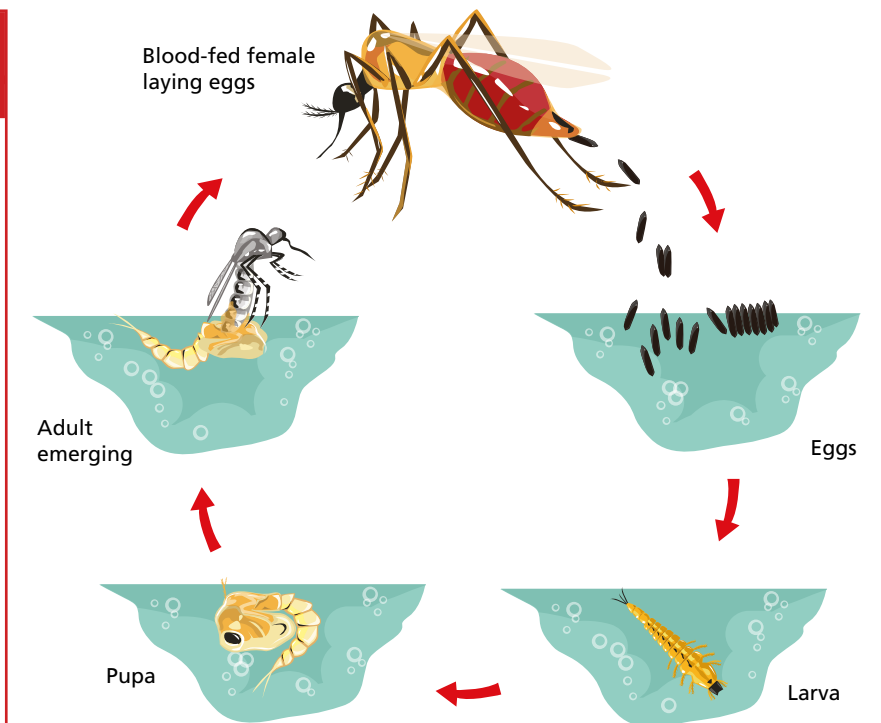
Climate change is a scientific fact. The Earth is warming, bringing with it extraordinary environmental issues. There is an increased risk of flooding, global food insecurity, loss of biodiversity and extreme weather events. These all have a serious impact on our environment and our future. But not all effects are so obvious. Climate change can influence the spread of diseases – in particular, viral diseases spread by mosquitoes.

## Box 1

### Why do mosquitoes spread disease?

Although male mosquitoes feed solely on nectar and plant juices, female mosquitoes require the nutrients in blood to help their eggs develop. They have a variety of ways of locating a food source, including detecting body heat and chemical signals. During feeding, they can ingest viruses along with the blood meal from an infected host. If these viruses can be replicated within the mosquito, they can be passed on to another person when the mosquito takes a further blood meal. This can be as often as every 2 or 3 days for the duration of her life. However, not all blood-borne viruses are spread by mosquitoes. HIV and Ebola cannot be replicated within the mosquito and so are not able to be spread by mosquito bites.

A female mosquito's proboscis (mouthpart) is not rigid, like a needle. It is flexible, which allows it to hunt around under the skin to find blood vessels. As soon as it pierces the skin, the mosquito starts to salivate. Mosquito saliva contains many different substances that prevent the blood from clotting and prevent inflammation. It is these substances that lead to the itchy red bumps on your skin after a mosquito bite. If the mosquito is infected, the saliva also contains the virus. This means that the virus is also deposited into the blood vessel along with the mosquito's saliva.



**Figure 1** Mosquito life cycle. The mosquito life cycle has four stages: egg, larva, pupa and adult. Each of these stages is easily recognisable

insects are spreading to an increasing number of new places and taking their viruses with them.

### Mosquito life cycles

Biting insects, such as mosquitoes, can transmit diseases to humans and other animals when they take a blood meal (see Box 1). They depend on certain environmental conditions for their survival. Changes in temperature, humidity, vegetation quality and animal availability make a big difference to their distribution. Differences in any of these factors, combined with increased international travel and trade, mean that these

Two of the most notorious disease-carrying mosquitoes are *Aedes aegypti* and *Aedes albopictus* (see Table 1). They are extensively distributed around the globe and are found in most tropical and subtropical countries. However, changes in climate have allowed this distribution to expand, and has led to them being found in more temperate countries. This makes them a major threat to human health.

Like other insects, mosquitoes undergo metamorphosis (see Figure 1). The cycle starts when a female mosquito bites her host and feeds on its blood. The

**Table 1** Comparison of *Aedes aegypti* and *Aedes albopictus*

	<i>Aedes aegypti</i>	<i>Aedes albopictus</i>
Common name	Yellow fever mosquito	Asian tiger mosquito
Description	Silvery patterned back with white banded legs	Single silvery stripe on its back with white banded legs
Best known for	Spreading diseases, like dengue	Secondary disease spreader
Preferred food	Human blood	Animal blood
Biting activity	Sneaky feeder	Aggressive feeder
Usually found	Indoors and outdoors	Mostly outdoors
Hangs out	Urban areas	Rural areas
Where eggs are laid	Artificial water containers	Natural water containers, such as tree holes



blood provides essential nutrients to make her eggs. These eggs are then laid into standing water. A female will usually lay around 200 eggs in one go. They are ready to hatch into larvae from a few days to several months after being laid. Unlike the *Anopheles* mosquito that carries the malaria parasite, *Aedes* eggs can enter a state of dormancy if conditions are not optimal. This allows them to survive environmental stress, such as cold or dry conditions, and remain dormant until conditions are more favourable.

Mosquito larvae are aquatic and breathe air from the water's surface using a funnel in their tail, much like we would use a snorkel. These larvae then develop into pupae approximately 5 days later. This stage is a lot like a caterpillar turning into a butterfly as the organs and body functions of the larvae completely reorganise to prepare for life as an adult mosquito. Finally, a fully developed adult emerges from a pupa onto the surface of the water 2–3 days later. The entire life cycle, from an egg being laid into water through to an adult, takes 8–10 days.

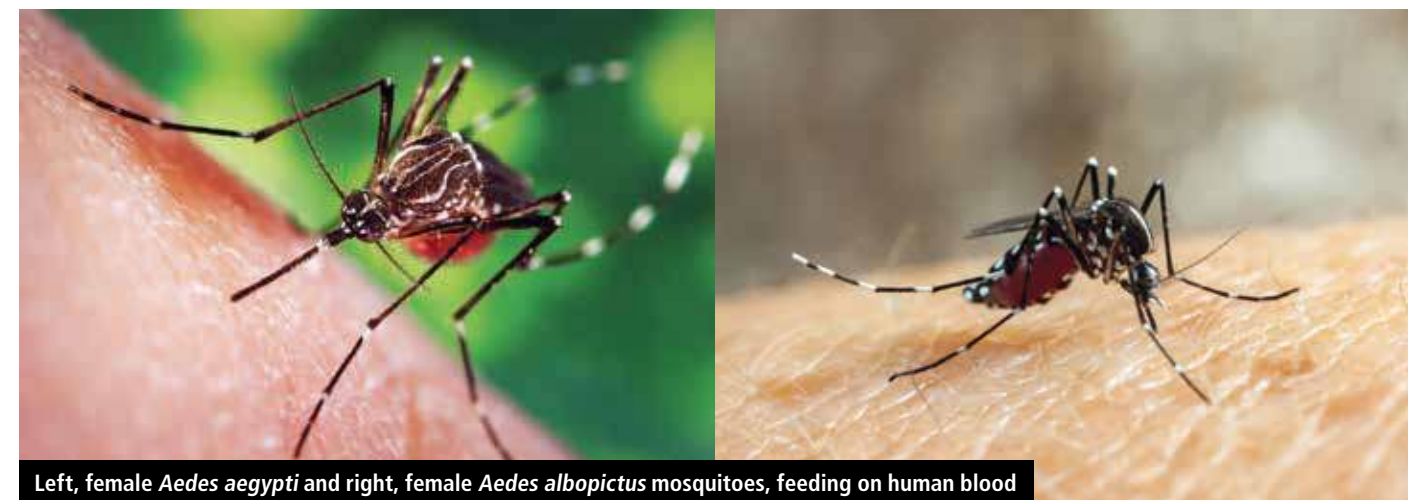
### Warmer weather

Mosquitoes cannot regulate their own body temperature, so they are dependent on air temperature and humidity to do this. As the temperature increases (up to a threshold of approximately 38°C, when it becomes too hot), mosquitoes develop faster and become more active. Therefore, increasingly hotter and wetter weather allows mosquitoes to spread to new areas that were previously too cold or dry for them to survive. Warm winters also promote egg survival, allowing them to withstand less favourable conditions until they can hatch. Changes in climate can also cause higher year-round temperatures, which can increase the length of the breeding season, leading to more mosquitoes.

Changes in our behaviour may affect our interactions with mosquitoes and increase the likelihood of disease transmission. For example, trying to keep cool by wearing fewer clothes increases the risk of being bitten. Warmer weather also encourages people to store water which, if left uncovered, can act as sites for mosquitoes to lay their eggs.

### Expanding horizons

What does all this mean for the viruses that mosquitoes carry? Research suggests that both *Aedes aegypti* and *Aedes albopictus* will have significantly expanded their geographical range by 2050. By doing so, 49% of the world's population will be at risk from the diseases that mosquitoes carry. Over the last 5 years, research has shown that *Aedes aegypti* have spread northwards at a rate of more than 240 km per year in the USA while in Europe *Aedes albopictus* have spread about 150 km per year. This alarming spread poses a major potential public health problem.



Left, female *Aedes aegypti* and right, female *Aedes albopictus* mosquitoes, feeding on human blood

Changes in weather can also have a direct impact on viruses themselves. More viruses are replicated by mosquitoes in warmer temperatures. This means that there is an increased risk that they can be passed from the mosquito when it takes a blood meal.

### Viruses we need to watch out for

#### Dengue virus

Dengue is the most common virus transmitted by mosquitoes. It is spread by both *Aedes aegypti* and *Aedes albopictus* and can cause a range of symptoms from a fever and headaches through to blood loss and organ failure. The number of dengue cases has increased 30-fold over the past 50 years and approximately half of the global population is currently at risk of dengue infections. Extreme predictions suggest that there may be dengue in the UK by 2100.

#### Zika virus

Zika virus is well known for its remarkable spread across the Americas in 2015–16, which coincided with the 2016 Olympic games in Brazil. Just a few months after the first infections were reported in Brazil, there were millions of cases, which received worldwide interest, not least because the virus caused symptoms with which it had not been previously associated. These included birth defects, such as microcephaly – a condition that means a baby is born with a small head and often brain damage. Particularly heavy rain in Brazil that winter is thought to have played a role in the increased number of cases in that area.

#### West Nile virus

The life cycle of West Nile virus involves spread from mosquitoes to animals including birds, horses and humans. Most human infections happen in the summer and cause symptoms such as fever, headaches and rashes. Severe cases can include disorientation, tremors and convulsions. The

spread of West Nile virus is influenced by wind patterns that can disperse the mosquitoes to new areas. Strong winds and storms may also affect the migration of birds, including the barred warbler and turtle dove, which can carry the virus and may be important for introducing it to new areas.

#### Chikungunya

Chikungunya virus (pronounced chick-un-gun-ya) causes a crippling arthritic disease with symptoms including fever and severe joint pain. Historically, it has been a disease of tropical climates. However, in the last decade it has significantly increased its geographical range. There have been outbreaks in the USA, South America, India, China and Europe, including Italy and southern France. Research suggests that increasing temperatures could provide optimal conditions for outbreaks of chikungunya virus in southeast England by 2050.

#### What's next?

The potential impact of global climate change on mosquitoes and the viruses they spread is a significant challenge for scientists and healthcare providers. Researchers use climate data to predict certain disease outbreaks. It is possible to forecast an outbreak due to the correlation between weather conditions and mosquito abundance. Improving our understanding of how environmental factors such as air temperature and the availability of standing water influence mosquito populations will help scientists identify effective disease control methods.

Mosquito control strategies have traditionally focused on killing them with insecticides. However, these can cause harm to the environment and their unregulated use has led to an increase in insecticide resistance. Therefore, it is important to develop environmentally friendly alternatives. Forecasting future virus outbreaks based on weather patterns can allow a proactive public health response. For example, anticipating optimal weather conditions for mosquitoes permits appropriate measures to be put in place to prevent them breeding, such as targeted removal or treatment of areas of standing water.

The interplays between climate change and the spread of diseases are complex. Other factors, including human movements and insecticide resistance, can also have an impact on the data. Some changes in the global climate can alter human activity in a way that reduces disease transmission. In extreme cases, some areas may become so intensely affected by climate change they become unsuitable for human habitation, thereby reducing the number of people at risk of



People living on the streets in Dhaka, Bangladesh, sleep under nets to prevent mosquito bites

certain diseases. This means that some predictions about how climate change will affect mosquitoes and their viruses can be unreliable.

As there are very few treatments or available vaccines for many diseases spread by mosquitoes, it is important to avoid being bitten. This can be achieved through the use of mosquito nets, insect repellent, or insecticides.

Mosquito bites are not just irritating, they can potentially be harmful to your health. As global temperatures rise and the climate becomes warmer and wetter, mosquitoes and the diseases they carry are on the increase.

### RESOURCES

World Health Organization factsheet on the impact of climate change on health: <https://tinyurl.com/y9vy8v1r>

Research from YaleEnvironment360 into the increase in mosquito-transmitted disease: <https://tinyurl.com/y8jp5xv8>

Using weather to track mosquito-transmitted disease, ZSL (Zoological Society of London), 3 August 2018: <https://tinyurl.com/ydx7dasp>

How will climate change affect mosquitoes and the diseases they spread? <https://tinyurl.com/pq29pzd> and <https://tinyurl.com/y79kgh8j>

Life cycle of a mosquito: <https://tinyurl.com/ya4eufwn> and <https://tinyurl.com/y8klzpdk>

### KEY POINTS

- Mosquitoes are responsible for spreading diseases including those caused by viruses such as dengue and Zika.
- Female mosquitoes spread viruses when they take a blood meal.
- Climate change is increasing the distribution of disease-carrying mosquitoes.
- Mosquitoes thrive in warm and wet weather.
- Scientists can use weather patterns to predict mosquito-transmitted virus outbreaks.

Dr Claire Donald is a virologist at the University of Glasgow. Her research focuses on Zika virus and how it interferes with immune responses in both mosquitoes and humans. She is studying how changes in temperature and daylight affect the ability of a mosquito to spread disease.