

Should you worry about mosquitoes on planes?

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Abstract

Imagine you are traveling home from a holiday in the *tropics* but a mosquito sneaks onto your plane... Could it spread some nasty disease, or even start an *epidemic* in your home country? Airplanes are routinely sprayed with *insecticides* (insect poison) to kill these pesky invaders, but how much of a health risk do these sneaky

mosquitoes really pose to us humans? We made some calculations to find out. Prepare to be surprised: Human travelers are much more likely to spread certain diseases than the occasional hitchhiking mosquito (about 1000 times more likely for *malaria* and 200 times more likely for *dengue fever*).

Introduction

Diseases that need insects to spread them (known as *vector-borne diseases*) are a big threat to humans worldwide. Among them are scary and potentially deadly illnesses such as Zika, malaria, yellow fever, and dengue. For each of these diseases, the *pathogens* (viruses, bacteria, *protozoa* or microbes) that make people sick are spread by mosquitoes (Figure 1).

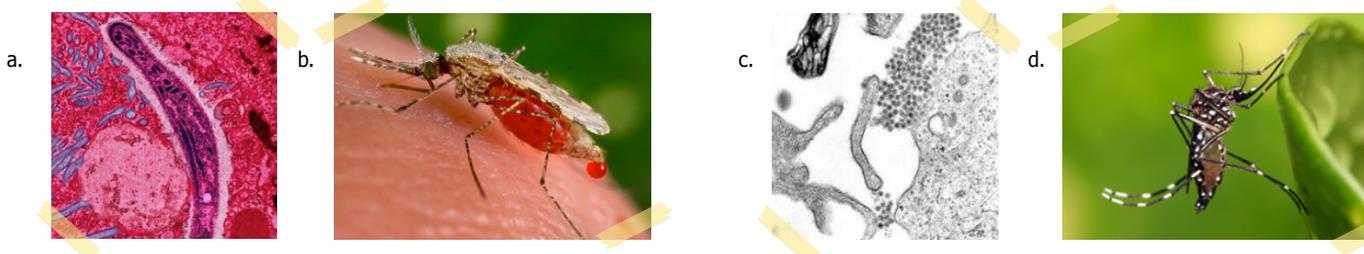
If a mosquito sucks the blood of an infected person (or other animal), it becomes infected with the pathogen. After the pathogen multiplies in the mosquito, the mosquito can then pass it on to other people (or animals) when it sucks their blood. And so the cycle begins anew! (Interestingly, the infected mosquito doesn't get sick like humans do.)

Many pathogens, and also their mosquito hosts (the mosquitoes

that carry them), originally come from the tropics or subtropics. (These areas are hot and humid, ideal conditions for certain kinds of mosquitoes and pathogens.) However, with increased airline travel, both of passengers and goods, pathogens and their hosts can easily travel all over the globe, potentially spreading diseases to new areas quickly.

Authorities therefore have airplanes routinely sprayed with insecticides in order to kill any mosquitoes that might have snuck on board. But does this really make sense, and does it really limit the spread of diseases? What kind of health risk do hitchhiking mosquitoes pose to people? We did some calculations to find out.

Figure 1: Two diseases that are spread by vectors (carriers), in these cases mosquitoes. One type of malaria is caused by the parasite *Plasmodium falciparum* (a), which is spread by the *Anopheles mosquito* (b). Dengue virus (c), which causes dengue fever, is spread by the yellow fever mosquito (*Aedes aegypti*) (d). Source: Wikipedia



Methods

We developed a mathematical model that allowed us to calculate the likelihood of mosquitoes or humans on planes spreading either malaria or dengue fever.

First, we calculated the likelihoods of single events that would lead to a person in another place getting infected, either by a mosquito, or by a fellow human traveling on a plane. Then, we calculated the overall likelihoods of all these events happening one after another.

In order for a mosquito to successfully carry the pathogen to a new location, the mosquito first needs to sneak onto a plane. Second, that mosquito, in order to pose any risk, needs to be a female. Third, the female mosquito needs to be infected, i.e. carrying the pathogen inside it. (Not all mosquitoes are infected! In fact, the majority are not.) Fourth, it needs to survive the trip. Fifth, it needs to then bite a human to pass on the pathogen.

In order for a person to successfully carry the pathogen to a new location, there needs to be an infected human on the plane. After landing, this person needs to get bitten by a mosquito and to pass the pathogen on to that mosquito. That mosquito then has to survive long enough to find, bite and infect another person.

To compare these two ways that the diseases can spread, we used the model to simulate planes traveling between tropical locations with lots of mosquitoes where these pathogens can be easily transmitted.

Did you know that only female mosquitoes suck human blood in order to produce eggs and babies? The male mosquitoes live off nectar from flowers instead!

Results

Interestingly, we discovered that human air travelers are far more likely to spread a disease (malaria or dengue) than a mosquito that has snuck on board (Figure 2) when a plane travels from one tropical place to another.

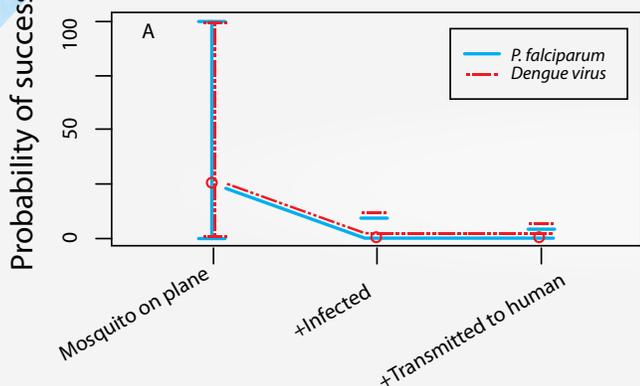
In our model, the overall likelihood that one person in the destination could be infected with dengue or malaria by a mosquito on a plane coming from an area where each disease is common was about 0.01%. In contrast, it was pretty certain (100% probability) that an infected human traveling by plane between two similar locations could infect at least one mosquito upon arrival and that that infected mosquito could then infect

at least one person. Dengue fever had a smaller probability of being passed on by traveling humans (40%), mostly because humans infected with dengue virus are infectious for a much shorter period of time.

Even for humans, the real life probabilities are much smaller than 40% or 100% because we designed our model to compare risk where it was highest. Overall, when compared to mosquitoes, humans traveling on planes are over 1000 times more likely to introduce malaria to new areas and over 200 times more likely to introduce dengue.

Who is more likely to introduce malaria to a new area, mosquitoes or people travelling on planes? What are the least (or the most) likely single steps required for each method of introduction?

Introduction by Mosquitoes



Introduction by Humans

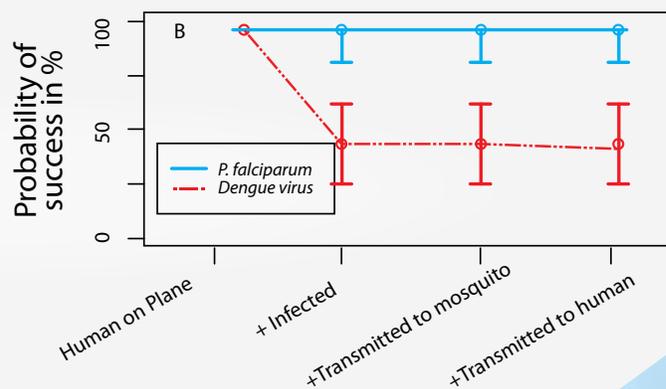


Figure 2.

Step by step and overall probability for malaria to be introduced to a new country via mosquitoes or humans traveling on planes. *P. falciparum* is the parasite that causes Malaria.

Discussion

Our calculations show that mosquitoes on planes pose a much smaller risk of spreading a disease to other countries than infected human travelers do. Why is that so? First, the chances that mosquitoes end up on a plane are relatively small to begin with (fewer than one per plane). Second, the chance that the mosquito is infected **and** bites someone **and** transmits the pathogen is even smaller!

For a mosquito to transmit the pathogen, it needs to survive long enough so that the pathogen can develop and multiply in its body (a period of time known as the *incubation period*). This makes the mosquito infectious. It then has to live long enough to find a suitable victim upon landing. Another factor is that a human is more likely to carry the pathogens in their body than a mosquito is.

Our calculations probably overestimate the chance of being infected by mosquitoes because we counted all reported mosquitoes on planes as bloodsucking females (in reality some of them would be harmless males), and we also assumed they would be alive (some mosquitoes found on planes are dead - and cannot infect anyone anymore).

Airport personnel routinely spray planes on some routes with insecticides to kill mosquitoes. However, mosquitoes on planes pose only a very low risk of spreading diseases. Plus, killing mosquitoes on planes is not as easy as it may sound, treatments need to be safe and effective and some mosquitoes are *resistant* to some commonly used treatments.

Conclusion

Stopping the spread of dangerous diseases is important, but mosquitoes that sneak onto planes only pose a minuscule risk. Instead of dreading six-legged plane passengers, we should focus on not getting infected when **we** travel! You can do so by wearing long-sleeved shirts and long pants when

outside and using insect repellent as directed. Other ways you can protect yourself include keeping windows closed and using air-conditioning. If windows and doors need to be open, use window and door screens. You should sleep under a mosquito net if your windows don't have screens.

Glossary of Key Terms

Dengue (or dengue fever): a mosquito-borne tropical disease caused by the dengue virus. Symptoms typically begin 3 - 14 days after infection, and may include a high fever, headache, vomiting, muscle and joint pains, and a characteristic skin rash.

Epidemic: a widespread occurrence of an infectious disease in a community at a particular time.

Host: someone who carries a pathogen or a parasite. Both the mosquito and humans are hosts for the malaria pathogen.

Incubation period: for people, this measures the time from when they are infected by a pathogen to when the first symptoms of disease appear. For the mosquito, it is the time the pathogen needs to develop and multiply in the mosquito's body to be infectious to people or animals.

Infectious: able to infect someone. The infectious periods for the pathogens in our study are very different: approximately 205 days for the malaria pathogen, and only about five days for the dengue fever virus.

Insecticides: chemicals that are used to kill insects.

Malaria: a mosquito-borne disease caused by a protozoan parasite. People with malaria often experience fever, chills, and a flu-like illness. Left untreated, they may develop severe complications and die. Millions of people (and especially children) die from the disease globally each year.

Model: a representation of a thing or system. A mathematical model represents real world situations using a variety of mathematical structures (e.g. graphs, equations, diagrams).

Pathogen: a small bacteria, virus, or multicellular organism that makes people or animals sick.

Protozoa: microscopic animals whose bodies consist of a single cell (e.g. amoebas)

Resistant/resistance: describes the fact that many insects or plants evolve in ways that mean the chemicals used to kill them are not effective anymore.

Subtropics: geographic and climate zones north and south of the tropics, between the tropics and the temperate zones. Subtropical areas include the Sahara Desert in North Africa and the southernmost parts of Europe (and more).

Tropics: the regions around the Equator. Tropical areas include most of Brazil, the Caribbean and Southeast Asia (and more).

Vector-borne disease: a disease that is spread by an animal or insect carrier (vector). For instance, many tropical diseases like malaria, Zika, and dengue are spread by mosquito vectors.

Check your understanding

- 1 What is a vector-borne disease?
- 2 Can you name any other vector-borne diseases (not mentioned in this article), and other vectors that are not mosquitoes?
- 3 Does spraying planes with insecticide reduce the spread of diseases? Why or why not?
- 4 Can you think of a situation in which trying to reduce the number of mosquitoes on planes might be useful, after all?
- 5 Name five ways you can protect yourself from vector-borne diseases.

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