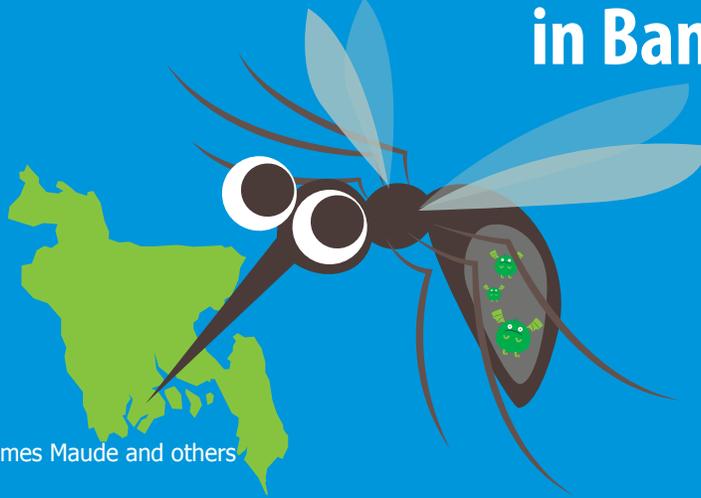


Where does malaria lurk in Bangladesh?



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Abstract

Malaria is the deadliest *parasitic* and mosquito-borne infection on the planet. It's a big public health problem in many tropical and subtropical countries. In Bangladesh, over 17 million people are at risk of malaria. Data on its distribution in the country, however, are limited. We wanted to track malaria *hotspots* through both space and time. To find these hotspots we used data on malaria cases, collected from non-governmental organizations in Bangladesh. We

generated maps of these regions for four years and analyzed their stability through time. We mapped several stable hotspots, most of them located in the southeast, and found out that only a small proportion of the population accounted for most malaria cases. Moreover, stable hotspots from one year can be used to predict future hotspots. This may help locate the best areas to target for elimination efforts.

Introduction

Malaria is the deadliest mosquito-borne disease — so deadly, that every two minutes this disease kills a child. Five tiny *parasites* of the genus *Plasmodium* (Fig. 1) cause malaria and female mosquitoes transmit it from human to human. We (people) are the only source for the four main parasites which cause this infection. There are drugs that can cure this disease, but more and more parasites are developing *resistance* against them. This and other factors, like infected people spreading malaria when traveling, make it difficult to control and eliminate malaria.

Malaria is spread in the tropical and subtropical regions of Africa, Asia and America. Bangladesh is one of the Asian countries where local *transmission* occurs. There are over 17 million people at risk in Bangladesh. In recent years governmental and non-governmental organizations (NGOs) renewed malaria control efforts, which led to a significant drop of malaria cases and deaths.

To eliminate malaria, however, Bangladesh has to fill in some knowledge gaps. The transmission of malaria is *heterogeneous* across the country's population, which means that the government should try different strategies in the different areas. For example, focusing efforts on

areas where malaria occurs more often, called *hotspots*, may significantly help the elimination of the disease. But the data on malaria distribution are incomplete. In addition, no one has investigated how this transmission heterogeneity changes over time and across the country.

By creating maps of malaria hotspots over time, we were hoping to help with these problems.

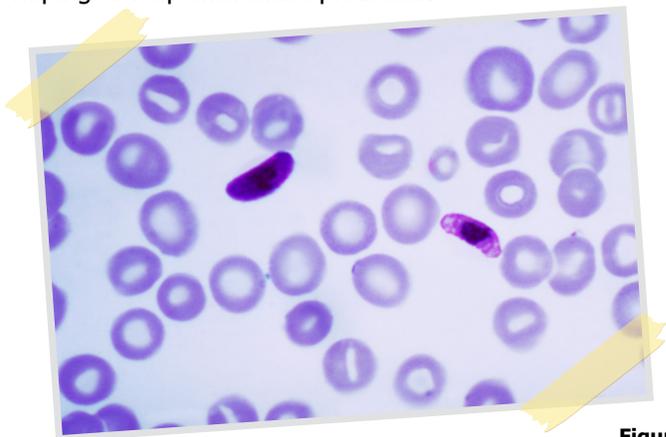


Figure 1:

A microscope image of *Plasmodium falciparum*, one of the causative agents of malaria, and blood cells.

Methods

There are 64 districts in Bangladesh and thirteen of them are *endemic* for malaria – eight in the northeast area and five in the southeast area (Figure 2). Every district in the country is divided into subdistricts (or upazilas), and further into *unions*. We used the data collected (between 2013 and 2016) from the NGOs regarding malaria surveillance in non-urban unions.

Using geographic and statistical software, we created and analyzed maps of the hotspots (the areas where malaria most often occurs). We wanted to track the changes in these areas through time as well, so we created monthly hotspot maps. These maps showed us the stability of the hotspots: the amount of time each union was a hotspot. They also allowed us to assess whether certain hotspots were responsible for the spread of malaria to other unions.

Results

Between 2013 and 2016 the NGOs have reported a total of 102,582 malaria cases in Bangladesh. 2014 was the year with the most cases. Almost 98% of the cases were from the southeast area.

In the **northeast** area:

- 33% of the *population at risk* accounted for 80% of the cases.
- the *incidence rate* in all unions declined.
- the hotspots were not as stable as the ones in the southeast area.
- all relatively stable hotspots were near a border with another district or another country.

In the **southeast** area:

- 11% of the *population at risk* accounted for 80% of malaria cases.
- the number of unions with no malaria cases increased.
- there were many stable hotspots from 2013 to 2016 (Figure 3).
- the stable hotspots didn't change much from year to year, and all of them were near a border with another district or another country.

When examining the monthly maps:

- there was an increase in the number of cases in some unions in the southeast area
- during these years there was no steady pattern of spread of malaria from hotspots



Figure 2:
Malaria endemic districts in Bangladesh.

Answer:
It was a hotspot every month for all four years.

What does it mean for a hotspot to be 100% stable?

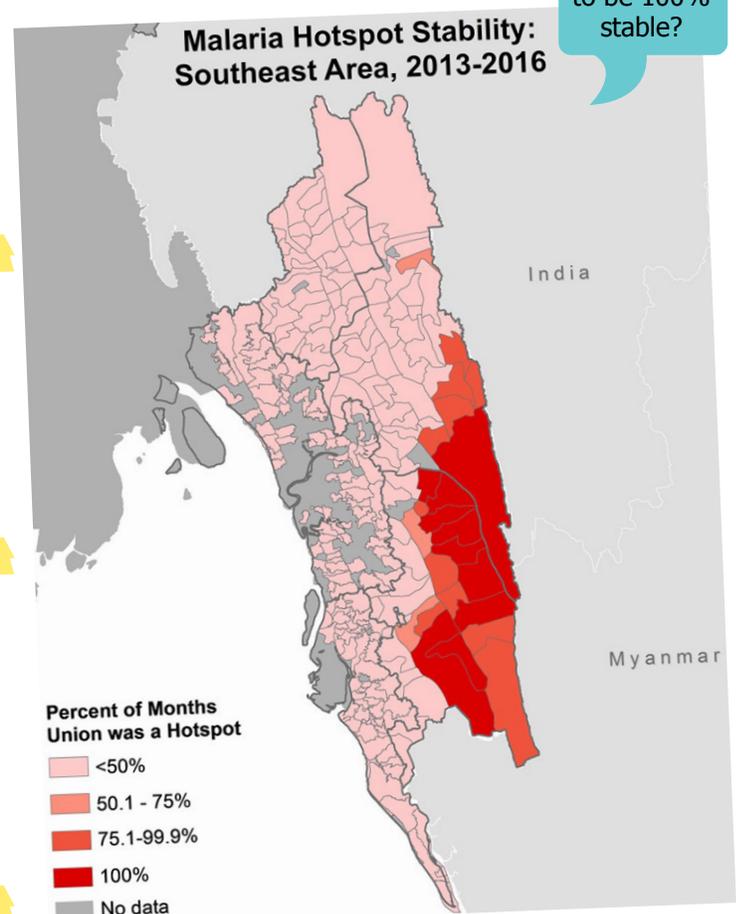


Figure 2:
Stable malaria hotspots in the southeast area of Bangladesh (2013-2016). The percentages show the portion of time a union was a hotspot.

Discussion

Our results demonstrate that only a small subset of the population at risk is responsible for most new malaria cases in Bangladesh. This further shows that the transmission in the country is heterogeneous in space. This is very important for planning strategies to reduce and eliminate the disease. But are there many differences through time? It seems that in the northeastern area, the high transmission season (the rainy one when there are more mosquitoes) isn't that different than the low one. This is perhaps due to the declining number of cases in the area overall.

Another important finding is that many of the stable hotspots are near borders with other districts or other countries. Mosquito species on international borders in the country are

different from the ones inside. This may lead to the need for different mosquito control strategies at international border hotspots. Moreover, drug-resistant parasites are more widely spread in Myanmar and Thailand. If these parasites enter Bangladesh they can further spread to India – the country with most malaria cases and people at risk in Asia.

From 2013 to 2016 there was hotspot stability in both space and time. Stable hotspots from one year made it possible to predict the occurrence of a future hotspot in the same union. This finding can be useful for planning malaria control strategies, because these areas seem highly susceptible to interventions which can reduce or stop transmission.

Conclusion

Malaria and many other diseases, such as dengue, Zika and yellow fever are mosquito-borne infections. If you live in or travel to an endemic area, the best way to protect yourself (and others around you) is to avoid mosquito bites. You can do that by:

- wearing long sleeves.
- using *repellents* (but if you use sunscreen it should be first, and the repellent second).

- using mosquito nets around your bed, preferably nets treated with insecticides.
- not leaving stagnant water outside for mosquitoes to breed in. If you travel somewhere that malaria is common, it is also advisable to take medicine to prevent malaria, known as prophylaxis.

Glossary of Key Terms

Endemic – a disease is endemic if it is regularly seen in some region.

Heterogeneity (transmission heterogeneity) – the disease is concentrated in a small proportion of individuals and not distributed evenly across the population.

Hotspot – an area with a lot of cases of a disease (i.e. the transmission is efficient).

Incidence rate – the number of new cases per population at risk for a period of time.

Parasite – an organism (i.e. flatworms, round worms and many others) that lives inside or attached to another organism, called the host. The relationship is always the same: good for the parasite, bad for the host.

Population at risk – individuals who are in danger (at risk) of developing a disease; for example, the number of people who live in malaria endemic areas.

Repellent – a chemical that is used to stop insects (and sometimes ticks) from biting you. Most commonly the chemical is DEET.

Resistance (drug resistance) – when microorganisms learn how to counteract certain drugs, which makes it harder to cure the disease.

Transmission – the passing of a disease from one individual to another.

Union – the smallest administrative, local government units in Bangladesh.

Check your understanding

1 Why is transmission heterogeneity a problem?

2 Many hotspots turned out to be on international borders. What are the main concerns?

3 Stable hotspots were able to predict the occurrence of future hotspots. How can this information be useful?

4 What is the best way to avoid malaria and other mosquito-borne diseases?

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MORU Bangkok: Mahidol Oxford Tropical Medicine Research Unit (MORU)

<https://youtu.be/jZTtbDrM9bo>

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