Insect Borne (Vectorborne) Infectious Diseases
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The route by which an infectious disease infects a human is important both to understand how it spreads but also how to combat it. In this series of talks we will be considering the five common groups of infections: vectorborne (the subject of this talk); food or water; sexual and blood-borne; respiratory; touch. Usually, one route of infection is dominant but there may be a secondary route. Infections seldom change their route of transmission even if they jump species. These notes are not a transcript of the lecture but rather highlight some of the issues that are covered.

Many major diseases are entirely or largely vectorborne. Most of the major vectors are insects (a few are arachnids). These include historically important diseases such as plague but also major current diseases including malaria, dengue, sleeping sickness, river blindness, Lyme disease and typhus.

Vectorborne diseases need different control measures from other transmission methods. Several things make it harder. Insect vectors are often very efficient at infection. With an insect vector you do not need to meet the person or animal that infects you, which may be over long distances or extended time. On the other hand, many vectorborne diseases have a specific geographical range because of where the vector lives, and critically if you can kill or reduce the population of the insect vector you can prevent or reduce transmission. Vectorborne epidemics are gone for now in the UK, but they were a serious threat when this College was founded. These included plague, epidemic typhus and malaria. The UK currently has relatively few vectors with epidemic potential although global warming could change that, but not for a long time. They do however remain a very major threat globally.

Plague is an example of the power of the vectorborne disease to shape human history. It is spread by two routes: vector (fleas) and respiratory. In the great plague epidemics 30 to 60% of Europe's population died. The risk of a plague pandemic is now zero. Another historically very important disease was epidemic typhus which was passed on by body lice. Killing lice by hot water washing or DDT was the key intervention.

Malaria is currently the most important vectorborne disease. Marsh fever or ague was well known from ancient times. It was a major problem globally including much of Europe, USA and Australia. Land-use changes reduced it in parts of Europe, including England but it is still a major threat globally. The discovery of the life cycle of malaria was one of the great breakthroughs in medicine. The female Anopheles mosquito sucks up malaria parasites when it feeds, these mature in the mosquito gut over around 9 to 11 days. They are then injected into any person it bites.

Because transmission depend geographically on where mosquitoes are breeding in large numbers, the transmission of malaria is highly variable. It can vary over quite short distances; for example, mountains or dense urban spaces make it much less likely. It can also vary over time, for example only being a significant problem over the rainy season/monsoon. The lecture will consider the mathematics of vectorial capacity and why killing mosquitoes after they have bitten a human is important. There are a number of ways to reduce malaria by preventing or killing the mosquito vector of which spraying DDT on walls and more recently

insecticide treated bed nets have proved the most effective.

A campaign to eradicate malaria significantly reduced its geographical footprint, including removing it from Europe, North America, parts of Asia, Australia and much of North Africa. It remains however a major threat in several areas, and in particular its African heartlands. In addition to attacking the vectors, the other key intervention has been early diagnosis and treatment. The combination of anti-mosquito measures and treatment has reduced mortality from malaria by over half since 2000 although over 400,000 people, mainly children in Africa, die every year.

Malaria remains a significant threat for those who travel to malaria areas. It is largely preventable by sleeping under a treated bed net and taking antimalarial drugs. People often forget that in many parts of Africa the average unprotected person gets malaria several times a year- malaria is very common.

The recent announcement by WHO in favour of deploying the first malaria vaccine adds a third potential pillar to malaria control along with anti-mosquito measures and treatment. The current vaccine (RTS,S) provides around 30% reduction in severe malaria. Whilst not as effective as many other vaccines, for example for COVID or measles, a moderate reduction in large risk is still a significant advance and should be warmly welcomed. It will need to be added to, rather than use instead of, other measures.

Mosquitoes can transmit other important parasites. For example, the worm species that causes lymphatic filariasis (elephantiasis) which can result in substantial swelling of the appendages has been a major threat in Africa and Asia. This is gradually decreasing due to a combination of mosquito control and mass drug administration.

Whilst malaria and filariasis are largely decreasing, a group of serious viral infections transmitted by one mosquito genus, Aedes, are currently spreading. This includes dengue and Zika. Aedes is well adapted to peri-urban living and is a daytime feeder making bed nets ineffective. Dengue is a relatively long-standing disease which is spreading geographically. It can cause long-term problems and deaths including in epidemic waves. The first major outbreak of Zika was in 2015 but further outbreaks are likely. The potential spread is limited to the vector distribution but one species of Aedes is spreading in Europe and is widespread across Asia, Latin America, the Caribbean and parts of Africa. It is quite difficult to control and vaccines for these infections are therefore a priority.

In addition to these diseases which are spread human to human, also important are the mosquito borne viruses that are spread from birds and animals to humans. These include Japanese encephalitis and West Nile virus.

Several fly species can also spread important diseases. Sleeping sickness has historically been an extremely unpleasant, almost always fatal neurological disease. It is spread by the tsetse fly. A combination of finding and treating people with the infection and tsetse control have led to a much better outlook at present.

Onchocerciasis, known as river blindness, is due to a worm transmitted by the blackfly. It causes vision loss. Vector control by spring lava side on breeding sites of the fly and mass drug administration using the antiparasitic drug ivermectin has been fairly effective in control. Flies are also important in two other eye diseases; the eye worm Loa Loa and the most important infectious cause of blindness, trachoma, where flies contribute, although are not the principal driver of the disease.

Ticks, which technically are arachnids rather than insects, transmit a number of important infections. A group of rickettsial diseases caused typhus and other spotted fever diseases. These include African tick typhus, Rocky Mountain spotted fever and other varieties. A similar mite born typhus is seen in Southeast Asia.

Lyme disease is an important tickborne disease. It tends to be highly geographically concentrated and occurs in particular areas of several countries including USA, UK and many European nations.

Tickborne encephalitis occurs across much of Europe and Asia causing inflammation in the brain and lifelong neurological complications in some cases. An effective vaccine is available.

This lecture has therefore considered several aspects of vectorborne diseases. They are common, varied

and can be very dangerous. They depend on the local vectors which are highly geographically varied, although most are more common in tropical environments. There are broadly three approaches to control: kill the vectors or stop them biting; early treatment to cure and prevent transmission; vaccines. The relative importance of each of these depends on the disease and the vector. With several vectorborne diseases we are making major progress but, in particular with Aedes associated infections, others are spreading.

References and Further Reading

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