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Frequently-Asked-Questions about Malaria

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What exactly is Malaria?

Malaria is a common and serious tropical disease. It is a protozoal infection transmitted to human beings by mosquitos biting mainly between sunset and sunrise. Human malaria is caused by four species of *Plasmodium* protozoa: *Plasmodium falciparum*, *P.vivax*, *P. ovale* and *P.malariae*.

Malaria is a public health problem in over 100 countries worldwide, inhabited by some 40% of the world population, *i.e.* over 2 billion people. It has been estimated that the incidence of malaria in the world may be in the order of 300 million clinical cases each year. Countries in tropical Africa account for more than 90% of these. Malaria mortality is estimated at almost 1 million deaths worldwide per year. The vast number of malaria deaths occur among young children in Africa, especially in remote rural areas with poor access to health services. Other high risk groups include women during pregnancy, and non-immune travellers, refugees, displaced persons, or labour forces entering into endemic areas.

What varieties of Malaria are known to exist?

In total there are nearly 120 species of *Plasmodia*, including at least 22 found in primate hosts, and 19 in rodents, bats and other mammals. About 70 other *Plasmodia* species have been described in birds and reptiles. Human malaria is caused by four species of *Plasmodium*: *Plasmodium falciparum*, *P.vivax*, *P. ovale* and *P.malariae*.

Various strains may exist within well-defined species, based on biological variations from one geographical area to another.

How do the known varieties differ?

The zoological classification of the almost 120 *Plasmodium* species is too complex to detail here. The 4 species causing human malaria differ morphologically, immunologically, in geographical distribution, relapse pattern, drug response, etc. *Plasmodium falciparum* causes the most serious disease.

What are the symptoms?

The classic clinical course of malaria consists of bouts of fever accompanied by other symptoms and alternating with periods of freedom from any feeling of illness. The intermittent type of fever is usually absent

at the beginning of the disease, when headache, malaise, fatigue, nausea, muscular pains, slight diarrhoea and slight increase of body temperature are the predominant and vague symptoms, often mistaken for influenza or a gastro-intestinal infection. Most severe forms of the disease result in organ failure, delirium, impaired consciousness and generalized convulsions, followed by persistent coma and death.

How long is the incubation period/onset of symptoms?

The incubation period in malaria covers the time between infection and the first appearance of clinical signs, of which fever is the most common. The length of the incubation period is usually between 9 and 30 days, depending on the infecting species (shortest for *P.falciparum*, longer for *P.malariae*). In some strains of *P.vivax* (*P.v.hibernans*) the incubation period may last some 8-9 months.

Falciparum malaria, which can be fatal, must always be suspected if fever, with or without other symptoms, develops at any time between one week after the first possible exposure to malaria and two months (or even longer in exceptional cases) after the last possible exposure.

Which parts of the body does it usually infect (at both the organic & cellular levels)?

Parasites (sporozoite stage) are injected into the skin capillaries by a mosquito. From there they travel via the bloodstream to the liver, where they develop and multiply in liver cells before entering the blood stream again (merozoite stage) and invading for further reproduction. From there other internal organs, e.g. the brain, can be affected as clumps of heavily infected erythrocytes start blocking capillary blood flow.

How is it transmitted?

Malaria is most commonly transmitted through the bite of an infected *anopheline* mosquito. Of the approximately 400 species of *Anopheles* throughout the world, only about 60 are vectors of malaria under natural conditions, some 30 of which are of major importance.

Malaria can also be transmitted by blood transfusion, and by contaminated needles and syringes.



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In congenital malaria, parasites are transmitted from mother to child before and/or during birth.

Can an infected person transmit Malaria to others before symptoms appear?

Malaria parasites are normally transmitted from one person to another via mosquitos of the *Anopheles* species. The form of the parasite that can infect mosquitos is called gametocyte. Gametocytes start developing in capillaries of the inner organs of infected persons after the invasion of the blood by merozoites. Mature gametocytes, which are infective to mosquitos, appear in the peripheral blood some 3 (in the case of *P.vivax*) to 10 days (*P.falciparum* and *P.malariae*) later. The female *Anopheles* mosquito ingests malaria gametocytes when it takes a blood meal from an infected person. The parasite then needs a period of development in the mosquito before it can infect other people again. The length of this period (sporogonic cycle) depends on the *Plasmodium* species and the ambient temperature.

In highly endemic areas, such as in parts of Africa, persons who have been repeatedly infected with malaria acquire a degree of immunity to malaria which suppresses most clinical symptoms. These people may carry gametocytes in their blood that will infect the mosquitos biting them. In non-immunes, clinical symptoms will usually have developed before gametocytes appear in the peripheral bloodstream.

Malaria infected persons who donate blood before the onset of clinical symptoms, but after merozoites have entered the blood stream from the liver, can unknowingly transmit malaria through their blood donation. Blood donations from (semi)immune persons without clinical symptoms may also contain malaria parasites. Similarly, malaria may be transmitted by contaminated needles and syringes.

For how long is a patient infectious to others after onset of symptoms?

In *P.vivax* and *P.ovale* infections the patient is practically immediately infectious to mosquitos after the onset of symptoms. In *P.falciparum* infections only after several days, when mature gametocytes appear in the peripheral bloodstream.

Antimalarial drugs such as chloroquine and mefloquine that are given to cure malaria infections do not eliminate mature *Plasmodium falciparum* gametocytes from the bloodstream. A person who has been successfully treated with antimalarial drugs may thus

be healthy but infective for several weeks until the gametocytes die off naturally.

Can a survivor transmit Malaria to others after she or he has fully recovered?

- Yes, as an asymptomatic carrier of a malaria infection.
- Examples are people who have built up immunity to *falciparum malaria* (see above), or people who, after having recovered from the primary attack of *P.vivax* or *P.ovale* infections, subsequently suffer a relapse.
- Antimalarial drugs such as chloroquine and mefloquine that are given to cure malaria infections do not eliminate mature *Plasmodium falciparum* gametocytes from the bloodstream. A person who has been successfully treated with antimalarial drugs may thus be healthy but infective for on average 2 months until the gametocytes die off naturally, or until another drug such as primaquine is given that does eliminate the gametocytes.

Is it airborne?

- Not in the usual sense of the word. However, mosquitos do fly, of course, and malaria-carrying female *anophelines* fly through the air to reach the source of blood needed to feed on and develop their eggs.
- *Anopheles* mosquitos are not usually found more than 2 or 3 kilometres from their breeding places in any large number. However, strong seasonal winds may carry *Anopheles* up to 30 km from their main breeding place.
- Occasionally malaria has been transmitted near airports in non-endemic areas, by mosquitos that were carried in on aircraft coming from endemic zones.

How do I avoid catching it?

- Protection from biting mosquitos is the first line of defense against malaria in endemic areas. The following measures are effective in reducing the risk of mosquito bites:
 - If possible, avoid going out between dusk and dawn when mosquitos commonly bite.
 - Wear long-sleeved clothing and long trousers when going out at night, and avoid dark colours, which attract mosquitos.
 - Apply insect repellent to exposed skin, choosing one with DEET or dimethyl phthalate.
 - Stay in a well-constructed and well-maintained building in the most developed part of town.

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- Use screens over doors and windows. If accommodation allows entry of mosquitos, use a mosquito net over the bed.

- Use anti-mosquito sprays or insecticide dispensers that contain tablets impregnated with pyrethroids, or burn pyrethroid mosquito coils in bedroom at night. In addition, malaria prophylaxis may be prescribed to protect against clinical symptoms. The type of prophylaxis depends on the area, local species of malaria, local pattern of antimalarial drug resistance, and personal characteristics such as allergies and contraindications, including (for some drugs) pregnancy. Contact your physician about the exact prophylaxis that would be suitable for you.

No antimalarial prophylaxis regimen gives complete protection. Malaria may be contracted despite taking antimalarial prophylaxis.

In general, pregnant women and parents travelling with young children should weigh the necessity of the trip when travelling to areas where malaria parasites have become highly resistant to chloroquine.

What is the basic treatment?

Treatment is a function of the infecting species, the degree of drug-resistance, the severity of infection, and personal allergies and contraindications. More information is available in publications such as International Travel and Health - vaccination requirements and health advice by the World Health Organization, Geneva.

Is there any cure or vaccine?

Adequately and promptly treated, malaria is a curable disease.

Various approaches to a malaria vaccine are under current study, but none is expected to be commercially available anytime soon.

Can blood from survivors be used to make a serum?

There is no need as effective drugs are available.

Does survival confer subsequent immunity?

Only partially and for a duration that is a function of the intensity and frequency of prior infections. In areas with seasonal or epidemic malaria where disease is infrequent, adequate protective immunity may never build up. In endemic areas with high levels of transmission, newborn children are protected in their first months of life by the antibodies of their immune mothers. After that they gradually develop their own immunity over the

years, if they do not die from the disease. The immunity is reversible, and fully "immune" adults who leave malarious areas are known to return to a state of non-immunity over a period of 1 to 2 years.

- In persons with sickle cell anaemia or the sickle cell trait, the abnormal haemoglobin S offers some protection against *Plasmodium falciparum* infection.

If Malaria can recur in a survivor (i.e. remain latent as opposed to a second infection), how does this occur?

- Reinfection is always a possibility in endemic areas.
- *P.vivax* and *P.ovale* can remain quiescent in the liver for many months. Relapses caused by the persistent liver forms may appear months, and occasionally up to 4 years after exposure. Untreated or partially treated blood infection with *P.malariae* may be present for many years before giving rise to a symptomatic episode, and can be carried for a lifetime.
- In areas with emerging drug-resistant *P.falciparum*, recrudescences of the infection may occur up to a month or more after what initially seemed to be a successful clinical cure of the infection.

Are there past illnesses of unknown cause that have since been identified as Malaria?

- Perhaps in the far past. References to seasonal and intermittent fevers exist in the ancient Assyrian, Chinese and Indian religious and medical texts, but their true identity with malaria is uncertain. Hippocrates was the first in the fifth century B.C. to describe in detail the clinical picture of malaria and some complications of the disease.

Geographically, where has Malaria been known to occur?

- The boundaries of malaria transmission are determined by the presence and abundance of anophelines, their susceptibility to malaria infection, the type of hosts they select for blood meals, and whether they live long enough to serve as effective transmitters of infection, which in turn is largely determined by ambient temperature and humidity. Although currently largely confined to what today would be considered tropical conditions, in the past, malaria (*P.malariae* and *P.vivax*) was epidemic as far north as Finland.



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What has caused Malaria epidemics to end in past occurrences?

Malaria epidemics, if uncontrolled, follow a natural course:

1. The epidemic grows in a series of steps representative of the incubation interval (the period between the occurrence of infective gametocytes in the primary case and their reappearance in a secondary case), which is about 20 days for *P.vivax* and 35 days for *P.falciparum*. The length of the incubation interval and the degree of the reproduction rate determine the rate of multiplication of transmission, which is much faster in *P.vivax* epidemics than in those due to *P.falciparum*. In areas where both *P.vivax* and *P.falciparum* are present, the initial stages of an epidemic will thus be determined by a predominance of *P.vivax* infections and a very gradual increase in severity of the epidemic, while in later stages *P.falciparum* is likely to be abundant.
2. The peak of new infections due to a *P.falciparum* epidemic will only be reached when roughly 50 percent of the population at risk is infected, unless climatic changes (notably colder temperatures) prevent further transmission.

Control of a malaria epidemic involves relieving the immediate clinical consequences, preventing the progress of the epidemic (in time and space), and preventing future recurrences of the epidemic. This means improving disease management and providing some form of transmission control.

What are the conditions that would lead to a major epidemic?

Epidemics occur when non-immune and partially-immune populations are exposed to high rates of inoculation. Potential epidemic situations can to a large extent be identified by combining some basic knowledge of the malaria situation in an area with general aspects of the geography, history and socio-economic situation. Potential epidemic situations include:

- areas of unstable malaria where conditions for malaria transmission are marginal in terms of altitude, rainfall patterns or temperature
- areas where the level of endemic malaria has been reduced and the malaria situation has become unstable after mass drug administration and/or vector control programs, which can no longer be sustained
- situations where non-immunes migrate into an endemic area. This would include refugee movements,

and migration of labour forces into endemic areas

- situations where persons harbouring malaria parasites migrate into a non-endemic, but receptive area. Receptivity refers to an abundant presence of anopheline vectors and/or the existence of other ecological and climatic factors favouring malaria transmission.
- The size and impact of potential epidemics can only to a lesser extent be foreseen. Insufficient coverage of the population by health care services will exacerbate the impact.
- In situations where a potential for malaria epidemics has been identified, responsible health services should be prepared to counter a beginning epidemic rapidly. Updated contingency plans should be at hand. At present many epidemic prone situations will, by their nature, stretch across national boundaries. Effective inter-country collaboration and sharing of experiences are paramount in developing emergency plans and preparing for adequate epidemic control measures.

How can Malaria be controlled?

The goal of malaria control is to prevent mortality and reduce morbidity and social and economic losses, through the progressive improvement and strengthening of local and national capabilities. Four basic technical elements of the malaria control strategy are:

- to provide early diagnosis and prompt treatment
- to plan and implement selective and sustainable preventive measures, including vector control
- to detect early, contain or prevent epidemics
- to strengthen local capacities in basic and applied research to permit and promote the regular reassessment of a country's malaria situation, in particular the ecological, social and economic determinants of the disease. Effective implementation of the malaria control strategy requires:
 - sustained political commitment from all levels and sectors of government
 - malaria control to be an integral part of health systems, and be coordinated with relevant development programmes in non-health sectors
 - communities to be full partners in malaria control
 - activities mobilization of adequate human and financial resources.

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Are there international regulations concerning Malaria?

International measures relating to malaria (source: Benenson, A.S. (ed.), Control of Communicable Diseases in Man, 15th edition, APHA, 1990. p269): (1) Disinsectization of aircraft before departure or in transit using a space-spray application of an insecticide of a type to which the vectors are susceptible. (2) Disinsectization of aircraft, ships and other vehicles on arrival if the health authority at the place of arrival has reason to suspect importation of malaria vectors. (3) Enforce and maintain rigid antimosquito sanitation within the mosquito flight range of all ports and airports. (4) In special circumstances, administer antimalarial drugs to potentially infected migrants, refugees, seasonal workers, and persons taking part in periodic mass movement into a areas or country where malaria has been eliminated. (5) Malaria is a Disease under Surveillance by WHO, as it is considered an essential element of the world strategy of primary health care. National health administrations are expected to notify WHO twice a year of: those areas originally malarious with no present risk of infection, those malaria cases imported into areas in the maintenance phase of eradication, those areas with chloroquine resistant strains of parasites, and those international ports and airports free of malaria.

Is quarantine required or permitted as a preventive measure?

No.

Is isolation required for the patient?

No.

Is vaccination required or recommended for international travel?

No vaccine is available.

What is the name of the infectious agent?

Plasmodium, a protozoa of which there are four species infecting humans: *Plasmodium falciparum*, *P.vivax*, *P. ovale* and *P.malariae*.

When was it identified?

In 1880, Laveran, a French army surgeon in Algeria, first saw and described malaria parasites in the red blood cells of man.

What is known of its genetic history?

According to Bruce-Chwatt in Essential Malariology

(page 1):

Prehistoric man in the Old World was subject to malaria, it is probable that the disease originated in Africa, which is believed to be the cradle of the human race. Fossil mosquitos were found in geological strata 30 million years old and there is no doubt that they have spread the infection through the warmer regions of the globe, long before the dawn of history. Malaria followed in the wake of human migrations to the Mediterranean shores, to Mesopotamia, the Indian peninsula and South-East Asia. How malaria established itself in the New World is subject to speculation, as no reliable historical or other data exist on this point. It is possible that *Plasmodium vivax* and *P.malariae* were brought in from South-East Asia by early trans-Pacific voyages, while *P.falciparum* is of post-Colombian origin, through the African slaves brought by the Spanish colonisers of Central America.

How is it detected?

The clinical diagnosis of malaria is difficult under the best of circumstances. Definite diagnosis is based on light microscopic observation of parasites in the red blood cells of the patient. Newer, less widely used diagnostic tools include fluorescent staining, genetic probes, and antigen detection in the form of a dip stick.

What is its rate of reproduction?

The rate of reproduction of malaria is the estimated number of secondary malaria infections potentially transmitted within a susceptible population from a single non-immune individual. This number represents the theoretical estimate of the intensity of transmission. In practice transmission will depend on the parasite species involved, fluctuations of the source of infection (gametocyte carriers), the density and infectivity of the *Anopheles* species involved, etc. Factors making up the mathematical formula of the basic reproduction rate are: bites per person per night by vector population, times the expectation of infective life of the vector population, times the expectation of life of female vectors (making up the "vectorial capacity of the vector population"), times the mosquito's receptivity to infection, and the days of infectivity per case.

What is the natural reservoir for Malaria?

Chimpanzees and gorillas are the natural reservoir for *P. malariae*.

What are the vectors for Malaria?

Anopheles mosquitos. Of the approximately 400 species of *Anopheles* throughout the world, only about 60 are



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vectors of malaria under natural conditions, some 30 of which are of major importance.

What are some comprehensive sources of information on this disease?

Wernsdorfer, W.H. and McGregor, Sir I., Malaria - Principles and Practice of Malariology, 2 volumes, published in 1988 by Churchill Livingstone, New York, USA.

Bruce-Chwatt, L.J., Essential Malariology. Second edition published 1985 by William Heinemann Medical Books Ltd., London, UK.

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