Malaria ~ Frequently Asked Questions

This document provides answers to commonly asked questions about malaria. The information within this document was taken from three sources (see end of document) and collated in one document for convenience sake. *Read the disclaimer at the end of this document.
Click on the question to see the answer.

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General questions about malaria

- What is malaria?

Malaria is a serious and sometimes fatal vector-borne disease. A vector is something that carries a disease from one living thing to another. The disease is caused by single celled parasitic protozoans that are transmitted to humans by specific mosquitoes. Other transmission methods do exist though (see transmission of disease). Malaria is a problem in 97 countries and territories across the globe, inhabited by about 40% of the world population. The estimate of malaria incidence is about 300 million clinical cases per year of which countries in Africa account for more than 90% of the cases. Malaria mortality is estimated at over half a million deaths worldwide per year. Most of these deaths occur in young children, under the age of five years, mostly in Africa and especially in remote rural areas. Other high risk groups include displaced people, labour workers starting in endemic areas, non-immune travellers, refugees and especially women during pregnancy. The disease causes a huge drain on the national economies of many of the endemic countries due to its high morbidity and mortality rates. The disease maintains the cycle of disease and poverty because most endemic countries are amongst the poorest nations. In spite of it being such a devastating disease, illness and death from malaria can be prevented most of the time.

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- Where does malaria occur?

Malaria transmission boundaries are determined by the incidence and abundance of the mosquito vector, their susceptibility to the parasite, the type of hosts they feed on, and if they survive long enough to transmit the disease. Ambient humidity and temperature is important for both the vector and parasite. Therefore, malaria is typically found in warmer regions such as tropical and sub-tropical countries, but does not occur in all warm climates. Large areas of Africa and South Asia and parts of Central and South America, the Caribbean, Southeast Asia, the Middle East, and Oceania are considered malaria endemic areas. For a world map showing malaria endemic areas, click here.

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- Why is malaria so common in Africa?

In sub-Saharan Africa, the principal malaria mosquito, *Anopheles gambiae*, transmits malaria very efficiently. The most commonly found malaria parasite, *Plasmodium falciparum*, causes severe and potentially fatal disease. Lack of resources and money, and political instability can prevent the sustainability of malaria control programmes. Malaria parasites are becoming more resistant to anti-malarial drugs, and insecticide resistance in vectors is also increasing, presenting another problem for malaria control.

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- What is the infectious agent?

The disease causing organism is a protozoan called *Plasmodium.* There are four species that infect humans: *P. falciparum*, *P. malariae*, *P. ovale* and *P. vivax*. Within each species there are variant strains. Recently, it has been recognized that *P. knowlesi*, that naturally infects macaques in Southeast Asia, also infects humans, causing "zoonotic" malaria (malaria transmitted from animal to human). *P. falciparum* is the deadliest type of malaria. Various strains may exist within well-defined species, based on biological variations between different geographical areas.

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- What varieties of malaria are known to exist?

There are nearly 120 *Plasmodium* species with at least 22 found in primate hosts, and 19 in rodents, bats and other mammals. About a further 70 other species have been described in reptiles and birds.

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- How do the known varieties of malaria differ?

The zoological classification of all *Plasmodium* species is very complex. The four species that cause human malaria differ immunologically, morphologically, in geographical distribution, relapse pattern, drug response, etc.

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- What are the vectors (carriers) for malaria?

Female *Anopheles* mosquitoes. Only about 60 of the roughly 400 species of *Anopheles* worldwide are vectors of malaria under natural conditions. Thirty of these are of major importance.

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- Can all mosquitoes transmit malaria?

No. Out of more than 2000 mosquito species identified by entomologists so far, only female *Anopheles* mosquitoes transmit malaria. The benign *Anopheles* males feed on nectar. The major malaria vectors in Africa are *An. gambiae sl* complex and *An. funestus*.

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- When do the vectors feed?

Most *Anopheles* mosquitoes feed at dusk or during the night, but not during the day. *An. funestus* feeds most actively between 2am and 4am.

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- How is malaria transmitted?

Malaria transmission most commonly occurs when people get bitten by an infective female *Anopheles* mosquito. Only *Anopheles* mosquitoes can transmit malaria and they must have been infected through a previous blood meal taken from an infected person. When an infected person is bitten by a mosquito, a small amount of blood containing microscopic malaria parasites is taken in. When the mosquito feeds again, about a week later, the parasites mix with the mosquito's saliva and are injected into the person being bitten. Due to the parasite living in red blood cells of an infected person, transmission can also occur through blood transfusion, organ transplant, or the shared use of needles or syringes contaminated with blood. In congenital malaria, parasite transmission occurs from a mother to the unborn infant before and/or during birth.

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- Explain the life cycle of the *Plasmodium* parasite.

A malaria infection or the *Plasmodium* life cycle is very complex. Whilst taking a blood meal from a human, the female *Anopheles* mosquito injects a small stream of parasites in the form of *sporozoites* that dwell in the mosquito's salivary glands, into the blood stream. These *sporozoites* move to the liver where each enters a liver cell and develop into *merozoites*. The merozoites multiply greatly for about two weeks, eventually destroying the host cell. Up till now there have been no symptoms of the disease. However, when the merozoites (spores) burst out of the destroyed liver cells and enter the blood stream, the human will experience a clinical attack of malaria with high fevers and sweating. Each spore enters a red blood cell, devours the hemoglobin, and the parasite grows and grows until it fills more than half of the cell. This is the trophozoite phase. Then the stage of asexual multiplication of the parasites within the blood cell starts. A parasite's nucleus breaks into separate parts, and each part forms into a spore (*merozoite*). These newly formed spores burst out of the blood cell, infect another cell and the process repeats. Each of these stages occurs at the same time for all the parasites within the body, and each new stage starts a new bout of fevers, resulting in the 48-hour intervals of *P. falciparum* and *P. vivax* and the 72-hour intervals of *P. malariae*. After several asexual multiplications, some *merozoites* become either female or male *gametocytes* and invade a red blood cell. These sexual spores don't multiply but increase in size, almost filling the blood cell, and circulate in the host's body. When the next female *Anopheles* mosquito feeds on the infected person, the sexual spores are taken up and the sexual cycle of the *Plasmodium* parasite then takes place in the gut of the mosquito. The male *gametocyte* transforms

and develops many peculiar filaments as they make their way to the female *gamete for fertilization to complete.* The fertilized egg rests on the wall of the mosquito's stomach for two to three weeks. Then the *sporozoites* burst out and travel to the salivary glands, ready to infect a new host.

For an illustration of the *Plasmodium* life cycle, click here.
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- What is malaria's rate of reproduction?

Rate of reproduction is the estimated number of secondary malaria infections potentially transmitted within a susceptible population from a single non-immune individual. This number is an estimate of transmission intensity. Transmission depends, amongst other things, on the parasite species involved, fluctuations of the source of infection (gametocyte carriers), and the density and infectivity of the *Anopheles* species involved. Other important factors that affect basic reproduction rate are: bites per person per night, the expectation of infective life of the vectors, the expectation of life of female vectors, the mosquito's receptivity to infection, and the days of infectivity per case.
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- What are the signs and symptoms of malaria?

Plasmodium falciparum malaria cases, the most common in Africa, can be diagnosed as either uncomplicated or severe (complicated), and treatment varies accordingly. Uncomplicated malaria does not usually require hospitalization in people that have had frequent bouts of the disease. Severe malaria normally occurs in people that either have no immunity or are immuno-suppressed. This would include young children, pregnant women and people that travel to malaria endemic areas and have no prior immunity.

  - Symptoms of uncomplicated malaria: consist of bouts of mild fever accompanied by flu-like symptoms alternating with periods of absence of feeling sick. The intermittent type of fever is usually absent at the beginning of the disease, when headache, malaise, fatigue, nausea, minimal vomiting, muscular pains, slight diarrhoea and slight increase of body temperature are the predominant and vague symptoms. Symptoms are often mistaken for influenza or gastro-intestinal infection. No delusions or other mental problems are experienced.
  - Symptoms of complicated or severe malaria: include delirium, generalized convulsions, impaired consciousness and respiratory distress (acidosis, ARDS or pulmonary edema). Patients can also become anaemic and jaundiced due to the loss of blood cells, start hemorrhaging, experience renal failure and go into circulatory shock, followed by persistent coma and death.

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- Is malaria a contagious disease?

No. Malaria is not spread from person to person like a cold or the flu. It is not sexually transmitted and casual contact with malaria-infected people cannot infect a person.
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- Who is at risk for malaria?

Anyone can get malaria, however majority of cases worldwide occur in people who live in countries with malaria transmission. If not from a malaria area, then infection can occur when travelling to an area with malaria, through a blood transfusion (very rare), or when transmission occurs from an infected mother to her infant before or during delivery.
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- Who is most at risk of getting very sick and dying from malaria?

Plasmodium falciparum most often causes severe and life-threatening malaria and this parasite is very common in many countries in sub-Saharan Africa. Most at risk for dying from malaria will be people who are heavily exposed to the bites of mosquitoes infected with *P. falciparum*. Young children, pregnant women or travelers from non-endemic areas, tend to have little or no immunity

against malaria and are therefore more likely to become very sick and die. Poor people in rural areas who do not have access to health care are at greater risk to get malaria. Due to all these factors about 90% of malaria-related deaths occur in sub-Saharan Africa, with most of these deaths occurring in children younger than five years of age.
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- How soon will a person feel sick after being bitten by an infected mosquito?

In most cases symptoms begin 10 days to four weeks after infection, however, a person may feel ill from as early as seven days up to a year later. Two kinds of malaria, *P. vivax* and *P. ovale*, can occur again and this is known as relapsing malaria. With *P. vivax* and *P. ovale* infections, some parasites remain dormant in the liver for anything from several months up to about four years after the person is bitten by an infected mosquito. “Relapse” occurs when these parasites come out of hibernation and begin invading red blood cells, causing the person to get sick.
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- How long is the incubation period/onset of symptoms?

The incubation period in malaria is the time from when infection occurred to the first appearance of clinical signs. The incubation period is normally between nine and 30 days long, depending on the *Plasmodium* species (shortest for *P. falciparum*, longer for *P. malariae*). The incubation period for some strains of *P. vivax* may last 8-9 months. Infection by *P. falciparum* must always be suspected if fever, with or without other symptoms, develops at any time between one week after first possible exposure and two months (or even longer) after last possible exposure.
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- For how long is a patient infectious to others after onset of symptoms?

A patient is almost immediately infectious to mosquitoes after the onset of symptoms of a *P. vivax* and *P. ovale* infection. With *P. falciparum* infections a patient is infectious only after several days, once mature gametocytes appear in the peripheral bloodstream. Anti-malarial drugs such as chloroquine and mefloquine infections do not eliminate mature *P. falciparum* gametocytes from the bloodstream even in successfully treated cases, leaving the patient healthy but infective for several weeks until the gametocytes die off naturally.
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- Which parts of the body does it usually infect (at both the organic & cellular levels)?

Mosquitoes inject sporozoite stage parasites into the skin capillaries of the human host. From there the parasites travel via the bloodstream to the liver, where development and multiplication occurs in the liver cells. Merozoite stage parasites then enter the blood stream again and undergo further reproduction. From there other internal organs, such as the brain gets affected as clumps of heavily infected erythrocytes block capillary blood flow.
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- How do I know if I have malaria for sure?

At the onset of the disease, one experiences fever, chills, headaches, malaise, muscles aches, nausea, sweats, and vomiting. However, malaria can rapidly develop into a severe and life-threatening disease. If sick and there is any reason to suspect that you have contracted malaria (see potential suspicion of malaria) you should go see a doctor or health care provider urgently.
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- How is malaria detected?

The clinical diagnosis of malaria is difficult enough. Definite diagnosis is done through a diagnostic test where a drop of your blood is examined under a light microscope for the presence of malaria parasites in the red blood cells. Newer, but less commonly used diagnostic tools include antigen detection (in the form of a dip stick), fluorescent staining, and genetic probes.
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- Can an infected person transmit malaria to others before symptoms appear?

The parasite form that can infect mosquitoes is called the gametocyte. Gametocytes start to develop in inner organ capillaries of infected hosts after the blood is invaded by merozoites. Mature gametocytes appear in the peripheral blood about three (*P. vivax*) to 10 days (*P. falciparum* and *P. malariae*) later. Gametocytes are ingested when an *Anopheles* female feeds from an infected person. The parasite undergoes a period of development (sporogonic cycle) in the mosquito before it can infect another human again. The length of this period depends on the type of malaria and the ambient temperature. In highly endemic areas people who have been repeatedly infected acquire a degree of immunity to malaria that suppresses most symptoms. These people might still carry gametocytes that can infect mosquitoes. In non-immune people gametocytes usually appear in the peripheral blood after clinical symptoms have developed. Malaria infected people who donate blood can unknowingly transmit malaria in the time before symptoms start developing, but also after merozoites have entered the blood stream from the liver. Blood from (semi)immune people with no symptoms may also contain the parasites. Contaminated needles and syringes may similarly transmit malaria.

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

Yes, as an asymptomatic carrier of malaria. People who have built up immunity to falciparum malaria (see above), or people who suffer a relapse, after recovering from the primary attack of *P. vivax* or *P. ovale* infections, are examples of this. Anti-malarial drugs such as chloroquine and mefloquine used to cure malaria infections do not eliminate mature *P. falciparum* gametocytes from the bloodstream. A successfully treated person may thus be healthy but infective for roughly two months until the gametocytes die off naturally. Alternatively a drug such as primaquine, that does eliminate the gametocytes, can be administered.

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- Is malaria a big problem?

Malaria has been eliminated in most of the developing world, but is still the leading cause of illness and death in Africa, Latin America and Southern Asia. The World Health Organisation (WHO) estimates an annual amount of up to 500 million malaria cases worldwide. The disease kills over half a million of infected people each year, around 90% of these deaths are in sub-Saharan Africa, and *P. falciparum* causes more than 90% of all these malaria infections. Malaria affects mostly young children and pregnant women, whom are more vulnerable due to a reduced immunity. It is the leading killer of children under the age of five years in Africa. Vector resistance to insecticides and parasite resistance to anti-malarial drugs is increasing. Malaria affects economic development, costing endemic countries about 1.3% of GDP annually in lost productivity, or rather an annual loss of $12 billion for the whole African continent.

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- Why are malaria cases increasing?

There are many contributing factors to the increase of malaria cases. Malaria parasites have developed resistance to many of the anti-malarials used to fight malaria. The movement of people displaced by different events introduces new parasite strains to different areas. Climate can play a part in increasing malaria transmission, but the relationship between malaria and climate is highly complex, and the type of vector could determine the effect. Increased rainfall can result in more breeding pools and an increase in the number of disease carrying vectors. Alternatively increased rainfall and higher temperatures could result in the flushing out of breeding pools, therefore reducing transmission. The discontinuation of vector control programmes that involve the spraying of insecticides on the inner walls of huts and houses in some countries, has contributed to an increase in cases. Research has demonstrated a causal link between reduction in DDT spraying and the increase in malaria rates. Other factors also appear to play a minor role.

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- Can *Plasmodium falciparum* malaria relapse?

Plasmodium falciparum malaria does not relapse whilst *P. ovale* and *P. vivax* malaria can relapse due to a reactivation of some of the parasites in the liver. However, a "relapse" from *P. falciparum* is most likely a re-infection or recrudescence of the parasite due to a failure in the malaria treatment.

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- Do mosquitoes transmit HIV/AIDS?

No. This is a common fear but no evidence exists to support the theory that mosquitoes can transmit HIV. Studies by the Centers for Disease Control (CDC) and others have produced no evidence that mosquitoes, or any other blood-sucking insect, can transmit HIV. The way that a mosquito bites affects the possibility of the insect transmitting HIV: i) When feeding, a mosquito injects a small amount of saliva into the wound, which acts as a lubricant that enables smooth feeding; ii) No blood is injected into the person that is being fed on; iii) Once feeding is done, the mosquito usually rests and digests the meal before feeding again. And any blood that may still be on the mosquito's mouth parts would have dried or be "cleaned" off by the next feed. However, co-infection with HIV/AIDS in a patient is possible.

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- What does co-infection mean?

Co-infection refers to a situation where one individual contracts and hosts multiple diseases at once. Scientists have determined that malaria co-infection with HIV/AIDS exacerbates the effects of both diseases on the individual. A person with HIV/AIDS will have a weakened immunity, and will more likely contract and die from malaria than a healthy person.

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- Does sickle cell anemia confer malaria immunity?

A gene coded for the manufacture of abnormal hemoglobin causes sickle cell anemia. When a child inherits sickle cell genes from both parents, the resulting anemia can cause eventual death. However if only one parent passes on the abnormal gene and the other contributes a normal hemoglobin gene, the resultant sickle cell anemia protects against the effects of *P. falciparum* malaria. Sickle cell children can still contract malaria, but the effects of the disease are less severe, and the duration of the malaria attack is likely to be shorter. As sickle cell children grow up, they will have greater acquired immunity to the disease and are more likely to survive the disease than non-sickle cell people.

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- Are there international regulations concerning malaria?

International measures relating to malaria include:

  - Dis-insectisation of aircraft before departure or in transit using a space-spray application of a vector susceptible insecticide;
  - Dis-insectisation of aircraft, ships and other vehicles on arrival at a destination if the health authorities have reason to suspect importation of malaria vectors;
  - Enforce and maintain rigid anti-mosquito sanitation within the mosquito flight range of all ports and airports;
  - Administer anti-malarial drugs to potentially infected migrants, refugees, seasonal workers, and persons taking part in periodic mass movement into malaria free areas, in special cases;
  - Malaria is under surveillance by the WHO, and is considered an essential element of the world strategy of primary health care. National health administrations are expected to notify the WHO twice a year of: originally malaria endemic areas with no present risk of infection, malaria cases imported into areas in the maintenance phase of elimination, areas with chloroquine resistant parasite strains, and international ports and airports free of malaria.

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Malaria Medicines and Treatment

- What is the best drug to take to prevent malaria when travelling to a malaria endemic area?

There are many effective anti-malarial drugs available. The CDC has a list of all endemic malaria areas and the malaria drugs that are recommended for prevention in each area. Speak to your doctor or health care provider to determine what drugs are best for you to take, based on your medical history, current health status, age, travel destination, and other factors. Some malaria drugs need to be taken a few days or weeks prior to travel to become effective and you should, therefore, visit your doctor or healthcare practitioner 4-6 weeks before travel.

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- Must a malaria patient be placed under quarantine?

No.

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- Must a malaria patient be isolated?

No.

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- What is known about the long-term effects of drugs commonly used to prevent and treat malaria?

Usually the drugs used to prevent and treat malaria have been known to be well-tolerated for at least one year or more.

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- Can blood from malaria survivors be used to make a serum?

Effective drugs are available so there is no need for a serum.

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- What drugs are used to treat malaria patients?

Quinine was first discovered in Peru about 400 years and doctors still use it today to treat severe malaria cases. Drug resistance, however, is a big problem and has contributed to the rise in malaria cases around the world. Sulphadoxine-pyrimethamine is used in many parts of Africa. Some countries still use chloroquine even though treatment failure rates are often unacceptably high. The most promising and efficient malaria treatment available to date originates from an ancient Chinese herbal remedy, *Artemesia annua*. Artemisinin-based Combination Therapies (with other drugs) are very effective at clearing malaria parasites from a patient's bloodstream.

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- Are new malaria drugs being developed?

Many academic researchers are continuously looking at new compounds and molecules that can target the different stages of the malaria parasite's development. Several drug companies, including GlaxoSmithKline, Novartis and Sanofi-Aventis, are actively researching new therapies. A private partnership between the WHO and the drug industry called the Medicines for Malaria Venture (MMV) has already isolated a variety of potential therapies that could result in new effective medicines soon.

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- Which prophylaxis should I use?

The type of prophylaxis depends on the area, local malaria species, local pattern of anti-malarial drug resistance, and personal characteristics such as allergies and contraindications (including pregnancy). Consult your doctor or health care provider about the best suited prophylaxis for you. No prophylaxis regimen gives complete protection, and malaria may be contracted despite taking prophylaxis. Malarone® (atovaquone and proguanil HCl) is a highly effective fixed-dose treatment with mild side-effects, but it requires a prescription. Mefloquine (Lariam®) is a highly effective weekly dosage prophylactic, and it also requires a doctor's prescription due to some contraindications. The

antibiotic Doxycycline is also effective and should be used when other prophylactics are unsuitable. The combination of proguanil and chloroquine is also often used; however resistance to these drugs is widespread in southern Africa. *NB – consult your doctor or health care provider first before taking any prophylaxis.*

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- Do malaria prophylactics mask the symptoms of malaria?

No. It is important to take prophylactics when going to a malaria area, especially if you have no immunity to the disease. By taking the prophylactics, the initial stages of the disease may be less severe and complications will be slower to arise, should you still get infected with the parasites. This can buy you time in which to seek medical help.

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- When should malaria be treated?

Rapid diagnosis and treatment is very important for people suspected of having malaria. The disease can progress to cerebral malaria, rapidly resulting in coma and death, within a few days. The disease should be treated as early in its course as possible, before it becomes serious or life-threatening. Several good anti-malarial drugs are available. If you feel feverish or have chills it is very important to keep malaria in mind if you are currently or have recently been in a malaria area. This will ensure that you can be tested for malaria and treated sooner rather than later.

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- What is the basic treatment for malaria?

Malaria can be treated and cured with prescription drugs. The type of drug treatment depends on the type of malaria (which species), the degree of drug-resistance, area where infection occurred, the severity of infection at the start of treatment, age of the person, pregnancy status, and personal allergies and contraindications.

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- When is malaria self-treatment recommended?

Very rarely. Travelers using effective prophylaxis but who will be traveling for a long period or who might be at greater risk of developing a malaria infection may decide to take along malaria treatment medication. This should be in consultation with a doctor or health care provider. If travelers develop symptoms of malaria, they must seek immediate medical attention and be examined appropriately. If diagnosed with malaria, they will already have a reliable supply of effective treatment medicine to take. Malaria self-treatment should start immediately if fever, chills, or other flu-like symptoms occur and if medical care is not available within 24 hours. Therefore, self-treatment of a possible malarial infection should be seen as a temporary measure and immediate medical care is important.

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- Is there a vaccine against malaria?

The search for a vaccine is considered to be one of the most important research projects in public health. Many scientists all over the world are working on developing an effective vaccine and up to date no vaccine approved for human use is currently available yet. The malaria parasite is a complex organism with a complicated life cycle. The parasite has the ability to evade the human immune system by constantly changing its surface, and the development of a vaccine against the complex *P. falciparum* parasite has therefore proven extremely difficult. With the creation of the Malaria Vaccine Initiative (MVI) has enabled massive progress towards finding an effective vaccine. Clinical trials with possible vaccines are occurring, and one candidate vaccine, RTS,S/A01, is now in a Phase III clinical trial. MVI together with GlaxoSmithKline and other partners is coordinating the third phase of testing at 11 sites in seven African countries. The latest results demonstrated that over 18 months of follow-up, RTS,S was shown to reduce by around a quarter the malaria cases in infants (aged 6-12 weeks at first vaccination) and to almost halve the number of malaria cases in young children (aged 5-17 months at first vaccination). However, even if an effective vaccine is

discovered, public health programmes will unfortunately face problems in deploying it. Anti-malarials and preventive tools will still be needed, and effective policies must be designed to ensure the vaccine reach those at risk of malaria.

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Preventive measures, avoidance and control

- How do I avoid or prevent getting malaria?

The first line of defence against malaria in endemic areas is protection from biting mosquitoes. The following measures are effective in reducing the risk of being bitten by mosquitoes:

- Avoid going out between dusk and dawn when mosquitos usually bite.
- Wear long-sleeved clothing if going out at night.
- Avoid wearing dark colours because they attract mosquitoes.
- Apply insect repellent to exposed skin (one containing DEET or dimethyl phthalate).
- Stay in a well-constructed and well-maintained building in the most developed part of town.
- Use screens over windows and doors.
- Use anti-mosquito sprays or insecticide dispensers, or burn mosquito coils at night.
- Sleep under insecticide-treated bed nets.

Prophylaxis may be prescribed to protect against clinical symptoms. Contact your doctor or health care provider about the best prophylaxis for you, but keep in mind that malaria may be contracted despite taking them. Pregnant women and parents travelling with young children should decide the importance of the trip or if the children should accompany them, especially in areas where parasites are resistant to chloroquine.

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- How do we fight malaria?

Malaria is avoidable and if treated sufficiently and quickly then it can be cured. A variety of strategies exist to prevent malaria transmission. The WHO endorses a strategy of integrated vector management (IVM) that considers local factors, including types of parasites and vectors, and climate and seasonal peaks of transmission. There are various prevention and control methods to ward off malaria. These methods either focus on the vector or on the parasite itself. Various drugs exist to treat malaria. Malaria parasites, especially in areas of sub-Saharan Africa, have grown resistant to certain cheap and previous effective such as chloroquine and Sulphadoxine-pyrimethamine (SP). The WHO therefore recommends that when the treatment failure rates exceed 10% then Artemisinin-based combination therapies (ACTs) should be used.

Resistance in vector control insecticides have been noted and new insecticides and alternative methods to insecticide usage is also being looked into to fight malaria.

Malaria education and health promotion within affected communities is important.

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- How can malaria be controlled?

Malaria control aims to prevent mortality and reduce morbidity and social and economic losses through the continuous improvement and strengthening of local and national malaria programmes. Four basic technical elements of the malaria control strategy are:

- to provide early diagnosis and quick treatment;
- to plan and implement sustainable preventive measures, selectivity based on a country's economy and needs;
- to detect early epidemics and try to or prevent them;
- to build and strengthen a country's capacity in basic and applied research to allow for the regular reassessment of a country's malaria situation and to work on safer and sustainable control strategies.

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Vector Control

- What is vector control?

In 1898, it was discovered that the female *Anopheles* mosquito was responsible for transmitting the malaria parasite. This discovery revolutionised malaria control by including the killing of the mosquito vector to help control malaria.

A variety of vector control methods exists and most of these focus on protecting inhabitants when in their dwellings because the *Anopheles* mosquito normally bites in the early evening and through the night. Most commonly used vector control methods focus on the adult phase of the vector. One of the most effective methods of vector control is the application of insecticide on the inside walls of dwellings; a method known as indoor residual spraying (IRS). Another favoured method is when a person sleeps under a bednet; either insecticide-treated nets (ITNs) or long lasting insecticide-treated nets (LLINs). Other vector control methods are used in countries around the world with varying degrees of success. These methods include larviciding (killing of mosquito larvae with insecticides), the removal of breeding grounds, drying up wetlands or pools of standing water, and the use of biological controls (i.e. fish that eat mosquito larvae).

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- What is integrated vector management?

Integrated Vector Management (IVM) is the targeted use of various vector control methods in order to reduce contact between humans and vectors in an economical and sustainable manner. Due to a variety of factors that influence the spread of malaria it would be best to apply a variety of vector control strategies to control vectors. IVM mostly involves indoor residual spraying (IRS) and the distribution of insecticide-treated nets (ITNs) or long lasting insecticide-treated nets (LLINs). Other methods could include the use of larvicides, the draining of mosquito breeding sites and the changing in irrigation practices to create fewer breeding sites, to mention a few.

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- What is indoor residual spraying?

Indoor residual spraying (IRS) is an effective tool, with twelve WHO recommended insecticides belonging to four different chemical groups. IRS involves the spraying of tiny quantities of insecticides on the inside walls of dwellings and under the eaves. Spray workers use hand held pumps, usually a Hudson pump, to apply the insecticide. Mosquitoes tend to rest on walls after their blood meal and then they absorb the insecticide through their feet. They then either die immediately or they get 'Knocked Down' (KD) and die later. Quality of spraying and high coverage is required for IRS to be effective from the start. Type of insecticide used and length of malaria transmission season will determine the number of times a home must be sprayed through the year. For example, if malaria is not transmitted throughout the year and the insecticide DDT is used then spraying need only occur once a year. This is because DDT has a longer-lasting residual effect and it is also among the cheapest approved insecticides, making it a very cost-effective option for vector control if DDT resistance is not a significant problem.

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- What is DDT?

Dichlorodiphenyltrichloroethane, commonly known as DDT, is an organochlorine pesticide. It became widely used in pest control after its insecticidal properties was noted in 1939. The discovery was hailed as a major public health achievement, which provided a cheaper way to manage major public health risks carried by mosquitoes, lice, and other vectors. DDT became an important tool for malaria control around the world, saving millions of lives. In 1972, based largely on concerns that DDT posed a threat to wildlife, the U.S. Environmental Protection Agency banned its use in agriculture in the United States. This decision lead to a decrease in the popularity of IRS prorammes amongst donors and programmes were discontinued. DDT was given an exemption for public health use by the Stockholm Treaty on Persistent Organic Pollutants (POPs) in 1999. Due to the persistent

malaria burden on sub-Saharan Africa, both the WHO and USAID reversed their longstanding policy in 2006 to support the use of DDT for IRS.
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- Does DDT used in IRS spraying programmes affect human health?

DDT is one of the most studied chemicals known to man. DDT has been used in public health programmes since the 1940s and for several decades was used very widely in agriculture; however its use remains controversial. The WHO conducts regular assessments of chemical risks in a programme known as the International Programme on Chemical Safety (IPCS). The IPCS provides the most comprehensive review of the scientific literature on DDT. The International Agency for Research on Cancer classifies DDT as a possible carcinogen, while some scientists express concern that DDT acts as an endocrine disruptor, affecting the reproductive capacity of humans and other mammals. The potential for endocrine disruption does exist but other potential sources (i.e. naturally occurring endocrine disrupting compounds in the human diet, and other endocrine disrupting compounds in the environment) must be taken into consideration when looking at endocrine disruption. There are claims that chemicals such as DDT cause declining male reproductive capacity and breast cancer, and that they are linked to a fall in sperm quality, and scientists are continuously researching this. Unfortunately the potential risks to human health from the use of DDT in malaria control must be weighed against the benefits that it brings in malaria control, and this makes the use controversial. It is therefore important to use DDT according to the guidelines as set out by the WHO while research towards safer and sustainable alternatives continues.
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- Will mosquitoes develop resistance to DDT?

Mosquitoes develop resistance to insecticides just as parasites inevitably become resistant to drugs. DDT resistance has been reported in Western- and in scattered parts of Eastern- and Southern Africa, but resistance to synthetic pyrethroids and most other insecticides have also been reported.
DDT's chief property is repellency, and therefore mosquitoes often avoid the DDT treated homes altogether. DDT is permitted strictly for public health application and its Stockholm Convention status and controversial nature ensure that its use is closely monitored whenever it is used for malaria control. Health ministries and donors/sponsors, such as the President's Malaria Initiative (PMI), increasingly monitor trends in vector resistance and will rotate insecticides when resistance levels reach critical levels.
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- Does the Stockholm Convention on POPs affect the use of DDT?

The Stockholm Convention on Persistent Organic Pollutants (POPs) allows a specific exemption for the use of DDT in public health programmes. Rules and regulations regarding the trade, storage and use of DDT, under the Stockholm Convention, could however make its use more difficult and expensive. The status of DDT in the Stockholm Convention is reviewed every three years.
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- Why not use alternatives to DDT?

Although DDT is extremely effective in malaria control and considerably cheaper than other insecticides suitable for use during IRS, alternative insecticides are used for various reasons:

  - DDT leaves white marks on walls and residents sometimes wash the walls or even plaster over the insecticide, rendering it useless;
  - Bedbugs are resistant to but are irritated by DDT, making them more active. This is unpopular with residents of DDT sprayed houses due to more bedbug biting occurring, and so alternative insecticides might be needed to control the bedbugs;

- DDT is only suitable on the walls of traditional mud structures. More western style houses with painted and plastered walls are being built these days and thus malaria control programmes will need suitable alternatives to DDT;
- In order to control for the development of insecticide resistance, malaria control programmes should use alternative insecticides either on an annual rotational basis or sprayed in a mosaic pattern. DDT will kill the mosquitoes resistant to pyrethroid insecticides and vice versa. Rotational and mosaic spraying has proved effective at controlling insecticide resistance in various parts of the world.

Good malaria control programmes should always be seeking alternative insecticides for use in IRS.

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- Are synthetic pyrethroids environmentally friendlier than DDT?

Pyrethrum is a natural insecticide derived from the chrysanthemum flower that people have used for many hundreds of years in various parts of the world. Synthetic pyrethroids are a synthetic version of this insecticide and are less persistent than organochlorines, such as DDT, and thus considered to be more environmentally friendly. Due to their shorter half-lives, these insecticides will break down faster than the alternatives and could pose less of a threat to wildlife.

Important to note is that agriculture widely uses synthetic pyrethroids so they are likely to be found in fairly high concentrations around agricultural land. Also important is that IRS for malaria control uses very small quantities of insecticides inside houses and under the eaves in a targeted way, and therefore the potential for environmental contamination is minimal.

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- If indoor residual spraying works, why doesn't every malarial country use it?

Recipient countries are not free to do whatever they want with donor funding. Although IRS is highly effective and many countries want to use it, most donor agencies have been reluctant to sanction its use. Policies have most likely been influenced by pressure from environmentalist groups, framing IRS as unsustainable or unsafe for humans and the environment. In most cases these notions have been proven false as more countries have adopted IRS programmes, which have proven to be quite successful.

More countries require funding for malaria control that gives them the independence to determine the best possible set of policies for their circumstances and not to simply adopt the policies that donors or non-endemic countries wish to force on them. The malaria control programme in each country must determine through research what would work best for their country, and unfortunately IRS may not be applicable in every situation. Countries must ensure that they have the technical capacity to run IRS programmes and use this intervention in the most appropriate settings.

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- What is an insecticide-treated net or long-lasting insecticide-treated net?

Insecticide-treated nets (ITNs) or long-lasting insecticide-treated nets (LLINs) are nets impregnated with synthetic pyrethroid insecticides that cover a person in bed, and are an effective tool for vector control. The WHO encourages pregnant women and young children, who are most at risk from malaria to use ITNs. When sleeping under the nets, the net creates a barrier between the mosquito and its intended meal, but also kills the mosquito if it lands on the net. Sleeping under an ITN or LLIN provides effective protection against malaria-carrying mosquitoes. However a person must remain under the net all night to avoid being bitten by mosquitoes, the net must not be ripped or torn, and the net must be treated with insecticide after one to two years (ITN). LLINs remain effective for four to five years. Ensuring that enough people have access to ITNs or LLINs has proven a significant challenge.

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- Why not just use insecticide-treated nets to control malaria?

ITNs are an effective tool against malaria control, but they ultimately rely upon the correct and consistent use. Relatively high prices are a problem when it comes to ITNs, but donors and governments are subsidizing or giving away freely an increasingly large proportion of ITNs. ITNs do provide good personal protection, but they require very high usage rates (above 80%) within a community to be considered an effective public health tool. Other issues that detract from ITLN effectiveness include:

- LLINs still need to be retreated periodically (after four to five years) to ensure that the insecticide is still effective;
- Torn nets are useless as protection against malaria;
- In some areas there is cultural resistance to using ITNs because people are not used to them or aware of their benefits;
- In warm climates ITNs can be uncomfortably hot to sleep under;
- It has been reported that people in Africa and India frequently use ITNs as fishing nets, which washes the insecticide off and making ineffective in vector control, and it also contaminates rivers and lakes with insecticide.

Therefore, one intervention should not be used to the exclusion of another. Malaria is complex and thus all effective interventions, as recommended by the WHO, are needed to eliminate the disease.

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Malaria and Infants, Children, Pregnancy, Preconception, and Breastfeeding

- Should infants and children be given anti-malarial drugs?

Yes, but not all types of malaria drugs. Children of any age can get malaria and any child traveling to a malaria endemic area should use the recommended prevention measures, which often include an anti-malarial drug. However, some anti-malarial drugs are not suitable for children and doses are based on the child's weight. *NB – consult your doctor or health care provider first before giving any anti-malarial drug to your child.*

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- Why is treatment important for pregnant women?

Malaria is especially dangerous for pregnant women. Pregnancy often weakens their immune systems, and the malaria parasite can be transmitted from the mother to the unborn child. Contracting malaria while pregnant greatly increases the chances of: maternal anemia, abortion, preterm birth or stillbirth, intrauterine growth retardation and low infant birth weight. Therefore it is essential that pregnant women seek treatment early in order to protect themselves and their unborn children.

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- If born in a malaria endemic country and if that person had malaria as a child, should that person worry about contracting malaria when returning to their country of birth again?

Yes. Anyone who goes to a country where malaria transmission occurs should take precautions against contracting malaria. During the time spent away from their country of birth, a person has lost any malaria immunity that might have built up over time while living in their native country. Without frequent exposure to malaria parasites, the body's your immune system has lost its ability to fight malaria and such a person is as much at risk as someone who was born in a non-endemic country. *NB – consult your doctor or health care provider about precautions to take against malaria.*

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- Is it safe if pregnant and planning on taking a trip to a malaria endemic country?

The Centers for Disease Control (CDC) advises women who are pregnant or likely to become pregnant not to travel to malaria endemic areas, if possible. Malaria in pregnant women can be more severe than in non-pregnant women. Malaria can increase the risk for serious pregnancy problems, including prematurity, miscarriage, and stillbirth. If travel to an endemic area cannot be avoided or

postponed, then an effective chemoprophylaxis regimen is crucial. However, no preventive drugs are completely effective. *NB – discuss your options with your doctor or health care provider before travelling to an endemic area.*
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- If a woman plans to become pregnant after returning from a malaria endemic, how long does it take for anti-malarial drugs to clear the body?

No evidence exist that chloroquine and mefloquine are associated with congenital defects when used for preventing malaria, and the CDC does not recommend that women planning pregnancy need to wait after using prophylaxis before becoming pregnant. However, if women or their doctor or health care providers wish to decrease the amount of anti-malarial drug in the body before conception, the following drug half-lives can be used as a guide: After two, four, and six half-lives, approximately 25%, 6%, and 2% of the drug remain in the body. *NB – consult your doctor or health care provider if you are unsure of what to do.*
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- Is it considered safe for a mother to breastfeed while taking an anti-malarial drug?

Limited data is available about the safety of anti-malarial drugs while breastfeeding. However, the amount of anti-malarial drug transferred from the nursing mother to her infant is not thought to be harmful to the infant. Some information: Very small amounts of the anti-malarial drugs chloroquine and mefloquine are excreted in the breast milk. Although there is limited information about the use of doxycycline in breastfeeding women, most experts consider it unlikely to cause any harm. No information is available on the amount of primaquine that enters human breast milk, but the mother and infant should be tested for G6PD deficiency before primaquine is prescribed to a breastfeeding woman. *NB – consult your doctor or health care provider before taking anti-malarials while breastfeeding.*
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- If taking an anti-malarial drug and breast-feeding, will the baby be protected from malaria because of the medication transferred in the mother's breast milk?

No. The quantity of drug transferred in breast milk is not likely to be enough to provide protection against malaria for the infant.
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- Can one give blood if they have been in a country where there is malaria?

It depends on what areas of that country were visited, how long ago it was visited, and if the person ever had malaria. In general, most travelers to a malaria area are deferred from donating blood for one year after their return. People who used to live in malaria endemic countries cannot donate blood for three years. People diagnosed with malaria cannot donate blood for three years after treatment, and they must have remained symptom free for that period. Blood banks follow strict guidelines for accepting or deferring donors of blood for transfusions, who have been in malaria-endemic areas. They do this to avoid collecting blood from an infected donor.
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- Wasn't malaria eradicated already?

No. **Eradication** refers to the permanent elimination of the parasite everywhere in the world. **Elimination**, on the other hand, is when pathogen transmission is declared obsolete in a specified geographical area. Malaria has been **eliminated** in many developed countries with temperate climates. The Roll Back Malaria (RBM) initiative launched its Global Malaria Action Plan (GMAP) in September 2008. The plan outlined a three-part global strategy towards global malaria **eradication**: i) reduce current malaria burden and attempt to sustain control; ii) eliminate malaria one country at a time; and iii) research new methods and develop new tools towards global control.
An **eradication** campaign was started in the 1950s, but it failed globally due to problems including insecticide resistance in mosquitoes, parasite resistance to treatment drugs, the non-inclusion of

Africa in the campaign, and administrative issues. Global malaria **eradication** cannot be achieved unless malaria elimination efforts are up-scaled in all the malaria endemic countries. It became clear from previous global malaria **eradication** attempts that, compared to other infectious diseases like smallpox and poliomyelitis, no single strategy will be relevant in the case of malaria. The target of worldwide malaria **eradication** has however been set as a feasible long term objective.
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- Is malaria airborne?

Not in the typical sense of the word. However, malaria-carrying female *Anopheles* mosquitoes fly to reach a blood source to feed on and develop their eggs. These mosquitoes are not usually found more than two or three kilometres from their breeding places, but strong seasonal winds may carry them up to 30 km from their main breeding place. At times malaria has been transmitted near airports in non-endemic areas, by mosquitoes that were carried in on aircraft coming from endemic zones.
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- Does survival confer subsequent immunity?

Only partial immunity and for a time period that depends on the intensity and frequency of prior infections. Adequate protective immunity may never build up in areas with seasonal or epidemic malaria, where disease is infrequent. In endemic areas with high levels of transmission, newborn babies are protected in their first months by the antibodies of their immune mothers. After that, if they do not die from the disease, they gradually develop their own immunity over the years. Immunity is reversible, and fully "immune" adults who leave endemic areas are known to return to a state of non-immunity over a period of one to two years. In people with sickle cell anaemia or the sickle cell trait, the abnormal haemoglobin S offers some protection against *P. falciparum* infection.
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- If a person gets malaria, will they have it for the rest of their life?

Not necessarily. Malaria is treatable. People who have malaria can be cured and all the malaria parasites can be removed from their body, if the right drugs are used. However, the disease can continue if it is not treated or if treated with the wrong drug. Some drugs are not effective due to resistance of the parasite to them. Some people may be treated with the right drug, but at the wrong dose or for too short a period of time.
Two types of parasites, *P. vivax* and *P. ovale*, have liver stages and can remain in the body for years without any symptoms If not treated, these liver stages may reactivate and cause malaria relapses after months or years with no symptoms. If diagnosed with *P. vivax* or *P. ovale*, a second drug is often prescribed to help prevent these relapses. If not treated, another type of malaria, *P. malariae*, has been known to sometimes stay in the blood of certain people for several decades. However, generally if you are correctly treated for malaria, the parasites are removed and you are malaria free.
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- If malaria can recur in a survivor (i.e. remain latent as opposed to a second infection), how does this occur? (also see previous question).

Reinfection is always a possibility in endemic areas. However, *P. vivax* and *P. ovale* can remain dormant in the liver for many months. Relapses caused by the persistent liver forms may appear months, and sometimes up to four years after exposure. *P. malariae* may be present for many years in untreated or partly treated blood infections before giving rise to a symptomatic episode, and can be carried for a lifetime. In areas with emerging drug-resistant *P. falciparum*, recurrence of the infection may occur up to a month or more after what seemed to be a successful clinical cure of the infection.
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Malaria in South Africa

- What areas in South Africa are considered malaria risk or endemic areas?

In South Africa malaria is mainly transmitted along the border areas. The three malaria endemic provinces in the country are Limpopo (northern parts), Mpumalanga and KwaZulu-Natal (north-eastern parts as far south as the Tugela River), and 10% of the population (approximately 4.9 million persons) is at risk of contracting the disease. There is no malaria in the Drakensberg, Hhluhlwe and Umfolozi Game Parks and St Lucia areas, however malaria is transmitted in the Kruger National Park (KNP). To see the latest South Africa malaria risk map click here.

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- When does the risk for malaria in South Africa increase?

Malaria transmission in South Africa is seasonal. September to May is considered malaria season in South Africa and malaria cases start to rise in October. An increase in the number of malaria cases is usually anticipated during the first quarter of the year, as summer rains occur at this time. Transmission is at its highest during warmer and wetter months of November through to April, peaking in January and February. Malaria cases start waning towards May. For May through to middle September/October, the risks of acquiring malaria are reduced. Low risk does not mean that there is no risk. Travellers going from moderate to high risk areas must make use of anti-mosquito measures and the use of malaria chemoprophylactic drugs are advised.

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- What are the common malaria vectors in South Africa?

The two major malaria vector species in South Africa are *Anopheles arabiensis* and *An. funestus*.

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- What are the common malaria parasites in South Africa?

The most common malaria parasite causing malaria in South Africa is *P. falciparum*. It is potentially the most dangerous type of malaria, and is rapidly fatal. A small unknown percentage of malaria is caused by the *P. vivax* parasite.

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- What is the South African government doing to eliminate malaria in the country?

The South African government is working towards elimination of malaria within the country by the year 2018. Malaria elimination involves the systematic process of developing strategies and ensuring their robust implementation. The government has completed the first phase of elimination that consisted of a programme review, the development of an elimination strategy, an implementation plan, and a monitoring and evaluation plan. The country is currently busy with the second phase, which involves the robust implementation of the interventions detailed in the strategic plan, and monitoring its progress towards achieving the goal of malaria elimination.

South Africa has been making use of IRS in its national malaria control programme (NMCP) and the WHO has authorised the use of DDT for this purpose. There is pyrethroid resistance in certain parts of South Africa and in the late 1990s it led to one of its worst regional epidemics ever. No ITNs or LLINs usage is recommended in the NMCP. Larviciding does occur in selected areas in some of the endemic provinces. Malaria diagnosis and treatment with Artemisinin combination therapy (ACT) is free in the public sector. G6PD testing is a requirement before treatment with primaquine may occur. A system for monitoring of adverse reactions to anti-malarials does exist. The prophylaxis mefloquine, doxycycline or atovaquone proguanil are recommended for use in areas where indicated.

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Sources

Compiled from sources *~ last accessed in November 2015*

Africa Fighting Malaria www.fightingmalaria.org/index.html
Centres for Disease Control and Prevention (CDC) http://www.cdc.gov/malaria/about/faqs.html
Roll Back Malaria http://rbm.who.int/malariaFAQ.html

South Africa malaria sources *~ last accessed in March 2016*

South African National Travel Health Network:
- ~ Malaria advice for travellers http://www.santhnet.co.za/index.php/advice2travellers
- ~ Malaria advice for travellers in SA http://www.santhnet.co.za/index.php/advice2travellersSA

Department of Health:
- ~ Treatment advice http://www.health.gov.za/index.php/malaria-prevention-treatment-advice
- ~ General malaria in South Africa information http://www.health.gov.za/index.php/introduction

Department of Health, Province of KwaZulu-Natal http://www.kznhealth.gov.za/malariainfo.htm
World Health Organisation report for 2014 http://www.who.int/malaria/publications/world_malaria_report_2014

Additional sites to visit or alternatively visit the Links page on the UP ISMC website

South African National Travel Health Network:
- ~ Malaria factsheet http://www.santhnet.co.za/index.php/factsheet
- ~ Malaria drug list http://www.santhnet.co.za/index.php/druglist

***Disclaimer:** The information provided in this document is a compilation of questions and answers obtained from different sources (sources are supplied) and in cases where treatment measures are mentioned, remember to always consult with your doctor or health care provider first to determine what would best work for you in your situation. The UP ISMC is a research organisation that focuses on malaria-related research, within a tertiary institution, supplying malaria facts towards health promotion, and may not be held accountable for any issues that may result due to any parties practising treatments mentioned within these FAQs.*

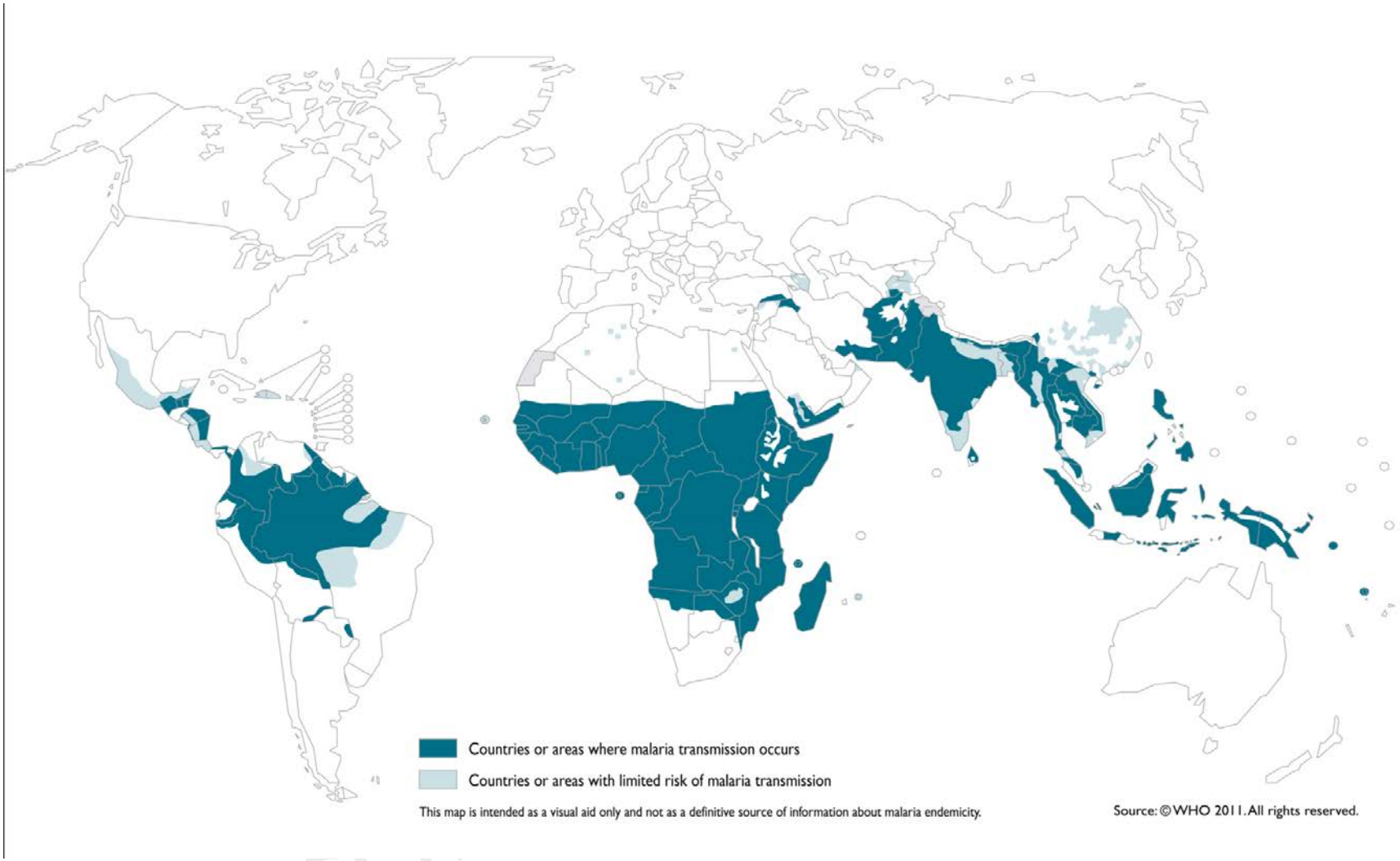

Figure 1: *Countries or areas at risk of transmission in 2010* http://www.who.int/ith/en/

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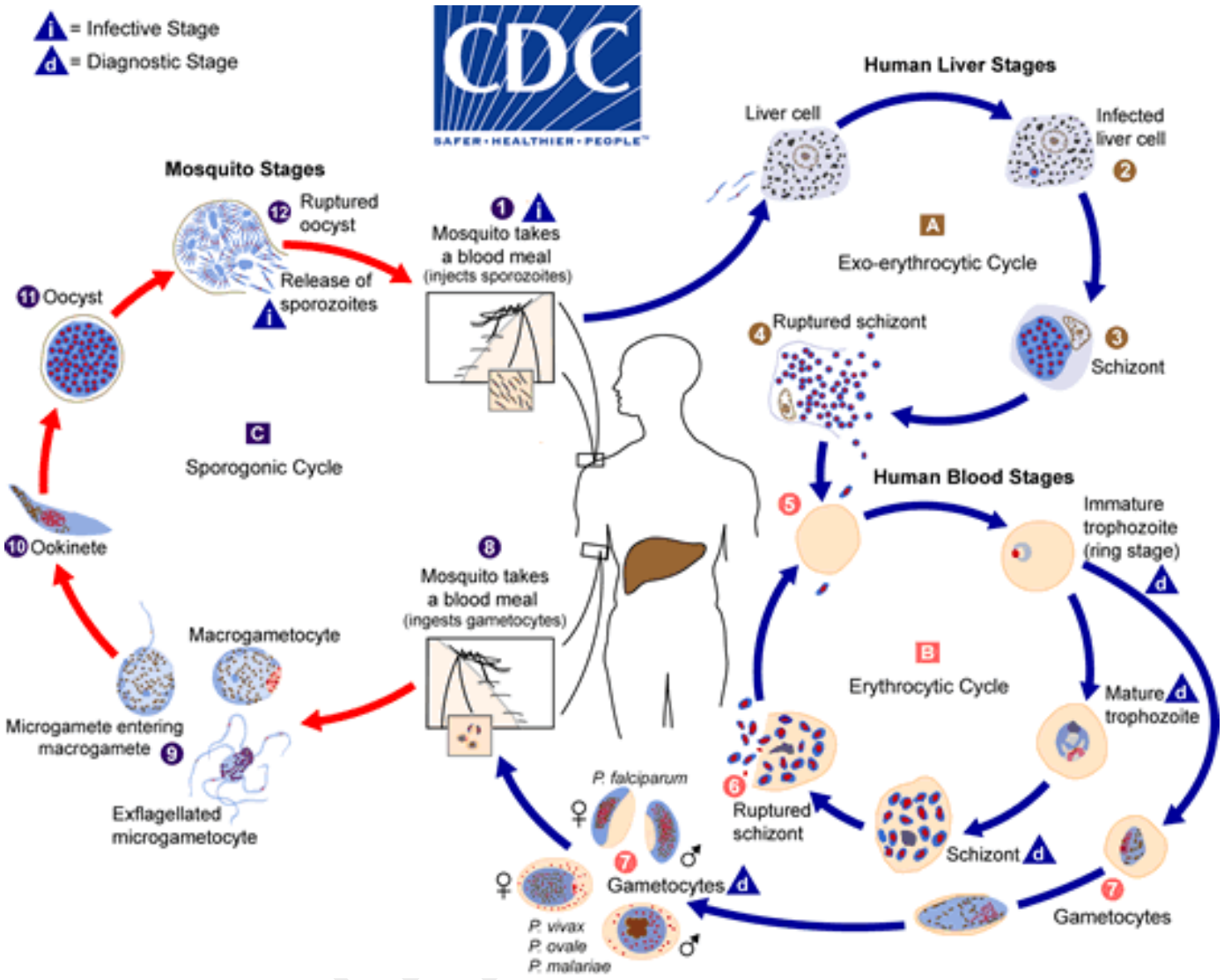

Figure 2: *The complex life cycle of the malaria parasite, taken from the Centres for Disease Control and Preventions website http://www.cdc.gov/malaria/about/biology/.*

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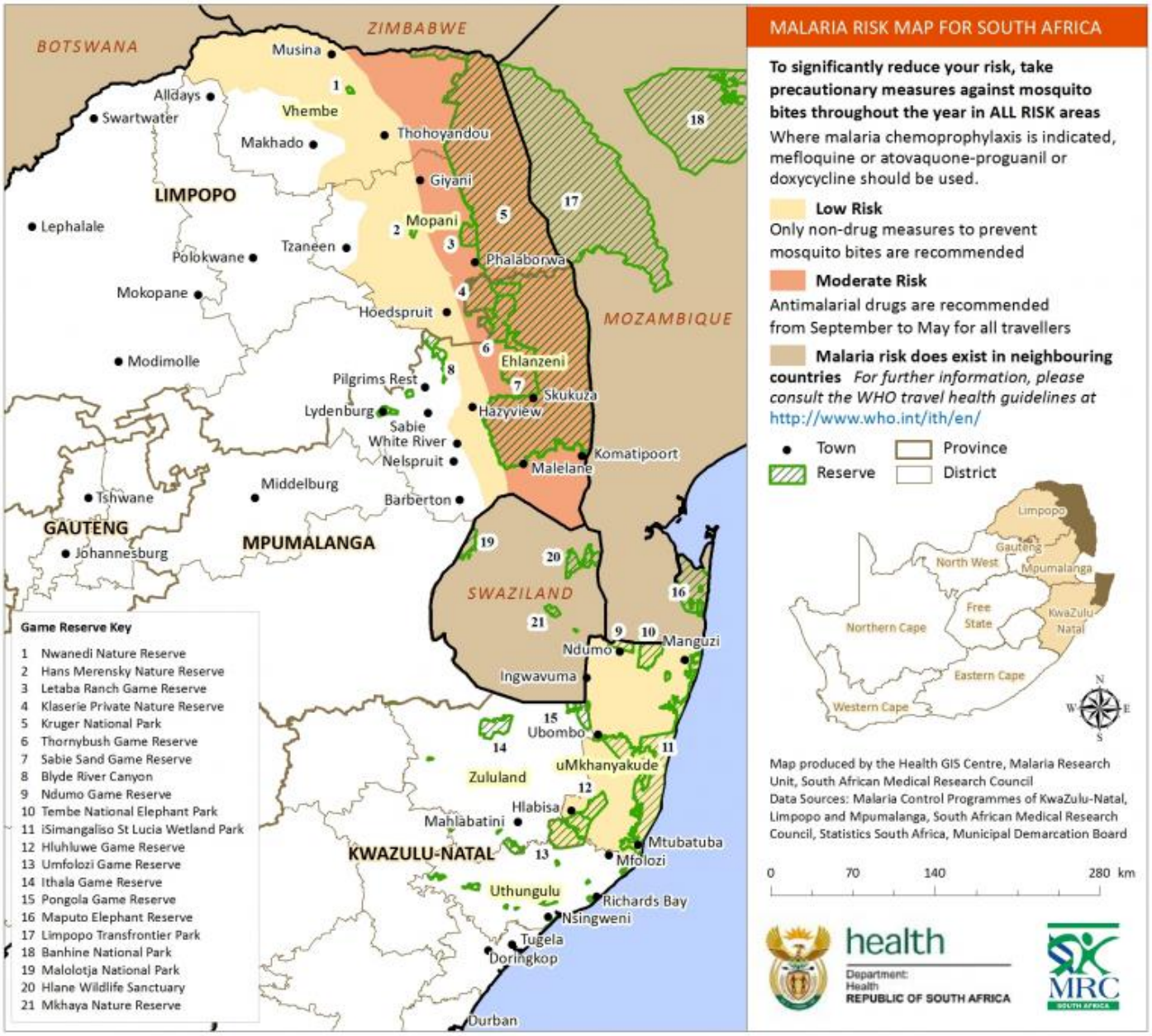

Figure 3: *The South African malaria risk map as released by the Department of Health. Map produced by the Health GIS Centre, Malaria Research Unit and South African Medical Research Council.*

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