Poverty 423

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Malaria as a cause of poverty: poverty as a contributor to malaria

Introduction

Most people in the developed countries have heard of malaria. We know it can cause

serious health consequences. However, most of us have limited knowledge of harms

inflicted by it upon developing countries and their citizens. It affects many as it severely

burdens these countries socially and economically. Many people, especially those who

are poor and weak, die from malaria every year and even more people get sick. The

countries lose productivity and expend more resources to combat it. Most of the malaria-

stricken countries are poor and lack capabilities to effectively combat it; thus, they

struggle to improve their current situations. Malaria is primary a disease of developing

countries. It exists in most of the tropical countries although it affects some areas more

severely than others.

In order to control malaria, we need to have a better cooperation among

developed and developing countries. Joel G. Breman, the director of the International

Training and Research Program in Emerging Infectious Diseases at National Institute of

Health, argues that this cooperation should certainly involve scientific research to create

better medicines, especially a vaccine (Breman), but I think it should not stop with

science and technology. It should extend to political, social, and economic areas and

should lead to better structure of governments and stronger economies. The governments

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of developing nations can become capable of implementing effective policies through political and social development. These policies should include appropriate personal protection, education, active community involvement, and improvement of living standards in general.

## History of malaria

**Early days**: Malaria comes from Italian words *mala* and *aria* which means "bad air". People have known about malaria for centuries; though they did not necessary differentiate it from other fevers. Greeks and Romans have recorded cases and later European documents describe occurrences of malaria, especially in the Mediterranean, throughout recorded history. Some people started to study it as a specific disease of its own in the 17th century as they found an effective treatment from cinchona tree bark, a native plant in Peru. We have more records on malaria cases outside of Europe becasue many colonies were established in the tropics where malaria was rampant. The modern understanding of malaria begun in the end of nineteenth century due to the discovery of causal parasites and mosquitoes as the medium of infection. More understanding of malaria led to a more aggressive measure of control (The Cambridge World History of Human Disease).

**Progress:** In the 1930s, researchers developed synthetic antimalarials that treat as well as prevent it. Scientists developed a residual insecticide, DDT, in the 1940s. By the early 1950s countries such as Italy, Venezuela, and the US attempted to eradicate malaria with the use of insecticide and medicine. In 1955, the World Health Organization (WHO) committed to malaria eradication and supported many countries' eradication programs

financially and technically. By the end of 1970s, these campaigns eliminated malaria in the areas with hundreds of millions of people, but malaria persisted in many other areas and forced changes in campaigns from aiming to eradicate malaria to managing malaria (The Cambridge World History of Human Disease). North America and Europe had successfully eliminated malaria. Their success may have contributed to this stagnation in malaria eradication because the developed countries lost motivations once they have solved their own problem; between 1975 and 1996, out of 1,223 new drugs developed, only 3 were antimalarial drugs. Due to this lack of effort from developed countries, the ex-colonies developing countries' malaria campaigns collapsed (Greenwood and Mutabingwa). The World Health Organization refers to the collapse of anti-malaria campaigns as one of the main reasons for recent increases in malaria cases. Other reasons include malaria drug resistance, failure of local healthcare, and insecticide resistant mosquitoes (WHO 2005). We will look into these contributors to the resurgence of malaria cases below.

Many developing nations and their citizens still suffer from malaria. The World Health Organization estimates that malaria caused more than 1.1 Million deaths in 2002. The majority of these victims are children under the age of five. We can prevent and cure this disease with our knowledge and technology, yet the poor nations have failed to prevent or treat it because of lack of will or capability. Sub-Saharan Africa carries the heaviest burden. More than 85 % of deaths from malaria occur there. Malaria is less rampant in other regions of the world as 8% of the deaths occur in Southeast Asia, 5% in the Eastern Mediterranean region, 1% in the Western Pacific, and 0.1 % in the Americas (The World Bank 3). The battle to eradicate malaria has achieved successes in more

temperate developing countries and failed in poorer tropical developing countries. The

citizens of developed nations live without terror of malaria and those who live in

developing nations still struggle to deal with the scope of the problem.


<center>Current health situation</center>

**Effects of malaria**: The effects of malaria are multidimensional. We tend to focus on lost

human lives, but the consequences reach far beyond the deaths toll (figure 1). This
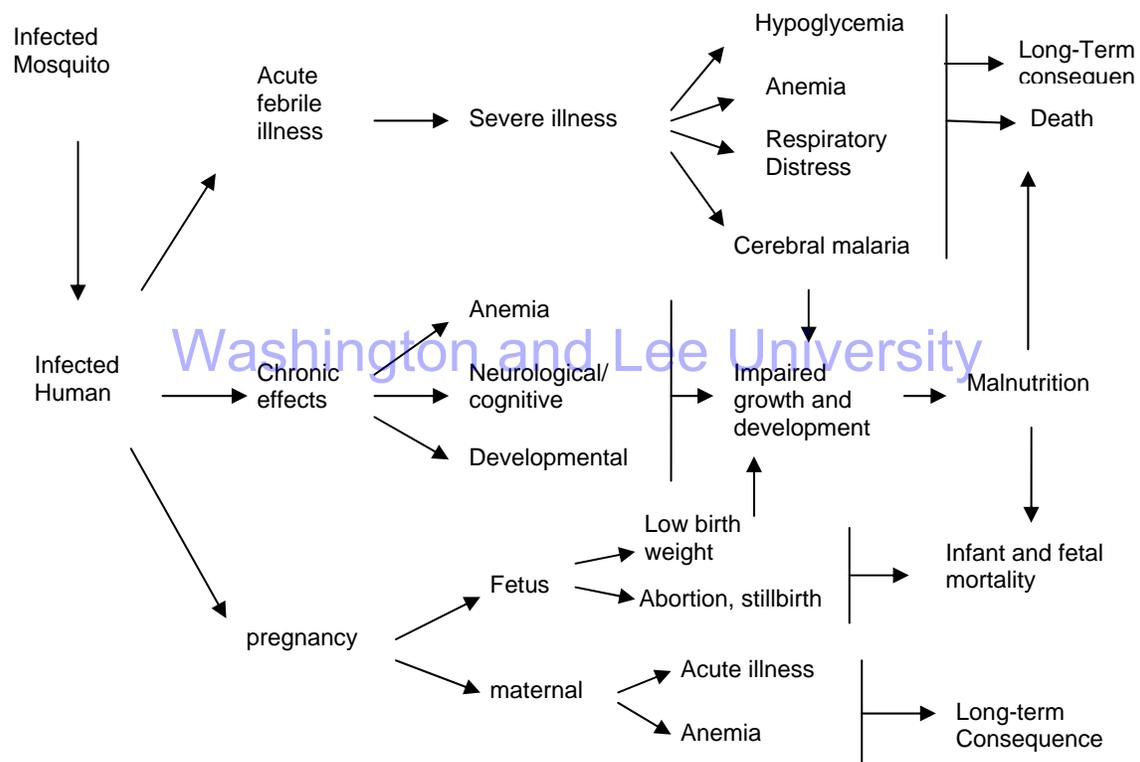
Figure 1. Malaria burden manifestation (Breman, Alilio, and Mills).

figure shows the different physical effects malaria can have. It shows three categories:

acute, chronic and pregnancy. Each categories have different consequences ranging from

death and long-term consequences to impaired growth resulting from the damage caused

by malaria (Breman, Alilio, and Mills). Malaria generates huge economic loss from lost

productivity. It may even influence peoples' behaviors (Sachs and Malaney).  We have

some difficulty comprehending just how much malaria affects people because many of the malaria endemic countries have poor surveillance and we cannot accurately know the full effects of poverty.

**Consequences**: Malaria causes problems worldwide. According to the WHO, at least some parts in 107 countries and territories had risk of malaria transmission in 2003 (figure 2). Up to 3.2 billion people are at risk. WHO estimates about 350-500 million clinical disease cases every year (WHO 2005). According to another estimate, malaria
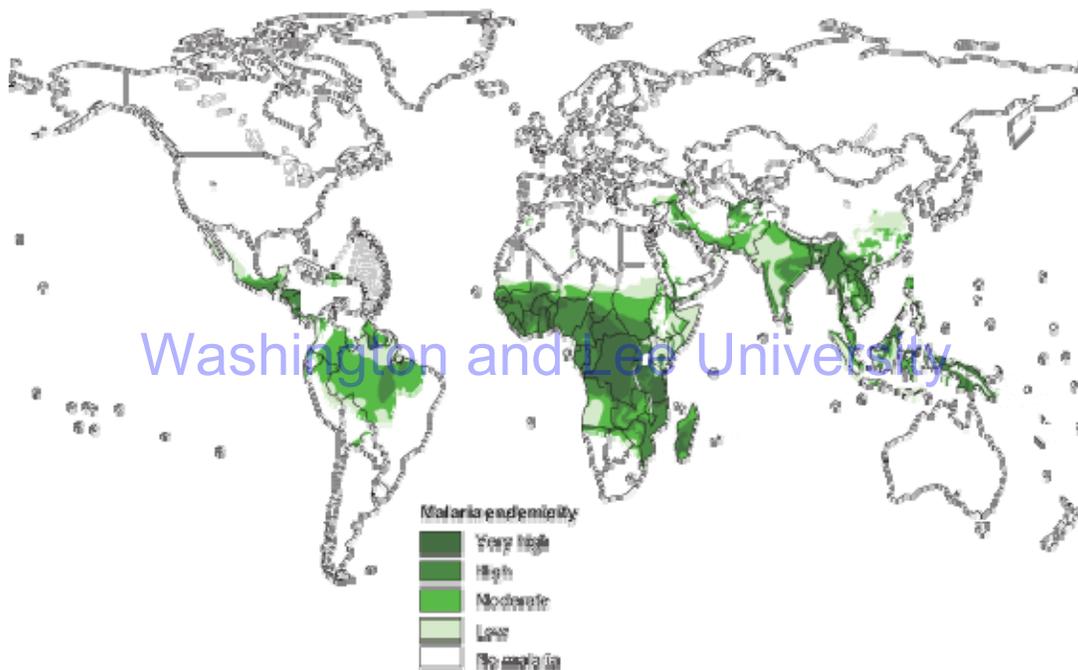
Figure 2. Global distribution of malaria transmission risk in 2003 (WHO 2005).

treatment occupies up to 40% of budgets for health and between 20-50% of hospitalizations in the countries severely affected (The World Bank 15). It especially affects children; every 40 seconds a child dies of malaria. It ranks in the top three most deadly transmitted diseases worldwide (Sachs and Malaney). According to some studies, the future does not look promising. Many environmental factors such as global warming, intensified El Nino cycles, breakdown in the healthcare systems in some poor countries,

changes in agriculture, deforestation and the increasing resistance of the malaria parasites to current medicine could contribute to sharp increase in the number of malaria cases in some parts of the world (WHO 2005; Casman and Dowlatabadi). We will address these factors individually in depth below.

In addition to costing lives, malaria creates huge economic cost and loss. Where we find high incidences of malaria, we find concentrated poverty (Fig. 3 and 4). The
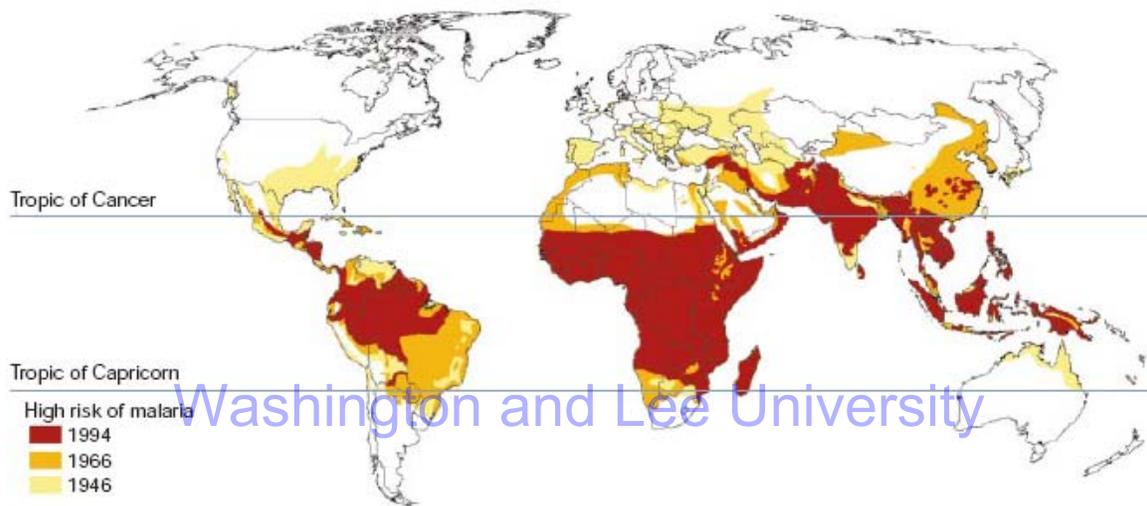


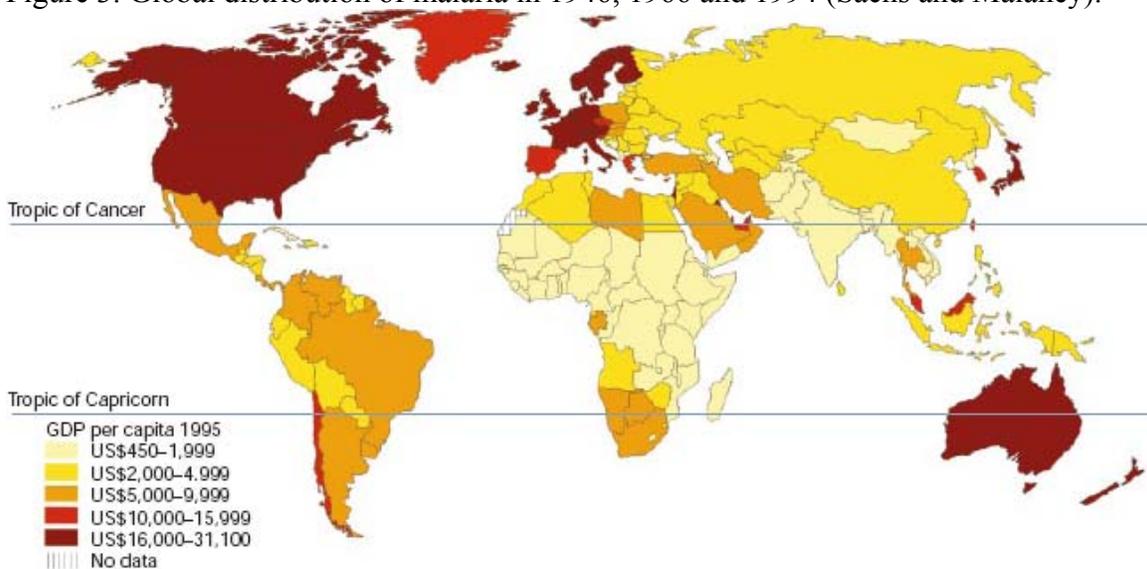Figure 3. Global distribution of malaria in 1946, 1966 and 1994 (Sachs and Malaney).



Figure 4, Global distribution of GDP per capita. Tropical regions have the lowest average (Sachs and Malaney).

average GDP per capita of countries that have significant amount of malaria was $1,526 and that of countries without intensive malaria was $8,268. Countries with malaria have a lower rate of economic growth. Between 1965 and 1990, countries with malaria had 0.4% GDP growth per year; the countries with little or no malaria had 2.3% (Sachs and Malaney) Another study shows that 3 out of 44 countries that suffers from high malaria risk have lower than average income per capita while the richest 31 counties are considered malaria free (Gallup and Sachs).

Although poverty does not cause malaria directly, it plays a big part in keeping poverty stricken countries severely affected by it. The poorest countries do not have sufficient capital to provide adequate preventions such as mosquito nets and insecticides. When the countries such as the US, Italy, Greece, and Spain successfully eliminated malaria, both socioeconomic development and active anti-malaria interventions by the government played a huge part. Poor nations typically lack both making them more vulnerable to malaria.

Malaria also places a significant economic burden on the countries affected. Studies estimate the economic cost as the sum of medical expenditures and the lost income. Private medical expenditures covers the cost of prevention, diagnosis, and treatment. Public medical expenditures cover the government spending on healthcare and education. Lost incomes are calculated by multiplying work days lost and incomes that could have been earned by the people affected by malaria (Sachs and Malaney). The economic losses affect the people in the lowest economic brackets the most. We must consider non-economic factors into account. One major factor is forced behavioral changes on the people who live in areas with high rate of transmitting. Malaria accounts

for about 25% of mortality in children between birth and age four. High mortality rates tend to cause high fertility rates as well. High fertility rate in poor households means that each child has fewer resources and thus are likely to have less education available. On top of this, children in endemic areas miss considerable portion of school days due to the disease. These factors contribute to lowering the human capital, a key factor in economic growth.

Another factor that has tremendous importance in economic growth is trade and foreign direct investment. Investors from non-malarious regions tend to avoid malarious regions for fear of contracting the disease. This fear is not farfetched as a London-based mining company, Billiton, invested $1.4 billion and built a factory complex in Mozambique. In two years, the company had 7000 cases of malaria among its workers and even 13 British workers died (Sachs and Malaney). These costs prevents poor countries from developing; thus, they are caught in a vicious spiral of increasing malaria cases and economic burdens.

**sub-Saharan Africa**: The burden of malaria is not equally distributed geographically. Africa, especially sub-Saharan Africa has most severe consequences. The current situation particularly looks grim for Africa. WHO estimates 66% of African population faces risk of malaria. Ninety three percent of malaria cases are caused by the more severe parasite, *Plasmodium falciparum* (We will discuss different strains of the parasites below). Africa accounts for 89% of the total mortality caused by malaria. Malaria causes about 20% of the deaths in African children under five years old. It also affects unborn infants through infection of pregnant women. Anemia, low birth weights, and premature delivery caused by malaria result in 75,000-200,000 infant deaths per year (WHO 2005).

Africa loses up to $12 billion in GDP from the effects of malaria (Financial Mechanisms

for Malaria). African countries are generally hard hit by the economic loss (Table1)

(Sachs and Malaney). Malaria has decreased the economic growth rate by 1.3% a year

| Country | Aggregate loss (PPP-adjusted US$ million)* | Per person loss (PPP-adjusted US$)* | Fraction of actual 1995 income |
|---|---|---|---|
| Benin | 1,172 | 214 | 18% |
| Botswana | 503 | 347 | 5% |
| Burkina Faso | 1,684 | 162 | 18% |
| Burundi | 730 | 117 | 18% |
| Cameroon | 4,227 | 318 | 18% |
| Central African Rep. | 884 | 270 | 18% |
| Chad | 995 | 154 | 17% |
| Congo | 759 | 288 | 18% |
| Congo, Dem. Rep. | 7,125 | 162 | 18% |
| Côte d'Ivoire | 4,107 | 294 | 18% |
| Gabon | 1,389 | 1,290 | 17% |
| Gambia | 251 | 226 | 18% |
| Ghana | 5,355 | 314 | 18% |
| Guinea Bissau | 152 | 142 | 14% |
| Kenya | 5,272 | 198 | 18% |
| Lesotho | 0 | 0 | 0% |
| Madagascar | 2,280 | 167 | 18% |
| Malawi | 1,072 | 110 | 18% |
| Mali | 1,222 | 125 | 17% |
| Mauritania | 611 | 269 | 15% |
| Mauritius | 0 | 0 | 0% |
| Namibia | 832 | 539 | 10% |
| Niger | 1,457 | 161 | 17% |
| Nigeria | 17,315 | 156 | 18% |
| Rwanda | 656 | 102 | 18% |
| Senegal | 2,426 | 286 | 18% |
| Sierra Leone | 366 | 87 | 17% |
| South Africa | 4,056 | 98 | 1% |
| Togo | 1,166 | 285 | 18% |
| Zambia | 1,359 | 151 | 18% |
| Zimbabwe | 4,214 | 383 | 18% |
| Total | 73,638 | 185 | 10% |

*Figures are reported in US dollars held constant at 1987 prices and are adjusted for purchasing power parity (PPP), that is, for differences in the local purchasing power of the currency with respect to a fixed market basket of goods and services.

Table 1. Estimated economic growth loss between 1980-1995 caused by malaria (Sachs and Malaney).

in African nations. The burden falls heavy on the citizens of these countries. In Ghana, the healthcare cost to treat malaria may occupy up to 32% of the household income (Financial Mechanisms for Malaria).

Determinants of malaria:

Africa, especially Sub-Sahara Africa, seem to have all the right ingredients to form breeding ground for malaria. Many determinants affect the prevalence and severity of malaria. A type of parasite called *Plasmodium* causes malaria. Different types of parasites cause different severity of malaria. These parasites need a vector, specific kinds of mosquitoes that can accommodate the parasite, to infect people. Not all types of mosquitoes can transmit the parasites and the mosquitoes have different rates of transmission. In some regions of the world, people have developed genetic variations that make them less susceptible to infection. Many adults who live in endemic areas develop partial immunity to malaria through constant exposure to infection. While the partial immunity protects the person from severe complications, the parasite remains in the body at a lower concentration. This partial immunity leads to weaker resistance against other illness.

The environment affects malaria as well. Warm climate and availability of water contributes to the longevities of mosquitoes and the parasites. We have little control over these determinants since they concern natural causes. We can control other determinants; the educational, social, political, and economic institutions affect the severalty of malaria. Adequate knowledge about malaria, a social structure that allows fast intervention, and the financial ability to support good policies would help these countries to deal with

malaria and control it (Breman). We will explore these determinants of malaria,

specifically, the parasite, mosquito, human, environment, and social, economic and

political factors.

**Malaria parasites**: Four types of *Plasmodium* cause malaria in humans: *Plasmodium*

*falciparum*, *Plasmodium vivax*, *Plasmodium ovale*, and *Plasmodium malariae*. All of

them have two-phases, sexual and asexual. In a female *Anophela* mosquito, they have a

sexual (sporogonic) phase during which they multiply and migrate to the salivary glands

of the mosquito to infect more vertebrate organisms. In a vertebrate host, they take an

asexual (schizogonic phase) phase during which they infect liver cells and multiply there

until they move into the blood and infect and destroy the red blood cells (figure 5) (The
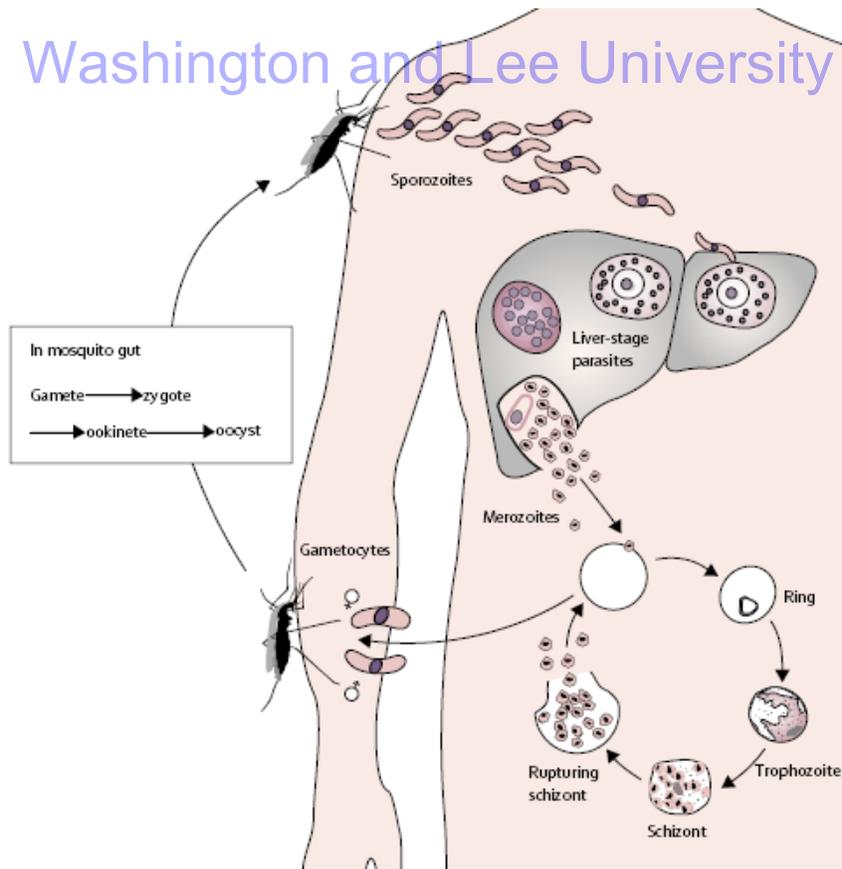
Cambridge World History of Human Disease).



Figure 5. Malaria parasite cycle (Greenwood at al ).

The Cambridge World History of Human Disease describes typical symptoms of a malaria attack:

> The classical malaria paroxysm is initiated by a chill, lasting up to an hour and often accompanied by headache, nausea, and vomiting. The chill is followed by a period of spiking fever lasting several hours. The subsiding fever is accompanied by sweating, often profuse.

As the disease progresses, the attacks occur more frequently. Attacks from *P. malariae* occurs about every 72 hours and attacks from other species occurs about every 48 hours. Infections by *P. falciparum*, can lead to severe complications as this parasite can destroy much of the Red blood cells and occlude capillaries in most of the organs (The Cambridge World History of Human Disease). Though all of them cause malaria, they all have differences. *P. falciparum* is the most prevalent in the world, particularly in sub-Saharan Africa and Southeastern Asia to some extent, and the most dangerous because infection by it can lead to complications and death (figure 6) (WHO 2005).
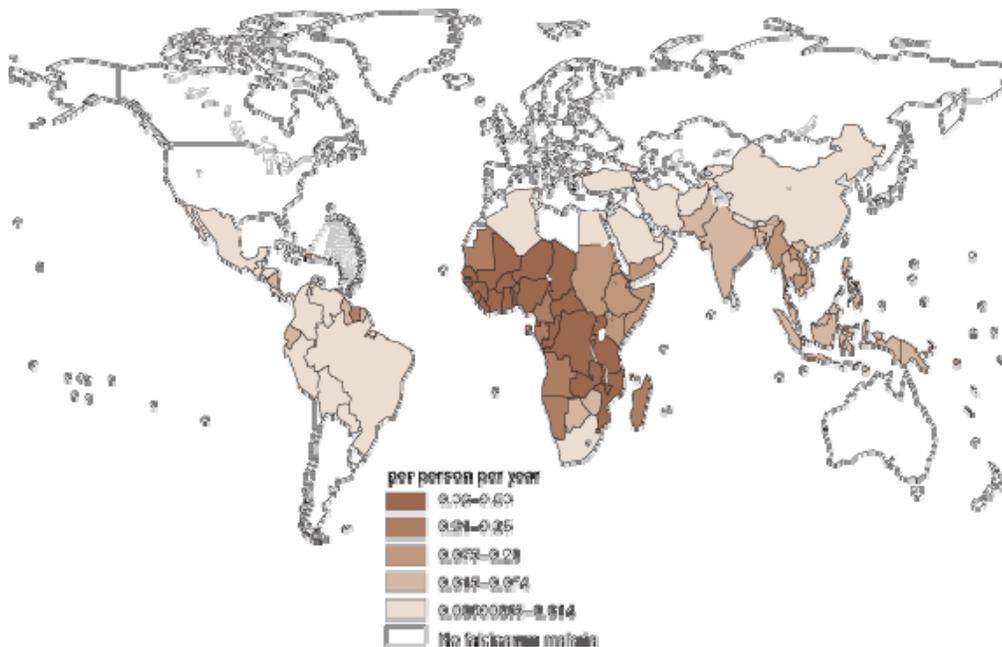


Figure 6. Extent of *P. falciparum* infection (WHO 2005).

On the other hand, *P. vivax*, *P. ovale*, and *P. malariae* are benign malarias and rarely fatal (White). *P. vivax* constitutes the second most common cause of malaria and it is most prevalent in Asia and parts of Americas (WHO 2005). It and *P. ovale* cause relapses. *P. malariae* can cause renal complications and can stay in the body for a long time if it is untreated. For the past twenty years or so, these parasites have become increasingly resistant to the drugs making treatment more difficult (Breman). (We will discuss drug resistance below).

**Malaria vectors**: About 60 species of *Anopheles*, a type of mosquitoe, can transmit malaria. Thirty of them have major importance in transmission. The amount of transmission relates directly to the number of the vector present. Different species of mosquitoes have different feeding habits, blood meal preference (e.g. does it prefer human blood or other animal blood?), and the lifespan. *Anopheles gambiae* and *anopheles funestus* have the highest efficiency of transmitting *p. falciparum* parasite (Breman). Sub-Saharan Africa is home to *Anopheles gambiae*, a long-lived mosquito that feeds primary on humans. About 1-5 % of them can transmit the parasite and several hundred mosquitoes collect in a room overnight. We can easily imagine the difficulty of preventing transmission. Some countries have achieved malaria eradication using insecticides such as DDT. The effectiveness of the insecticides have decreased as some species have acquired resistance to insecticide making them difficult to control (The Cambridge World History of Human Disease).

**Human factors**: People in the malaria-stricken areas have developed genetic variations that make them less susceptible to infection by the parasites. We know that Sickle cell mutation of red blood cells(RBC) alter the structure of the RBC so that the parasites

would have difficulty multiplying inside RBC. It is not the only genetic mutation that reduces the risk of malaria (Breman). Absence of Duffy blood factor, some protein on the surface of red blood cells, prevents the *P. vivax* infection completely because *P. vivax* needs Duffy blood factor to infect red blood cells. Since, over 90 percent of sub-Saharan African population lack the Duffy factor, *P. vivax* does not exist in most of the area. Other conditions that could prevent severe disease have been identified. The list includes, Hereditary ovalocytosis (change in the shape of red blood cells), β and α thalassemia (also deformed red blood cells), and glucose-6-phosphate dehydrogenase deficiency (Breman). While these genetic mutations give people some advantages against malaria, the immune system also plays a large role. Researchers have found antibodies for different forms of malaria parasites. But this immunity (also called premonition) provides only partial protection. While the adults with immunity can function normally in the society, they still have some parasites in their bodies. As the result, the body's resistance towards other diseases decreases due to the consistent exposure to the parasite. Children lack these partial immunity making them more susceptible to malaria (The Cambridge World History of Human Disease). Many scientists have tried to develop malaria vaccines and the future looks hopeful. Thirty five malaria vaccines are currently in clinical development (Breman, Alilio, and Mills). (We will discuss the vaccine development below).

**Environmental factors**: Malaria parasites need mosquitoes to infect people. Therefore, the parasites can only infect people in a warmer areas with heavy rainfall and high humidity. Mosquitoes need surface water to breed. Human engineering projects, such as irrigation systems and dams can cause more malaria because of increase in the breeding

ground (Breman). Malaria parasites engage in life phase change inside the vector mosquito; the speed or initiation of the phase changes depending on the temperature. They stop developing below 16 ºC (The Cambridge World History of Human Disease). This is the primary reason why malaria mostly harms tropic nations and persists in the tropics. The global warming casts some uncertainties of malaria in the future. The climate changes may lead to increase in malarial areas (Casman and Dowlatabadi).

**Economic, social, and political factors**: Developed countries no longer suffer from malaria. At the international level, economic state of countries affect how well they can cope with malaria. The countries that cannot effectively deal with malaria slip further into poverty. However, high-income level alone does not lead to eradication of malaria by itself. Oman has an income per capita of $10,000, but suffers from severe malaria (Gallup and Sachs). The amount of wealth plays a large part but the capacity of governments also plays a large part in determining how well the country deal with malaria.

For individuals, socioeconomic levels seem to have less bearing in the risk of infection by malaria. Some studies concluded that in African nations, difference in socioeconomic level did not affect the likelihood of sever malaria, anemia, and reinfection (Breman). The calculated risk of acquiring malaria may not differ much between different socioeconomic levels, but wealthier households have more capacity to deal with malaria (Onwujeke at al).

We need to have more information to see the effectiveness of present malaria control measure. To gain more accurate information, better social structure is absolutely necessary (Breman). Acquisition of more accurate information becomes crucial because different areas (e.g. different parts of sub-Saharan Africa) have different prevalence of

malaria and determinants differ from one place to the other. We need to study different

areas in their own light to accurately analyze the area's needs and provide for them

(Breman).

**Interventions**: Personal protection, drug use, and vector control constitute the core of

interventions. Personal protection here refers to use of mosquito nets and other tools.

Drug use means that people have access to the effective drugs and use them correctly.

Vector control means using insecticides and other means to reduce the number of the

mosquitoes. Precise and effective combination of these interventions would decrease the

mortality from malaria. It would still be a difficult task to control malaria even with these

interventions; these interventions cannot cover all aspects of malaria; they are hard to set

up and maintain; and malaria parasites can acquire resistance to medicine. The ultimate

hope to overcome malaria is in vaccine development or genetically engineering

mosquitoes so that they do not transfer malaria (Breman). While I agree, other factors

such as education of the people, establishing better healthcare systems and better

governance need to be improved at the same time. Education can provide correct

information about malaria and help people to be more aware of malaria. Better healthcare

system would allow more accurate diagnosis and adequate treatment. Better governance

would help the countries to commit to malaria control campaigns.


Management

Countries affected by malaria have different strategies to combat it. These strategies

complement each other. For example, The choice of drugs for treatment is important but

when the healthcare and treatment providers have incorrect knowledge of the drug or the

patients do not understand the proper course of treatment, then drugs are less effective

(Bloland). Countries can only achieve effective management when they can diagnose

malaria accurately; provide effective drugs to people; educate healthcare providers and

patients; commit to financing and distributing necessary medicine and other supplies such

as insect nets; and monitor the effectiveness of their strategies.

**Diagnosis**: Proper treatment of malaria starts from proper diagnosis. Many people in the

developing countries lack access to malaria laboratory confirmation. Diagnosing malaria

without a lab test can be difficult be cause it has multiple symptoms (McCombie 1996).

For example, presence of fever is a typical symptom of malaria but it can be caused by

other sickness just as easily. The accuracy of diagnosis without a proper test is between

20-60% (Guerin et al). Microscopy tests are the standard procedure for malaria

confirmation. The magnification of 1000 is used in the tests (White). This method has

very high sensitivity (20-50 parasites per μL) but the diagnosis is not always easy. In a

low-transmission area, presence of parasites means that the patient has malaria and the

symptoms are caused by malaria. However, in a high-transmission area, most of the

people have partial immunity (which mean they have low amount of parasite in their

blood at all time but they have no symptoms). In this case, the presence of malaria

parasite does not prove that the parasites are causing the sickness. In the high

transmission areas, the tests must detect more than the threshold count (about 10,000

parasites per μL) of parasites. Therefore, the appropriate sensitivity of the test must be

administered (Guerin et al). Local understanding of malaria can play a large part in

diagnosis. A study conducted in Liberia showed a correlation between traditional

understanding of malaria symptoms and the test results. Another study in Sri Lanka

showed that less than half the people receiving treatment at hospitals did not realize they had malaria (McCombie 1996). Another paper reports that uncomplicated malaria is widely recognized as a common febrile sickness that can be treated at home using traditional or antimalarial medicine (Williams and Jones). Some papers show that the many of the malaria cases lack proper diagnosis but the people normally have access to antimalarial medicine either from pharmacies, hospitals and clinics, or neighbors and friends. While having widespread access to medicines is a good thing; but it is less effective without proper diagnosis (Guerin et al; McCombie 1996; Williams and Jones). Many clinics in developing countries need microscopes or other methods of diagnosis and personal who can are knowledgeable to diagnose malaria and provide adequate treatment.

**Drugs**: Drugs can be used to treat and prevent malaria. While some drugs are used to prevent malaria for tourists and visitors, preventive drugs are only used for protection of pregnant women and infants in the areas with high malaria transmission (Greenwood and Mutabingwa). The treatment of malaria relies heavily on anti-malarial medicine. Many class of anti-malaria medicine have been discovered or synthesized. The first anti-malarial medicine was Quinine, which comes from *Cinchona* tree bark and led to a class of drugs related to it called quinolines (also know as 4-aminoquinolines). Quinine had been the drug of choice, but it had strong toxicity and it needed to be administered three times a day for seven days (Ridley). The use of Quinine is less common today, but it still remains useful in treating severe malaria (Robert at al). The discovery of the chemical structure of Quinine led to the development of fully synthetic related drugs such as Chloroquine (CQ) and Amodiaquine. CQ costs less and needs only three days of

administration; it has been widely used around the world. This widespread use of chloroquine has led to the rise of chrloquine resistant parasites, making it ineffective (Ridley).

In Asia, chloroquine resistance in *P. falciparum* was suspected as early as 1950s. In 1999, *P. falciparum* had 100% resistance to chloroquine in Thailand. In sub-Saharan Africa, the parasites resistant to chloroquine have spread during 1980s. South America faces a similar situation with chloroquine resistant parasites (Guerin). Amodiaquine had been used extensively but it has high toxicity to the liver and its use has been limited (Robert at al). Mefloquine (commercially know as Lariam[®]) and Halofantrine are newer quinoline medicines that can work on chloroquine resistant malaria parasites but the resistance can develop rapidly in these drugs as well (Ridley). Mefloquine can sometimes cause side effects such as nausea, weakness, clouding of consciousness, and nightmares. More sever neuropsychiatric reactions have been reported to 0.5 to 1% of Europeans and Africans and about 0.1 % of Southeast Asians (White). Mefloquine has a long half-life time of two to three weeks. A half life is the time it takes for the body to metabolize half of the initial chemical intake. This long half life probably has enabled the parasites to gain resistance to this drug. Because of this susceptibility to resistance, Mefloquine should be used with another drug (Roberts at al).

Folate antagonists are another class of antimalarial drugs. They are not extracted from plants but designed from knowledge of cell biology and chemistry. Pyrimethamine-Sulfadoxine (SP) is the most widely used folate antagonists. This combination drug is inexpensive and requires only one dose. It is prone to parasites' resistance acquisition (Ridley; Robert). Resistance to SP has been prevalent in Asia, much of east and south

Africa, and South America making malaria harder to treat (Gueriin at al). Another combination drug is a mixture of proguanil and atovaquone (commercially know as Malarone®). Atovaquone is prone to fast resistance development but proguanil helps to prolong the resistance development. This combination is more effective than CQ alone, CQ and SP, or mefloquine against acute uncomplicated *P. falciparum* with resistance to other drugs. However, it is more expensive than other drugs making it harder for people in developing nations to purchase (Ridley; Roberts).

Artemisinins are fairly new types of antimalarial drug that have been used increasingly over the past two decades. It originates from 'qinghao' plant (*Artemisia annua*) in China which had been used by the local Chinese people for thousands of years to treat fever. It has since been extracted from Sweet wormwood plant. Artemisinins have shown faster relief from fever and faster clearance of parasites compared to other antimalarial drugs without apparent toxicity (Ridley; White). Artemisinins have short half-lives and are metabolized rapidly. Treating malaria solely by artemisinins takes 5-7 days and may allow enough time for the parasites to gain resistance. Therefore they should be used in combination with other antimalarial drugs with longer half life such as mefloquine and SP (Ridley; Roberts). They have become the drug of choice. The mixture of artesunate and mefloquine has been used in Southeast Asia where multi-drug resistance have caused problem. This mixture appears to have stopped development of further resistance to mefloquine. These mixtures are normally referred to as Artemisinin-based combination therapy (ACT). WHO recommends ACTs as the new drug policy for developing countries (The World Bank 20). ACTs provide highly effective and tolerable treatment that prevents the parasites from developing resistance to artemisinin itself and

the combined drug; they also reduce parasites ability to infect mosquitoes and reduces

transmission (Guerin at al). ACTs are currently the only first-line antimalarial drugs that

should be used widely in the areas where parasites have acquired multi-drug resistance.

Countries should work towards policies that allow them to provide ACTs to patients

immediately but carefully so that the parasites will not acquire resistance to ACTs (The

World Bank 20).

Many drugs have been discovered to prevent and treat malaria but malaria

parasites have also acquired resistance to these drugs. Malaria can be treated effectively

to reduce mortality and morbidity if the drugs are used properly. But in reality, most

people in severely malarial areas lack proper diagnosis and treatment. They lack access to

effective drugs or lack knowledge to complete the treatment. Many countries have

outdated drug policies that are no longer effective (Guerin). Countries need to make

ACTs as their first choice treatment. ACTs cost much more than other common

antimalarial drugs such as chloroquine and SP. The cost of ACT is about $1.20-2.50 per

adult treatment and CQ and SP cost about $0.10-0.20 per treatment (Breman, Alililo and

Mills). One study in Kenya showed that the inadequate availability and high cost of

ACTs; only one brand of ACTs was available. It costed $7.11 for a treatment course and

only 2.4% of providers handled it (Amin and Snow). To provide for people who can not

afford ATCs, a global subsidy for ACTs has been proposed. This would encourage the

use of ACTs and make them more available. The cost is estimated to be $300-500 million

a year to make the ACT price more comparable to chloroquine (Financial Mechanisms

for Malaria). Considering chloroquine's wide availability in countries with high malaria

transmission, ACTs can be distributed if their price and availability can match

chloroquine.

Vaccines for malaria will provide a completely different way to fight the

infection. They can work against different stages of parasite's life cycle and can

theoretically achieve prevention or immunity similar to the partial immunity acquired by

adults in the severe malaria area. But no one has been able to produce a vaccine that

works. Some potential vaccines have failed during human trials due to the lack of

potency (Guerin; Richie and Saul). To develop a vaccine quickly, persistent research and

funding is essential. The public sector in developed nations must play a large role in

encouraging the private sector to be involved. It will take many years for a potent vaccine

to be ready (Richie and Saul). Until vaccines can protect people, effective medicines need

to prevent expansion of malaria.

**Treatment:** Studies have shown that the majority of people who suspected themselves of

having malaria receive some sort of treatment including treatment from official health

sector, self-treatment (use of antimalarial medicine bought at pharmacies), and the use of

traditional healer and medicine (Jones and Williams; McCombie 1996). The official

health sector here refers to hospitals, clinics, private practitioners, and village health

workers. While the use of official health sector seems fairly high, most people have

treated the illness at home before they decided to seek treatment at an official health

institution. Major reasons for choosing self-treatment seems to be difficulty to access,

lack of money, and lack of knowledge or misunderstanding (McCombie 1996). Lack of

knowledge could lead to the use of traditional healers and traditional medicine. The

parents could regard convulsions in their child as the sign of supernatural disease and

seek treatment by a traditional healer. Education level also seems to affect people's decision to seek treatment. In Tanzania and Malawi, people with higher education visited official facilities faster (McCombie 2002). Malaria is so common that people regard uncomplicated malaria as a common sickness much like cold or flu. If infected individual lives far away from a hospital, or do not have enough money to pay for the fee and transportation, it makes sense for them to chose not to seek proper treatment (Williams; Jones).

**Vector control:** Vector control has been an integral part of antimalarial campaigns. Insecticide treated nets (ITNs) can dramatically decrease the mortality among younger children by 20%. ITNs are easy to use and to maintain. Nets without insecticide treatment cost $1.7 per net and long-lasting insecticidal nets (LLIN) cost $4.55 per net which is not much more expensive than having a insecticide a net without insecticide and paying $0.3-$0.6 a year for retreatment with insecticide. The delivery cost of these nets on average is $2.73 though it depends on countries. To achieve thorough coverage, 330 million ITNs are required (Financial Mechanisms for Malaria).

| Year | No. NETS NEEDED | | | COST (at US$7.28/ITN) | | |
|---|---|---|---|---|---|---|
| | Scenario 1: 100% coverage of vulnerable population | Scenario 2: ANC & measles campaign | Scenario 3: ANC, EPI & measles campaign | Scenario 1: 100% coverage of vulnerable population | Scenario 2: ANC & measles campaign | Scenario 3: ANC, EPI & measles campaign |
| 2006 | 135,262,874 | 69,515,656 | 79,932,941 | 984,713,723 | 506,073,974 | 581,911,813 |
| 2007 | 26,205,756 | 33,581,586 | 44,170,023 | 190,777,904 | 244,473,946 | 321,557,766 |
| 2008 | 26,840,334 | 26,840,334 | 37,398,303 | 195,397,632 | 195,397,632 | 273,691,307 |
| 2009 | 71,356,796 | 27,483,724 | 38,398,303 | 519,477,478 | 200,081,511 | 279,539,649 |
| 2010 | 52,591,156 | 28,135,957 | 39,202,769 | 382,863,616 | 204,829,767 | 285,396,158 |
| Total | 312,256,916 | 185,557,257 | 239,298,996 | 2,273,230,351 | 1,350,856,829 | 1,742,096,692 |

Table 2. Estimate quantities and costs of ITNs (Financial Mechanisms for Malaria).

Table 2 shows cost estimates of three scenarios. Scenario one covers all the target population but it does not take distribution cost into account. Scenario two covers all the

pregnant women during antenatal clinic (ANC) and children under 5 years old in 42 countries where measles campaigns are planned (to combine these programs to reduce the distribution costs). Scenario three includes delivering one more ITN with an expanded program on immunization (EPI) to 9 months old children. Distributing ITNs has been successful when it was integrated with a national immunization campaign in Togo.

Indoor residual spraying (IRS) is another preventive method. Countries such as Mozambique, South Africa and Thailand have successfully used IRS. DDT or other insecticides used in IRS are toxic and could cause problems. IRS costs about $0.86 making it cost effective. IRS and ITNs does not cost much to purchase; however, a case study in Sudan found that the richer households spend much more money on these preventive methods than the poor households.

**Cost:** Financing effective malaria policies cost countries a lot of money and they have not been able to cope with the burden. One study estimated that $3 billion a year is required to promote an effective worldwide antimalaria campaign. The estimate does not include R&D for new malaria drugs which is becoming essential as the malaria parasites gain resistance to medicine. In 2004, the total malaria specific international funding was $600 million. Currently, an organization called the Global Fund to Fight Against AIDS, Tuberculosis, and Malaria (GFATM) handles the majority of malaria specific international funding. GFATM supports wide array of intervention programs. It provides and replaces free long-lasting insecticide treated nets (LLINs) for people in high risk areas. It introduces ACTs and rapid diagnostic tests (RDTs) to accurately diagnose malaria. It provides Pyrimethamine-Sulfadoxine (SP) preventive treatment for pregnant women; it also provides clinical support and supplies. It improves epidemic prevention

and response capabilities through training health workers, and supporting infrastructure (Figure 7) (Financial Mechanisms for Malaria).
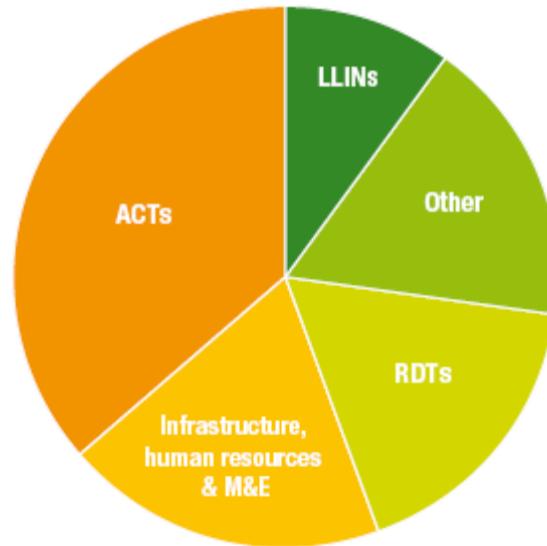


Figure 7. Breakdown of how much different programs cost (Financial Mechanisms for Malaria).

GFATM is one of the major contributors of foreign aid (Figure 8). It has agreed to fund malaria programs worth $1.28 billion dollars ($900 million has been paid so far). The US has pledged a significant portion of funding for GFATM (Figure 9). In addition to the
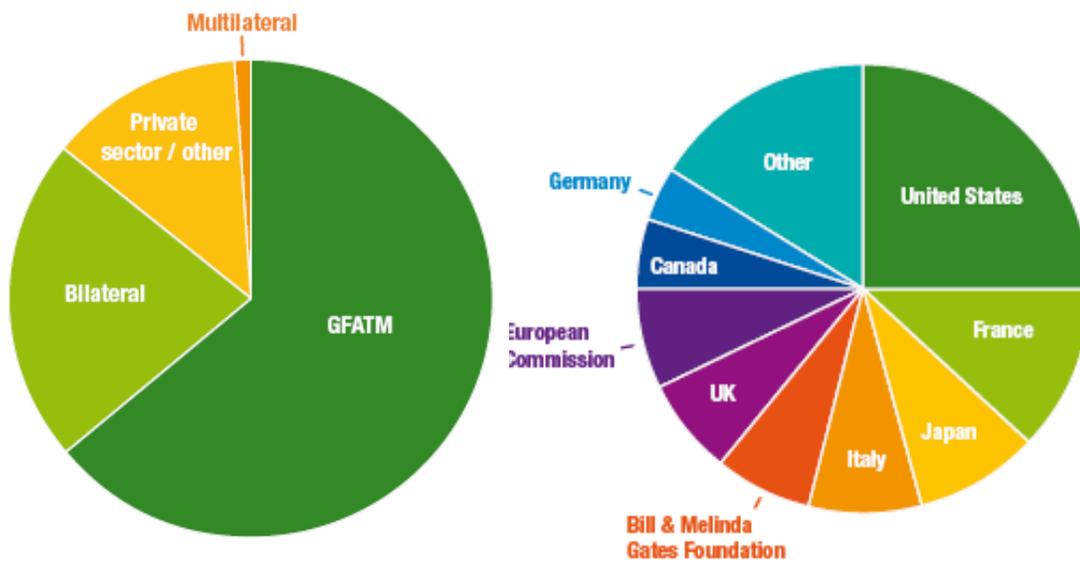
Figure 8. The source of international funding to combat malaria (Financial Mechanisms for Malaria).
Figure 9.The amount pledged to GFATM by countries (Financial Mechanisms for Malaria).

support of GFATM, the President's Malaria Initiative, a separate grant of $1.2 billion over 5 years, was introduced in 2005; the Initiative hopes to half the death tolls in target countries in Africa (Financial Mechanisms for Malaria). Not all programs supported by GFATM perform well. These programs have two phases and the funding for phase two is only approved if phase one performs well.

The world Bank has agreed to fund its own Booster Program to compliment the work done by GFATM, WHO, and UNICEF. In order to commit to combat malaria, African Union countries have pledged to dedicate at least 15 % of their budgets to healthcare expenditures (Financial Mechanisms for Malaria).

The general lack of global funding means that the people of these malarial countries must pay out of their pockets. Low income countries in sub-Saharan Africa and South Asia contribute about half of the health expenditures. In some countries, the numbers are even higher, exceeding 60%. The poor citizens of these countries suffers from this lack of international funding as they must spend their own money to treat malaria. Foreign aid, In 1970, At UN General Assembly, Developed countries have pledged to donate 0.7 % of FDP as aid. Only Norway, Sweden, Luxemburg, Netherlands and Denmark had fulfilled this agreement by 2005.

The distribution of the aid may determine the effectiveness of the aid because it determines how effectively the aid is used. The governments receiving money can use it to benefit only the elite and the powerful groups in these countries. Foreign aid must be distributed to help the poor. The abilities and willingness of governments must improve

in malarial countries because a low level of accountability and transparency and high levels of corruption are prevalent. In order to improve accountability and transparency, major structural changes are necessary in the existing governments of many countries. The effectiveness of the aid should be monitored (Financial Mechanisms for Malaria).

Encouraging private corporations such as multi-national pharmaceutical companies to be involved in malaria research has been a large step forward. Currently, Public Private Partnerships (PPPs) play the most important role in malaria medicine research and development (Financial Mechanisms for Malaria). Drug research and development is expensive and takes a lot of time. It is not profitable for pharmaceutical companies to develop a new drug for malaria because typical R&D cost about $160 million and 8 to 12 years (Pecoul at al). In PPPs, Public organizations can give funds to private sectors so that they have incentives to invest in research as they require much smaller risk and less effort. Medicine for Malaria Venture (MMV) is a PPPs that came about after meeting between the WHO and the International Federation of Pharmaceutical Manufacturers Association (IFPMA) in 1999. MMV incorporates pharmaceutical companies, academic institutions and research institutions to develop new medicine for malaria (Figure 10) (MMV website). Many international PPPs exist. Malaria Vaccine Initiative (MVI), Global Alliance for Vaccine and Immunization (GAVI), Drugs for Neglected Diseases (DNDi) are larger ones. Perhaps the most important one is Multilateral Malaria Initiative (MMI). MMI consists of scientists from developing and developed countries. It engages in various types of work from drug development to socioeconomic and behavioral studies (Financial Mechanisms for Malaria). More funding is needed to support these public private research groups.
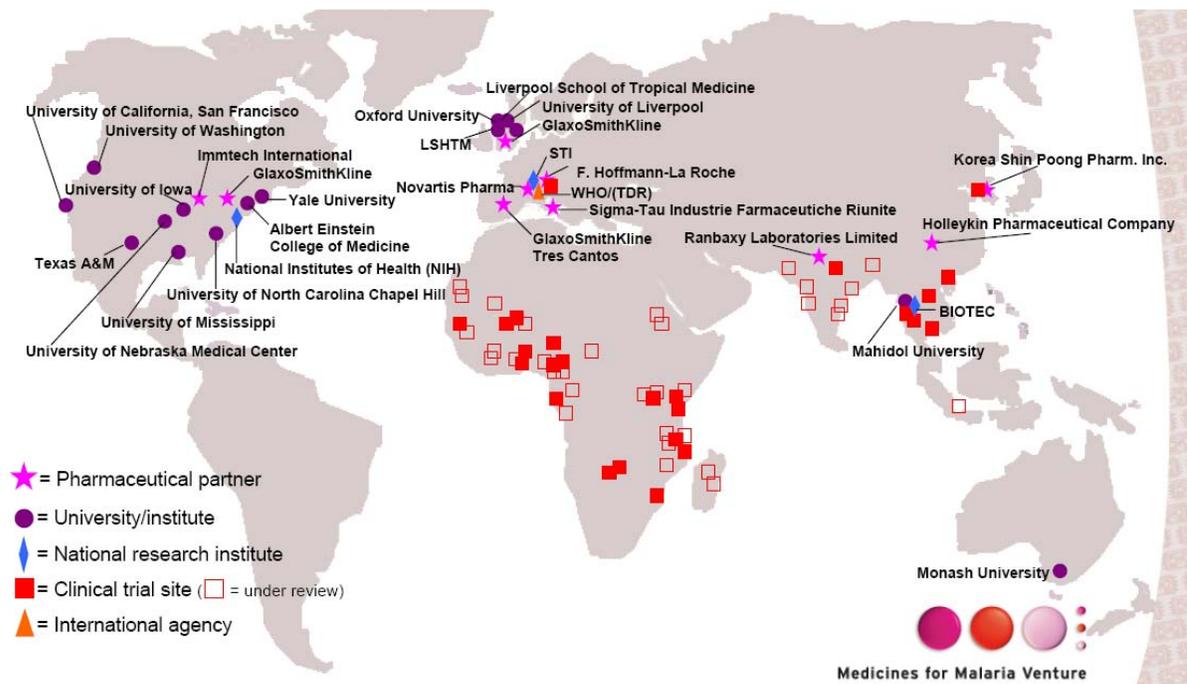
Figure 10. Institutions involved in Medicine for Malaria Venture ([www.mmv.org](http://www.mmv.org)).

## Conclusion

Malaria remains to be a huge problem in developing countries. We cannot ignore this problem as we try to eradicate global poverty. Malaria causes a downward spiral of poverty without effective interventions. It causes huge economic loss and loss of capabilities at both individual and national level; these effects burden the poor and make them more susceptible to further infections by malaria. Unfortunately, for tropical countries, total eradication of malaria appears to be unattainable in the near future. However we can improve the current situation greatly through campaigns that promote education, more accessible and competent healthcare and improved access to first-line medication and other necessary goods. To finance such a wide array of programs, the international organizations must work together to supply foreign aid, and support public private partnerships. Fortunately, the international community seems to be moving in that

direction. We must keep going down this road if we are seriously committed to eradicate

global poverty.

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