1

Malaria, a Pending Problem in Sub-Saharan Africa

Omolade O. Okwa
Department of Zoology, Parasitology Unit, Lagos State University (LASU), Lagos, Nigeria

1. Introduction

Human Malaria is still a serious problem in sub-Saharan Africa and the risk exists throughout the region. It is a real fact that most malaria cases and deaths occur in sub-Saharan Africa. This region has some of the poorest countries of the world with 90% of deaths occurring (approximately 3,000 deaths each day) [1]. The disease remains one of the leading causes of morbidity and mortality in the tropics. It is the most important and widespread of the tropical deadly diseases.

It exacts a heavy toll of illness and death on children and pregnant women [2].

In 2008, there were 247 million cases of malaria and nearly one million deaths – mainly among children living in sub-Saharan Africa [3]. A child dies every 45 second as a result of malaria, the disease accounts for 20% of all childhood deaths [3]. Malaria kills 3,000 children every day in sub-Saharan Africa—that is, a million a year [4].

In sub-Saharan Africa, many households, even children are familiar with malaria, where it has a reputation of causing teeth chattering chills, shakes and fever.

Specific population risk groups include:

- **Young children** in stable transmission areas who have not yet developed protective immunity against the most severe forms of the disease.
- **Non-immune pregnant women** are at risk as malaria causes high rates of miscarriage (up to 60% in *P. falciparum* infection) and maternal death rates of 10–50%.
- **Semi-immune pregnant women** in areas of high transmission. Malaria can result in miscarriage and low birth weight, especially during the first and second pregnancies. An estimated 200 000 infants die annually as a result of malaria infection during pregnancy.
- **Semi-immune HIV-infected pregnant women** in stable transmission areas are at increased risk of malaria during all pregnancies. Women with malaria infection of the placenta also have a higher risk of passing HIV infection to their newborns.
- **People with HIV/AIDS** are at increased risk of malaria disease when infected.
- **International travelers from non-endemic areas** are at high risk of malaria and its consequences because they lack immunity.
- **Immigrants from endemic areas and their children** living in non-endemic areas and returning to their home countries to visit friends and relatives are similarly at risk because of waning or absent immunity.

The following factors have made malaria a pending problem in sub-Saharan Africa.

2. The malaria parasite

Human Malaria is a parasitic disease caused by apicomplexan protozoan (single celled) coccidian. These parasites are haematozoans or haemosporinas of the family plasmodiidae. A contributing factor to the malaria problem in sub-Saharan Africa is the diversity of the parasite that infects humans. Four species infect man of which *Plasmodium falciparium* is the most virulent. The other species are *P. vivax, P. malariae* and *P. ovale. P. falciparium* and *P. vivax* are the most common [3].

In sub-Saharan Africa, *P. falciparium* poses the greatest threat because of its high level of mortality and the complications arising. *P. vivax* is worldwide in tropical and some temperate regions. *P. vivax* accounts for more than half of all malaria cases outside sub-Saharan Africa. *P. vivax* is unique in that a sporozoite injected into the blood stream may stay in hepatocytes as hyponozoites. *P. ovale* is mainly in found in tropical West Africa and *P. malariae* is found worldwide but with patchy distribution [3]. These malaria parasites can develop within, invade red blood cells (erythrocytes) and consume up to 75% - 80% of their haemoglobin as nutrient source [1].

For both *P. vivax* and *P. ovale*, clinical relapses may occur weeks to months after the first infection, even if the patient has left the malarious area. These new episodes arise from "dormant" liver forms (absent in *P. falciparum* and *P.malariae*), and special treatment – targeted at these liver stages – is mandatory for a complete cure [3].

3. Complications of malaria

P. falciparium causes severe complications as cerebral malaria, severe anaemia, acute renal failure, hypoglycemia and pulmonary infection. The two features that actually separate *P. falciparium* from the other human malaria are the ability to attack erythrocytes of all ages, causing high parasitaemia and enhanced growth and the capability to adhere to vascular endothelium through sequestration [2].

P. falciparium is a threat because of high level of mortality and spreading drug resistance. Cerebral malaria caused by *P. falciparium* is when infected blood cells obstruct blood vessels in the brain; other vital organs can also be damaged often leading to death of patient.

Malaria in pregnancy is widespread. Pregnant women are especially vulnerable because of iron deficiency, a special problem in malaria endemic areas .It endangers the health of women and prospects for the new born. Malaria causes anaemia and low birth weight babies. This is due to the loss of previously existing immunity. *P. falciparium* infects the Red Blood cells (RBC) that adheres to and accumulates in the placenta in pregnant women. Pregnancy exacerbates malaria through a nonspecific hormone-dependent depression of the Immune system. The protective antiplasmodial activity is suppressed at pregnancy, which has clinical consequences with important public health implications on pregnant women [2]. Malaria accounts for 6.5% of abortions, 15% of premature deliveries and 0.7% death in utero [3].

Malaria infection leads to increased morbidity and mortality and the delivery of premature infants with low birth weights due to intrauterine growth retardation (IUGR) that may have been as a result of placental parasitisation [2]. Malaria infection in pregnancy is significant in

sub -Saharan Africa where its fatality as a result of virulent *P. falciparium* is a far greater problem than in most parts of the world [4].

Anaemia is another malaria complication that can lead to death. It occurs when *P. falciparium* disrupts the erythrocytes and so decreases the production of erythrocytes. The pathology associated with *P. falciparium* malaria is in particular due to adherence of infected red blood cells in the brain causing metabolic disturbances and organ dysfunction [5].

What of the devastating effect on children? Those children who succumb to the infection but survive are often left damaged. Recurrent infections can leave the child listless and with a poor appetite. It reduces social interaction, leading to poor development. Two percent of children who survive the cerebral form of the disease are left with learning difficulties and conditions such as spasticity and epilepsy [4].

4. The malaria vector

Malaria is transmitted by the *Anopheles* mosquito which carries infective sporozoites stage in its salivary glands which it injects into the human blood stream during a blood meal. Several *Anopheles* mosquitoes have been incriminated as the major malaria vectors. About 20 different *Anopheles* species are locally important around the world. The vector population in sub-Saharan Africa is uniquely effective, with the six species of the *Anopheles gambiae* complex being the most efficient vectors of human malaria in the region, and often considered the most important in the world [4]. *An. funestus* is also capable of producing very high inoculation rates in a wide range of geographic, seasonal, and ecological conditions. These vectors have proven effective in transmitting the malaria parasite to humans across the region, in rural and urban areas alike. *An. pharoensis* is also widely distributed in Africa, geographically and ecologically, and can maintain active transmission of malaria even in the absence of the main malaria vector.

All of the important vector species bite at night. They breed in still waters or shallow collections of freshwater like puddles, rice fields, and hoof prints. Transmission is more intense in places where the mosquito is relatively long-lived (so that the parasite has time to complete its development inside the mosquito) and where it prefers to bite humans rather than other animals. For example, the long lifespan and strong human-biting habit of the African vector species is the underlying reason why more than 85% of the world's malaria deaths are in sub-Saharan Africa [3]. Mosquito's habits therefore determine the geographic spread of the disease.

Malaria transmission is variable from one area to the other and this will impact on its epidemiology and control. In a study by Oyewole *et al* [7] in a coastal area of southern Nigeria in sub-Saharan Africa, several species of *Anopheles* mosquitoes occurred in sympatry. These species all combined to the transmission of malaria in the area. They were all competent vectors. For a mosquito to transmit malaria to man or other hosts the following points are crucial:

i. Vector capacity and competence:

Vectoral capacity has been used interchangeably to describe the ability of mosquitoes to serve as a disease vector. It is defined qualitatively and is influenced by such variables as vector density, longetivity and vector competence. Vectoral capacity takes into account environmental, behavioral, cellular and biochemical factors that influence the association

between a vector, the pathogen transmitted by the vector and the vertebrate host to which the pathogen is transmitted [7].

Vector competence is a component of vectoral capacity and is governed by intrinsic and generic factors that influence the ability of a vector to transmit a pathogen. Susceptibility to sporozoite stage of *Plasmodium species* is an important component of vectoral competence.

Vectors competence, however differ from one species to another and from place to place. There are vector species complexes that vary in their behaviors, vectorial capacities and competence and these present a real problem to malaria control. The main factor governing the ability of *Anopheles* specie to act as malaria vector is the frequency with which it feeds on humans. The vectors associated with stable malaria are those which are strongly antropophagic, often feeding on humans to the exclusion of other hosts. Anopheline vectors of malaria consists of various behavior associated with their biting activities and hence transmission dynamics [6].

There is a considerable lack of information regarding vector habits, such as where *Anopheles* rest during the day, information that is critical for control efforts. Awolola *et al.* [8] reported that there is little information on sporozoite rates of *Anopheles* mosquitoes. This observation was the basis of several studies he carried out in Nigeria from 2003 – 2005. The paucity of data on species complexes and their bionomics hampers future vector control as an important component of malaria control.

Correct analysis of the distribution of specific malaria vectors is one of the prerequisites for meaningful epidemiological studies and for planning and monitoring of successful malaria control or eradication programmes. Control measures can only be effective if the abundance, behaviour and proportion of the vectors are known. The existence of species complexes containing morphologically cryptic sibling or isomorphic forms presents a major challenge to malaria control programmes as these require vector identification using molecular techniques. Meanwhile, the distribution of the molecular M (Mopti) and S (Savannah) forms of *An. gambiae s.s* is still being determined for much of the West African regions [6, 8]. The malaria problem in sub-Saharan Africa represents a peculiar case because the vectoral system is the most complex anywhere.

Beier [9] had suggested that malaria transmission dynamics is variable throughout Africa with huge variability in transmission patterns even within villages few kilometers apart. This vectoral system diversity impacts on malaria epidemiology and control. The *An. gambiae* complex is not the only vector in the field [6, 8]. Targeting only this species by whatever method is nonsense. The diversity of the epidemiological situation within sub-Saharan ecotypes presents differing malaria situation. Comprehensive knowledge of behaviour and heterogeneities that exist within, and among these vectors, will always be of benefit. Any strategy aiming at control will have to account for this heterogeneity.

ii. Host preference:

In some areas of sub-Saharan Africa people receive 200 to 300 infective bites per year [4]. This is another component of vectoral capacity and competence. The attractiveness of a blood meal host and the subsequent feeding success of a mosquito depend on characteristics such as host size, proximity to mosquito habitats, host abundance during mosquito host-seeking periods, and host defense mechanisms [7, 8].

There can also be differences in host attractiveness for those mosquito species that feed on humans, and it is not uncommon for some people to be more attractive to mosquitoes than others. Studies have shown that humans appear to exude different amounts of the volatile compounds that mosquitoes loves. Scientists are currently studying the reasons for the difference in attractiveness in order to assist development of repellent compounds for preventing blood feeding and attractants for mosquito traps [10,11].

Some mosquito species may never attack man. Different mosquito species have evolved to blood feed on various types of vertebrate hosts. Some mosquitoes prefer mammalian blood, while others would rather feed solely on birds. There are even mosquitoes specialized to feed on amphibians or reptiles. Opportunistic feeding mosquitoes will feed on any animal, depending on host availability during the host-seeking period [10].

Some *Anopheles* mosquitoes feed indoors and hence endophagic, while others feed outdoors hence exophagic. After blood feeding, some *Anopheles* mosquito may prefer to rest indoors hence are endophilic, while others prefer to rest outdoors hence exophilic. Some mosquito species search for hosts during daylight hours while others are active at dawn and dusk [10, 11]

The main factor governing the ability of *Anopheles* specie to act as malaria vector is the frequency with which it feeds on humans. The vectors associated with stable malaria are those which are strongly antropophagic, often feeding on humans to the exclusion of other hosts. Anopheline vectors of malaria consists of various behavior associated with their biting activities and hence transmission dynamics [6].

5. Human immunity

This is another important factor, especially among adults in areas of moderate or intense transmission conditions. Immunity is developed over years of exposure, and while it never gives complete protection, it does reduce the risk that malaria infection will cause severe disease. For this reason, most malaria deaths in sub-Saharan Africa occur in young children, whereas in areas with less transmission and low immunity, all age groups are at risk [3].

6. Climatic conditions

Transmission also depends on climatic conditions that may affect the abundance and survival of mosquitoes, such as rainfall patterns, temperature and humidity. In many places, transmission is seasonal, with the peak during and just after the rainy season. Malaria epidemics can occur when climate and other conditions suddenly favour transmission in areas where people have little or no immunity to malaria. They can also occur when people with low immunity move into areas with intense malaria transmission, for instance to find work, or as refugees [3].

7. Drug and vector resistances

Treatment and control of malaria have become more difficult because of drug and vector resistances. Growing resistance to antimalarial medicines has spread very rapidly, undermining malaria control efforts. Chloroquine was introduced in the 1950s. When resistance to the drug developed in the 1970s, (Fansidar) sulphadoxine-pyrimethamine (SP) was introduced. Resistance to these drugs is now so high as to render them “virtually useless [12]. These ineffective drugs continue to be used despite the spectacular levels of resistance, leading to

increased treatment failure. There have also been reports of increasing multiple-drug resistance to drugs other than chloroquine, such as amodiaquine, mefloquine, rendering treatment of malaria even more problematic. Currently, the best available treatment, particularly for *P. falciparium* malaria, is artemisinin-based combination therapy (ACT) [3]. Artemisinin is part of a combination therapy that reduces or prevents the problem of drug resistance.

Artemisinin and its derivatives like Artesunate, artemether, arteether and dihydroartemisin are the more common drugs now in sub- Saharan Africa. This is not surprising as there is currently no evidence for clinically relevant Artemisinin resistance. Nevertheless, Chloroquine and SP continue to be used because they cost around 10 US cents per treatment, whilst artemisinin combination treatment (ACT) costs US$1.50 per treatment. This is estimated to be an annual cost of between US$100 million and US$200 million a year [4].

When treated with an artemisinin-based monotherapy, patients may discontinue treatment early following the rapid clearance of malaria symptoms. This results in partial treatment and patients still have persistent parasites in their blood. Without a second drug given as part of a combination (as is done with an ACT), these resistant parasites survive and can be passed on to a mosquito and then another person. Monotherapies are therefore the primary force behind the spread of artemisinin resistance [3]. The limitations of these group of drugs are the short duration of antimalarial activity and high recrudescence rate. However, there is low toxicity and they are highly potent and rapidly metabolized [10].

If resistance to artemisinin develops and spreads to other large geographical areas, as has happened before with chloroquine and (SP), the public health consequences could be dire, as no alternative antimalarial medicines will be available in the near future [3]. At least 300 to 500 million malaria episodes are treated annually in sub-Saharan Africa. Moreover, many communities engage in preventive and treatment practices outside what is provided by "official" programs.

Malaria vectors have shown resistance to numerous insecticides, including DDT, various organo-phosphates, and some carbamates. Mosquito control is being strengthened in many areas, but there are significant challenges, including:

- an increasing mosquito resistance to insecticides, including DDT and pyrethroids, particularly in Africa; and
- a lack of alternative, cost-effective and safe insecticides.

The development of new, alternative insecticides is an expensive and long-term endeavour. Detection of insecticide resistance should be an essential component of all national malaria control efforts to ensure that the most effective vector control methods are being used [3].

8. Socio economy aspects

Malaria was a serious obstacle to the colonization of Africa. It caused a lot of suffering and tragedy. Its effect was devastating. It interfered with human progress and development. The disease is still a serious impediment to economic and social development in sub- Saharan Africa.

The socio- economic aspects of a disease is a significant factor in the epidemiology and control of the disease. Malaria causes significant economic losses, and can decrease gross domestic product (GDP) by as much as 1.3% in countries with high levels of transmission. Over the long term, these aggregated annual losses have resulted in substantial differences in GDP between countries with and without malaria, particularly in Africa.

The health costs of malaria include both personal and public expenditures on prevention and treatment. In some heavy-burden countries, the disease accounts for:

- up to 40% of public health expenditures;
- 30% to 50% of inpatient hospital admissions;
- up to 60% of outpatient health clinic visits.

Malaria disproportionately affects poor people who cannot afford treatment or have limited access to health care, trapping families and communities in a downward spiral of poverty.

Malaria is the commonest cause of work and school absenteeism in the tropics. It is the commonest cause of outpatient attendance in sub-Saharan Africa. Economic costs due to malaria are enormous if quantified [13].

Socio economic consequences of diseases are better appreciated when expressed as loss of manpower. Poverty promotes malaria and malaria yields poverty. Socio economic cost can be measured in terms of absenteeism, drugs purchase, doctor's fee, transport, and opportunity cost of time spent waiting for treatment. In Africa alone, the estimated annual direct and indirect costs of malaria were US$800 million in 1987 and exceeded US$1800 million by 1995. Malaria undermines the health and welfare of families, endangers the survival and education of children, debilitates the active population and impoverishes individuals and countries. It is one of the most serious obstacles to mankind's effort to develop agriculture, settlement, development projects and irrigation

Knowledge, attitudes and practices are essential for control programmes. Without the rational concept of the cause of a disease, it is impossible to design control programmes. There still exist wrong misconceptions of malaria in sub Saharan Africa.

Women bear more brute of the disease than men in sub-Saharan Africa. They often tolerate symptoms of malaria until they are critically ill because of the perception that sick women are mean or lazy. Women are reproached when there are malaria epidemics for having failed as custodians of health. Women are increasingly been informed to help them recognize the symptoms of malaria in themselves and family members e.g., fever chills, headache. When children are sick from malaria, women usually bear the psychological effects. Severe convulsions, fever and other symptoms affecting children leave a psychological effect of fear and restlessness on the mothers [14].

9. Conclusion

Malaria in sub-Saharan Africa is a problem of dimensions unlike malaria seen anywhere else in the world today [13]. The magnitude of malaria is affected by a variety of factors, none of which addressed alone is likely to effect a resolution. It is further compounded by the generally poor social and economic conditions in sub-Saharan Africa.

Malaria could be brought under control in sub-Saharan Africa as it has been in Europe and America. Instead, it is being allowed to run out of control just like the AIDS epidemic because of the indifference of Western governments to the lives of the poorest people on the planet [15].

Poor people who represent most of the continent's malaria disease burden cannot afford to pay much more than what they currently pay for the old treatments, so costs must be subsidized by national governments with the help of international donors. What is missing

is political will. Unless this situation changes, people will continue to die needlessly from taking drugs that no longer work.

Malaria has therefore remained a deadly scourge and pending problem in Africa and is a yet to be conquered disease.

10. References

[1] Anonymous. Africa malaria reports Executive summary. http://www.rbm.who.int. 2003.

[2] Okwa OO. The Status of Malaria among Pregnant Women: A Study in Lagos, Nigeria. African Journal of Reproductive Health : 2003; 7 (3): 77– 83

[3] WHO: Malaria fact sheet No 94 April 20l0. http://www.who.int/mediacentre/factsheets/fs094/en/

[4] Mason B. Malaria appalling death toll in sub-Saharan Africa. http://www.wsws.org/articles/2003/may2003/mala-m14.shtml world socialist web site.international committee of the fourth international (ICFI); 2003

[5] Amajoh N, Odukoko JB, Monsanya ME. Preliminary investigations on malaria and anemia in the Atlantic coastal margin of Ibeju Lekki, Lagos Nigeria. Journal of Malaria in Africa and the Tropics. 2002; (1)17-22.

[6] Oyewole IO, Ibidapo CA, Okwa OO, Oduola AO, Adeoye GO, Okoh HI, Awolola TS (2010). Species Composition and Role of *Anopheles* Mosquitoes in Malaria Transmission along Badagry axis of Lagos Lagoon, Lagos, Nigeria. International Journal of Insect Science 2010; (2) 51–57

[7] Okwa OO, Carter V, Hurd H. Abundances, host preferences and infectivity rates of malaria vectors in Badagry Local government area of Lagos, Nigeria. Nigeria Journal of Parasitology. 2006; 27:41-48.

[8] Awolola TS, Oyewole IO, Koekemoer LL, Coetzee M. Identification of three members of the *Anopheles funestus* (*Diptera: Culicidae*) group and their role in malaria transmission in two ecological zones in Nigeria. Transactions of the Royal Society of Tropical Medicine and Hygiene. 2005; 99: 525-531.

[9] Beier JC. Malaria parasite development in mosquitoes. Annual Review of Entomology 1998; .43, 519-543.

[10] Richards SL, Ponnusamy L, Unnasch TR, Hassan HK, Apperson CS . Host-feeding patterns of *Aedes albopictus* (Skuse) (Diptera: Culicidae) in relation to the availability of human and domestic animals in suburban landscapes of Central North Carolina with notes on blood meal hosts of sympatric mosquito species. Journal of Medical Entomology 2006; 43 (3): 543-551.

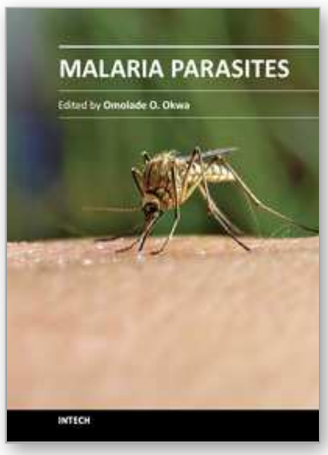
[11] Richards SL, Anderson SL, CT Smartt. The female mosquito's quest for blood: Implications for disease cycles. University of Florida/IFAS Fact Sheet, ENY-855, IN-811. http://edis.ifas.ufl.edu/IN811.2009

[12] Krishna, S.O., Ursula, E., Joet, T; Uhlemann, A.C., Monnc, Webb R., Woodrow, C, Kun, J.F.J and Kremsner P.G. Transport processes in *Plasmodium falciparium* erythrocytes potential as new drug targets. International Journal of Parasitology. 2002; 32:1567-1573

[13] Gallup JL, Sachs JD. The economic burden of malaria. American Journal of Tropical Medicine and Hygiene. 2001; 64: 85-96.

[14] Okwa, O.O: Tropical parasitic diseases and women. Annals of African medicine 2007; 6 (4): 157-163.

[15] Anonymous: Malaria and development in Africa .A cross sectional approach. http://www.aaas.org/international/africa/malaria91/background.html.2010.



Malaria Parasites

Edited by Dr. Omolade Okwa

ISBN 978-953-51-0326-4
Hard cover, 350 pages
Publisher InTech
Published online 30, March, 2012
Published in print edition March, 2012

Malaria is a global disease in the world today but most common in the poorest countries of the world, with 90% of deaths occurring in sub-Saharan Africa. This book provides information on global efforts made by scientist which cuts across the continents of the world. Concerted efforts such as symbiont based malaria control; new applications in avian malaria studies; development of humanized mice to study P.falciparium (the most virulent species of malaria parasite); and current issues in laboratory diagnosis will support the prompt treatment of malaria. Research is ultimately gaining more grounds in the quest to provide vaccine for the prevention of malaria. The book features research aimed to bring a lasting solution to the malaria problem and what we should be doing now to face malaria, which is definitely useful for health policies in the twenty first century.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Omolade O. Okwa (2012). Malaria, a Pending Problem in Sub-Saharan Africa, Malaria Parasites, Dr. Omolade Okwa (Ed.), ISBN: 978-953-51-0326-4, InTech, Available from: http://www.intechopen.com/books/malaria-parasites/malaria-a-pending-problem-in-sub-saharan-africa-

INTECH
open science | open minds

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821

IntechOpen