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Malaria (Part 1)

Lessons From Somalia and General Slim

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British forces were being routed; a new strategy was necessary to avert a military catastrophe. Addressing his plight, Sir William Slim, British Field Marshall in Southeast Asia in World War II, stated, "In 1943, for every man evacuated with wounds, we had one hundred and twenty evacuated sick. The annual malaria rate alone was 84 percent per year of the total strength of the army and even higher among forward troops. A simple calculation showed me that in a matter of months at this rate my army would have melted away."⁽¹⁾ Slim realized that the main source of the problem was failure to comply with malaria discipline and that he had the power to change that. Slim's solution was to perform surprise checks on whole units to determine whether quinacrine hydrochloride (the chemoprophylactic agent at the time) was being taken. "If the overall result was less than 95 percent positive, I sacked the commanding officer. I only had to sack three; by then the rest had got my meaning." As a result of such actions by General

Slim and other commanding officers, attack rates of malaria decreased dramatically during the last half of World War II, even though combat was still occurring in malarious areas.⁽²⁾

Malaria Prevention: A Dual Responsibility

This account illustrates malaria's well earned reputation as a potential "war stopper." During World War II it accounted for 113,256 cases, 90 deaths and 3,310,800 lost man-days in naval forces,^{*}(2) and disrupted U.S. Army operations in Southeast Asia and North Africa. In Vietnam, entire combat battalions were at times rendered ineffective by the disease.

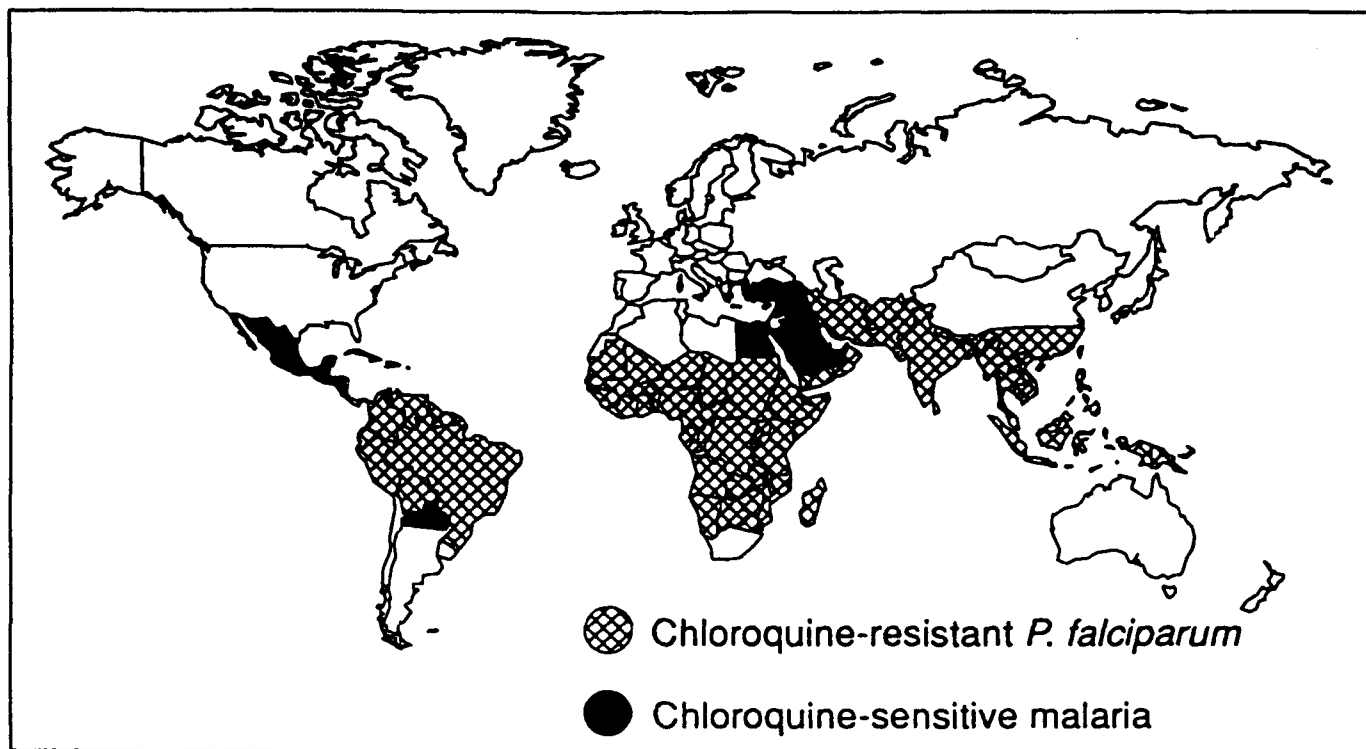
It also illustrates the effort that is required to combat malaria in operational settings—a combined effort of line commanders and their medical departments. Both components are

* Naval forces refers to both Navy and Marine Corps personnel. Marines are the group at highest risk of malaria because of the nature of their mission.

essential because malaria prevention in the field is a multicomponent and ongoing program (referred to as malaria discipline) which requires constant monitoring and maintenance. Although the Medical Department provides recommendations for prevention, the line must provide the means of enforcement. Without it, preventive medicine programs are doomed to failure and high disease rates can be expected, compromising operational readiness. As Slim himself stated, "more than half the battle against disease is fought, not by doctors, but by regimental officers."⁽¹⁾ To do this, however, line commanders must be well informed by the Medical Department of the risk of disease and the means of prevention. Other Medical Department responsibilities include monitoring and education. In this and a subsequent article we will review the basics of malaria prevention in the context of recent naval malaria experiences and provide guidelines to help medical officers prepare for deployment to malarious areas.

Distribution of Malaria and Chloroquine-Resistant *Plasmodium falciparum*, 1993

Centers for Disease Control



Widespread Threat

The causative organism of malaria is a protozoan of the genus *Plasmodium*. Four species infect man, *P. falciparum*, *P. vivax*, *P. ovale*, and *P. malariae*. *P. falciparum* is the most important of the species since it causes much more severe disease than the others, frequently fatal if untreated. Also, drug resistance is common with *falciparum* malaria.

Malaria is primarily a disease of the warmer areas of the world, being present in most tropical and some subtropical areas (see map). It is common in areas of military operations. Within malaria endemic areas, transmission may vary seasonally and geographically.

Globally, *P. falciparum* and *P. vivax* cause the vast majority of malaria cases; *P. ovale* and *P. malariae* are much less common. *P. falciparum* is found in most areas of the world and is the predominant species in Africa. *P. vivax* is also common in

most malarious areas except Africa, Haiti, and the Dominican Republic. It may be more prevalent in some areas of Africa than was previously known, as attested to by the large number of *P. vivax* cases in U.S. forces returning from Somalia. *P. vivax* is the predominant species in India, Pakistan, Bangladesh, and Central America.

P. ovale is found mainly in Africa, with much lower prevalence in other parts of the world. *P. malariae* is found in most malarious areas of the world, but at a lower prevalence than the other species.

The vector of malaria, the *Anopheles* mosquito, feeds at night. The greatest risk of infection is therefore from dusk to dawn. In most parts of the world the greatest risk is in rural areas, with little or no risk in cities. However, urban transmission occurs in some areas, especially Africa. In Somalia, several malaria cases occurred in troops who were only in Mogadishu.

A Complex Disease

Malaria has a complex life cycle, consisting of several developmental forms in both the human host and the mosquito. Within the human, there are two phases of infection—liver and blood. The infection begins when an infected *Anopheles* mosquito injects sporozoites into a person when taking a blood meal. Sporozoites enter the circulation but within a matter of minutes leave the blood and invade liver cells, where they begin to multiply. Generally, 6-16 days later the infected liver cells rupture and release thousands of merozoites into the circulation. In addition to this normal phase of liver development, *P. vivax* and *P. ovale* also have a dormant form known as a hypnozoite. This form may remain in liver cells for months or years before beginning to develop, ultimately causing delayed onset or relapses of malaria. There are no symptoms during the liver phase of infection.

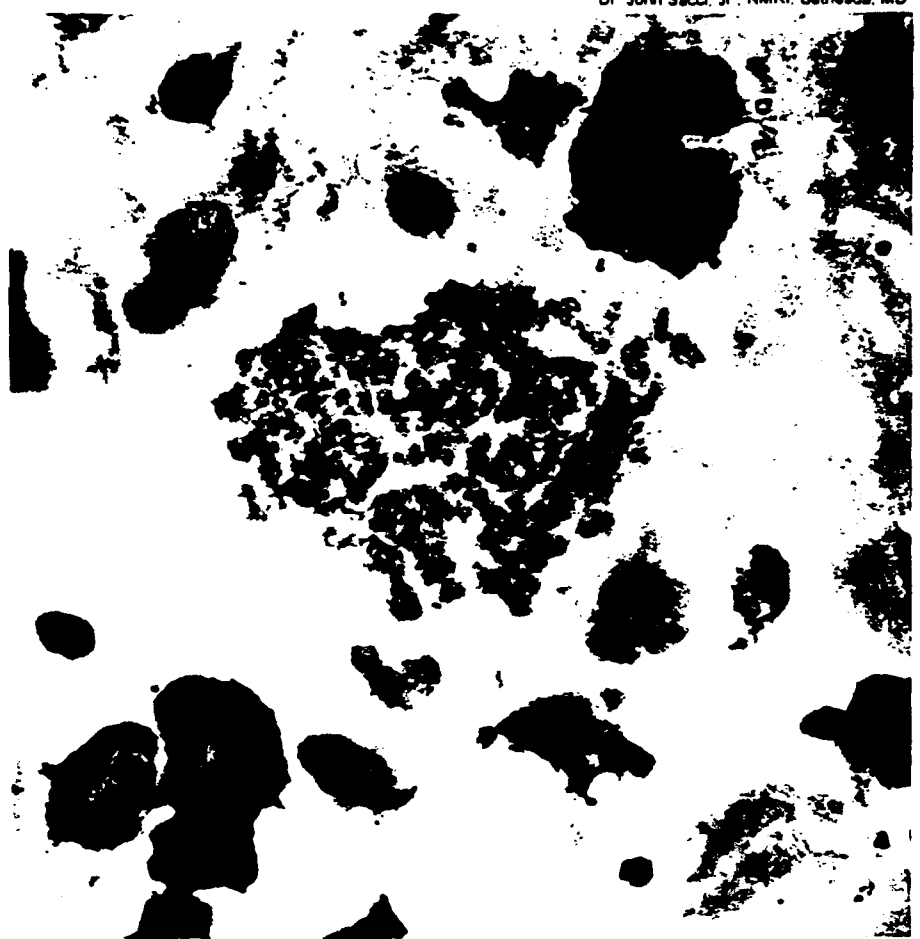
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Liver stage infection of *P. falciparum* in chimpanzee. Although asymptomatic, this single infected liver cell will release up to 30,000-40,000 malaria organisms into the blood to infect RBCs, causing disease.

After release from liver cells, merozoites invade red blood cells (RBCs) where they again begin to grow and divide. After 48-72 hours the RBC ruptures, releasing from 6 to 30 new merozoites into the circulation. These merozoites invade other RBCs, thus starting the cycle over again. It is only at this point, when RBCs begin to rupture, that persons will experience the symptoms of malaria—fever, chills, headache, and muscle ache. The usual incubation period is about 2 weeks. However, the disease may occur from as short as 8 days after exposure for *P. falciparum* to as long as 2-3 years after exposure for *P. vivax* and *P. ovale*.

Several days after the onset of symptoms, some merozoites differentiate into the forms which are infective for the mosquito, male and female gametocytes. When ingested by an Anopheles mosquito, fertilization takes place in the stomach of the mosquito, ultimately resulting in the formation of sporozoites 8-16 days later. Sporozoites migrate to the salivary glands and are ready to be injected when the mosquito takes a blood meal.

Two points concerning the life cycle are very important in malaria prevention. First, there are no symptoms during the liver phase of infection, which may be as short as several days for *P. falciparum* to as long as 2-3 years for *P. vivax* and *P. ovale*. Consequently, persons may leave malarious areas with the organism in their liver, asymptomatic but destined to become ill at some later time. Second, no single antimalarial drug works against all forms of the organism. For



Dr. John Sacchi, Jr., NMRI, Bethesda, MD

example, drugs that kill the organism in the blood (e.g., chloroquine, mefloquine, and doxycycline) do not eradicate it from the liver. Primaquine is currently the only drug which eradicates hypnozoites in the liver, but it has little effect on blood stages, except for gametocytes. These points underlie the need for continuing prophylaxis after leaving the malarious area, generally with more than one drug.

Malaria in the Navy: 1988 Through Somalia

Although the greatest numbers of malaria cases in military forces generally occur in times of war, sporadic cases and occasional outbreaks occur in peacetime during deployments to endemic areas. Reported malaria cases worldwide in naval forces from

February 1988 to May 1993, excluding cases from Somalia, totaled 210 malaria cases in active duty Navy and Marine Corps personnel. As can be seen, most cases occurred in marines and in personnel operating in Pacific-based commands.

Among naval forces, marines are the group at greatest risk for malaria since their mission is usually in rural areas, where transmission is greatest. The Philippines has been the source of most malaria cases in U.S. forces since the end of the Vietnam War, mainly because it was the primary training site for marines in the Pacific. That will obviously change now that Subic Bay Naval Base has closed. Where most cases will occur in the future will likely depend upon where the marines go for training. Thailand is one area where training



Infected RBC rupturing and releasing merozoites, which will infect other RBCs.

exercises are now being conducted. That is a concern since some of the most resistant malaria in the world exists along Thailand's borders with Cambodia and Burma.

Malaria in Somalia

Operation Restore Hope, the humanitarian assistance mission to Somalia which began in December 1992, has resulted in almost 300 malaria cases among military personnel. Of the 48 confirmed cases which occurred in-country, 35 were in Marines, 10 in Army and 3 in Air Force personnel. Additionally, about 115 cases have occurred to date in Marines and 127 in Army troops (3) after return to the United States. Eighty-eight percent (42/48) of cases in military personnel in-country were due to *P. falciparum* (five cases were due to *P. vivax* and one was unspciated). In marines, most cases occurred among troops deployed near Baardera in the highly malaria-endemic southern region of the country. Several factors common to operational settings increased the likelihood of malaria infection. Many troops had to spend nights guarding river crossings and

other strategic posts near mosquito breeding sites. Although mosquitoes were abundant at night, it was not possible for many troops to sleep under bed nets, due to the nature of their mission. Insect vector control teams deployed later and were effective, but initially mosquito eradication efforts were limited. Moreover, the extremely hot and dusty environment made the use of repellents (DEET) uncomfortable. Many marines also failed on occasion to take doxycycline, the daily malaria chemoprophylactic.

Compounding these difficulties, marines in Baardera switched from daily doxycycline to weekly mefloquine in order to conform with general theater malaria policy and to improve compliance. Because it takes a few weeks to build a protective blood level of mefloquine, however, stopping the doxycycline at the same time the mefloquine was started left many marines underprotected. This drug change was associated with an increase in malaria cases. This episode highlights the importance of achieving an adequate blood level of mefloquine prior to exposure.

Almost 90 percent of the malaria

cases in marines who had returned to the United States were due to *P. vivax*. The few *P. falciparum* cases were seen in troops soon after return to the United States, while the *P. vivax* cases have occurred up to 7 months after departure. Although some drug resistance certainly exists in this area of Africa, investigation revealed that the majority of cases failed to take proper terminal prophylaxis (J.A. Newton, personal communication). As discussed, this means they left Somalia with asymptomatic liver infections, and later developed malaria when the organisms emerged from liver cells.

The malaria cases from Somalia illustrate many of the problems associated with malaria prevention in operational forces. Although it is not possible to prevent all malaria cases associated with operations in endemic areas, it is possible, through good malaria discipline, to markedly decrease the impact of the disease.

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(Part 2, *Malaria Discipline*, will appear in May-June.)

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