I. Malaria Disease and Transmission

Malaria is a parasitic protozoa that produces bloodstream infections in its hosts. Four different malarial species infect humans: *Plasmodium falciparum, P. vivax, P. ovale, and P. malariae*. The species vary in virulence, with *P. falciparum* being the most virulent and causing the most mortality[4].

Plasmodium infection often causes cycles of fevers and chills as well as anemia. Other symptoms of infection include headaches, nausea and vomiting, fever, enlarged spleen, and liver enlargement. Without treatment, *Plasmodium* infection can lead to severe disease (cardiovascular shock, pulmonary edema, acute kidney failure, etc) and death[4].

Malaria is transmitted person to person through an insect vector, the female *Anopheles* mosquito. *Plasmodium* exhibits a complex life-cycle that occurs between its human host and its *Anopheles* vector: The human host's bloodstream is infected with malarial sporozites from the *Anopheles* salivary glands after being bitten by the mosquito. For 8-14 days the sporozites multiply in the liver; they are then released to the blood and the host's erythrocytes. The organism continues to divide and mature within the blood cells, eventually bursting the cell and releasing many merozoites to infect new red blood cells. However, some merozoites in the blood go into a phase of sexual reproduction (gametocytes) and do not enter the erythrocytes—these gametocytes are taken up by biting mosquitoes. *Plasmodium* completes its sexual reproduction in the mosquito and sporozites collect in the salivary glands of the mosquito, ready to infect another host.

The geographic distribution of Malaria, particularly *P. falciparum,* centers in warm regions near the equator. Transmission can not occur at high altitudes or in cool temperatures, or in regions without the *Anopheles* vector. Transmission patterns will vary with temperature (*Plasmodium* lifecycle inside the vector depends on it), rainfall (for *Anopheles* breeding), and species of both *Plasmodium* and *Anopheles*. Currently, Sub-Saharan Africa suffers the most from Malaria.

II. The State of the Problem

Malaria causes the "greatest harm to the greatest number" of all infectious diseases[4]. It is estimated that 300-500 million individuals are infected annually, causing over one million deaths[2]. These deaths most heavily affect children in Sub-Saharan Africa[2].

Now seen as a tropical disease, Malaria was once endemic in many temperate regions such as the United States. However, in the 1950's a Global Malaria Eradication Campaign was started, and it effectively rid the United States, the former Soviet Union, and Taiwan of Malaria. It also reduced the amount of malarial disease in Latin America, southern Africa, and the Middle East [5]. Unfortunately, most of tropical Africa was ign ignored during these eradication efforts, and Ma malaria continued to be a major health threat.

There is now a resurgence of Malaria in many countries where it was once controlled, and increasing severity of disease in regions where it remained endemic throughout the century [2]. This resurgence is due to a globalized community where there is increased travel and of individuals without immunity to endemic regions. It is also caused by once rural populations' migration to urban regions, where a dense human population is prime for vector transmission of the disease.

The most troubling cause of Malaria's resurgence and increase urgency is that many inexpensive and widely used treatments for the disease are no longer effective—Plasmodium has developed resistance. The new drug therapies for Malaria are up to 20 times more expensive than traditional treatments [5], and most endemic countries can not afford them. Infections which were once treatable are becoming more and more the cause of severe disease and death.

III. Control of Malaria

Complete control and eradication of Malaria is highly unlikely now or in the future. A global eradication would need the help of a vaccine, but the infectious form of plasmodium exhibits antigenic variation, so a stock vaccine would be very difficult to develop [6].

However, even in the absence of vaccine, measures can be taken to effectively control Malaria and reduce morbidity and mortality.

Drugs may be used on the infectious agent, *Plasmodium*. Early diagnosis and treatment are critical in preventing morbidity from infection. Chloroquine is the traditional choice, but now many strains of *Plasmodium* are resistant. Due to resistance, artemisinin-based combination therapy (ACT) is now available to effectively treat Malaria infections, but ACT is much more expensive than Chloroquine [5].

There are many insecticide treatments available to prevent transmission of Malaria. ITN or insecticide-treated bed nets are effective at preventing the vector from transmitting disease, and the insecticide also kills vectors that land on them. IRS/indoor residual spraying of insecticides can also be used with similar results. Larviciding is the application of insecticides to vector breeding sites, but there is difficulty with finding the breeding sites and it requires frequent application [6].

Beyond these measures, governments, hospitals, and community infrastructure must be strong enough to educate about and carry out preventative measures and treatments.

IV. Should the U.S. government be involved in controlling the spread of Malaria?

The U.S. should absolutely be involved in controlling the spread of Malaria. Malaria is unprecedented in its numbers, both that of infections and deaths. It is also unlike any other disease in that it lays a heavy social and economic burden on the communities and countries it ravages.

As stated before, Malaria infects 300-500 million people annually and causes 1.1-2.7 million deaths [5]. Tropical Africa accounts for 90% of this burden [5]. For comparison, the terrorist attacks on 9/11 caused 2,752 deaths[10]. Using the lowest estimate of malarial deaths/year, Malaria kills 400 times as many people every year—more deaths than having one "9/11" every single day.

In addition to deaths, Malaria causes a multitude of complications and disease to those who do not die from infection: seizures, coma, severe anemia, pulmonary edema, thrombocytopenia, cardiovascular collapse, shock, acute kidney failure, and hypoglycemia[4].

It is this very heavy public health burden of human suffering that provides the first impetus for countries like the US to help. Malaria is a controllable disease that costs relatively little to cure when speaking in westernized terms. Unfortunately, the most malaria-endemic countries are also the world's poorest countries[2]. Without aid, these countries cannot purchase ACT or provide ITNs to treat and prevent Malaria.

Because these malarious countries tend to be so much lower in economic strength, they cannot effectively treat and prevent the disease. Unfortunately, the disease itself is a cause of economic distress. This is the second reason the US should be involved in Malaria control. The GDP of malarious countries grows 1.3% less every year than non-endemic countries[2], and their per-capita GDP's were 1/5 those of non-endemic countries [2]. Over 35 years this has led to a $100 *billion* dollar deficit in the GDP of Sub-Saharan African countries [8].

Malaria is also very detrimental to business in endemic countries. Malaria causes absenteeism from work, decrease in productivity, and decreased morale of workers. Many investors may steer away from endemic areas, and people in endemic countries themselves are less likely to invest in general when life expectancy is shorter [3].

It is difficult for families in endemic areas to succeed economically and be able to have "purchasing power". Because the risk of disease is so high, many farmers favor subsistence crops over cash crops because cash crops are more laborious and too risky if someone in the family falls ill [3].

> The disease has a large impact on the social demographic of endemic countries. With more children dying from malaria, families will tend to have more children, decreasing the amount of resources spent on each child and increasing the amount of time the woman spends at home taking care of children, giving little reason to invest in women's education and decreasing the amount of years a woman can be economically productive in society.

Because Malaria causes so much human suffering, and because it has such a harmful effect on the economies of endemic countries, the United States should continue to be involved in Malaria Control. Adequate aid for just a few years can resolve many problems associated with malarial disease and transmission, and create stronger economies in these countries to keep their citizens healthy enough to perpetuate the strong economy. For instance, in some endemic countries, 40% of health spending is on Malaria [7]. These countries have very poor health services and infrastructures—if the US aids in Malaria relief, those funds can be diverted towards strengthening the health systems, which will be able to adequately handle future malarial episodes.

I propose that the U.S. help fund a Malarial intervention program that involves treatment with prevention methods, centered in Sub-Saharan Africa where Malaria causes the most suffering. The program would include global subsidies for the following: ITNs for all children, preventative treatments for pregnant women (who are especially susceptible to malaria), changing treatments from chloroquine to ACT, and scaling up protocols and hospital stocks from chloroquine to ACT. For Sub-Saharan Africa, this plan costs 824 million dollars annually [5]. The U.S., in conjunction with other economic powerhouses and the World Bank, would fund this program for a minimum of 5 years until these countries had a significant decrease in prevalence of Malaria and a strengthened economy/health system infrastructure.

V. Cost/Benefit and Comparative Analysis of a U.S. International Anti-Malaria Program

At the most recent G8 summit, leaders of the world agreed to forgive nearly 40 billion dollars of debt to the world's poorest countries. Most of these countries are African, and most of these African countries are endemic with Malaria. Had Malaria been controlled in these regions 35 years ago, the GDP of these countries would be approximately $100 billion dollars greater—it is probable this debt would never have existed.

Spending money on Malaria control now will undoubtedly save money on foreign aid in the future. Besides reducing the need for foreign aid, controlling Malaria will have positive effects on the countries' economies. After successful

malaria control programs, Spain, Italy, and Jamaica all experienced economic growth [3]. In a world that is increasingly globalized, their success will translate into economic possibilities for businesses all over the world. For example, Exxon Mobile funded its own anti-malaria program in Africa, and it reported 9.8 million dollars in productivity gains after program implementation [3].

With Malaria controlled, tourist industries in Africa can develop and thrive. Better economies will increase household spending or "purchasing power", and businesses that produce consumer goods will profit and be able to exist in countries that were formerly too poor or too risky to operate in.

Every year, Malaria kills at least 400 times the amount of people that terrorist attacks on 9/11 did. The lives lost on 9/11 were the foundation for public support of the Iraqi war—Americans saw the war as a preventative measure against future terrorist attacks. While it is likely the reasons for war in Iraq are a more complex web of economic and political factors, the U.S. is currently spending 2 billion dollars/week [11]. A significant contribution to the malarial control program by the U.S. would cost less than .2% of annual spending on the war.

Even if the U.S. were to foot the bill for the entire malarial control program in Sub-Saharan Africa ($824 million annually), malaria control would cost 1/6 of the amount the United States spends annually on funding for cancer-research [9]. While cancer research is important and will save many lives in the future, malaria control can save millions of lives *right now*. It can also help bring impoverished countries out of debt and help them become participants in a strong global economy, and provide trade and investment opportunities for American businesses. It is a win-win situation—saving millions of lives, helping impoverished countries climb out of economic ruts, and increasing U.S. and business opportunities for trade and investment abroad. For the comparatively low cost, Malaria Control is a good cause that the U.S. will benefit from in the future—it is not so much foreign aid as it is an empathetic yet smart investment.