Minimizing the Impact of Malaria in Communities around Monrovia, Liberia

Artimus Russell ‘13
Department of Biological Sciences

Faculty Advisor: Alan B. Hale, Ph.D.

Thesis submitted in partial fulfillment of the requirements for the Global Diseases minor.
# Table of Contents

Acknowledgements 4

Abstract 5

Introduction 6
  - Overview 6
  - Personal Experience 7
  - Location and Population 7
  - Brief History 8

Culture 10
  - Ethnic Groups 10
  - Religion 10
  - Language 11

Major Health Concern 11
  - Malaria 11
  - Cholera 12
  - Measles 13
  - Non-Communicable Diseases 14
  - Tuberculosis 15
  - Infant Mortality 16

Risk Factors 17
  - Poor Drinking Water and Sanitation 17

Education System 19
  - Lack of Health Education 19

Political, Economic, and Social Structure 20
  - Governmental Structure 20
  - Economic Opportunities 21

Current Healthcare Systems 22
  - Hospitals and Clinics 23
  - Doctors and Nurses Availability 23
  - Educational opportunities 24

Malaria 24
  - Transmission 24
  - Prevalence 25
Implemented Solutions 25
    Community Solutions 25
    Government and Non-governmental Solutions 26

My Personal Plan 27

Literature Cited 31
Acknowledgement

I would like to extend special thanks to my family for supporting me through this project. Additionally, I would like to thank Dr. Alan Hale for affording me the opportunity to participate in the capstone course of the Global Diseases program; this course was an integral part of my self-designed major, *International Health Promotion*. I would like to say many thanks to Ms. Kenza Glass for her unwavering support in helping me pursue this opportunity. She has been that bridge over troubled waters for many students like me.
Abstract

Malaria is ranked third on the environmental burden disease chart with diarrhea coming first followed by respiratory infections. Liberia is one of the many countries in sub-Saharan Africa that has been devastated by the malaria epidemic. The main malaria vectors in Liberia are the *A. gambiae, A. funestus, A. melas, A. hancocki*. Liberia has been a part of previous malaria elimination endeavors over the past years that were spearheaded by the government in collaboration with the World Health Organization (WHO) and other non-governmental organization. The community solutions include the use of commercial insecticides, bed nets, malaria prophylactics that are sometimes given freely or at low-cost, and sometime some local remedies such as tree leaves that are believed to keep the mosquitos out are placed in bedrooms at night. The government is doing little to minimize the impact of malaria on the population; however, they are providing cheaper malaria drugs and bed nets for the population. Non-governmental organization such as (WHO) are providing education and bed nets that have been treated with insecticide. The projected solutions to the malaria epidemic will focus on environmental strategies that were used in Zambia in 1929. The project will be divided into three phases: the first educational phase will focus on educating the local people on the correlation between sanitation and the transmission of malaria; the second phase, which is the implementation phase, will focus on vegetation clearance, modification of rivers, draining swamps and oil application to open water and latrines; the third phase will focus on the maintainability of the project.
Introduction

Overview

Malaria is one of the more common infectious diseases in the world and the cause of one of the greatest public health problems that has a major implication on the economies of countries that are directly impacted by this disease (1). Over 40 percent of the world population is at risk of malaria (1). Most of the areas mainly impacted by malaria are in sub-Saharan Africa. In 2010, 90 percent of deaths associated with malaria occurred in regions of Africa (29). Those impacted most were children under the age of 5. Although increased prevention and control had led to the reduction of the malaria related mortality rates by 25 percent worldwide and by 33 percent in Africa, there is still a lot to do in reducing the malaria burden (2). Still, about 655,000 deaths were related to malaria in 2010 alone.

Liberia is one of those countries affected by the malaria epidemic. The rate of malaria burden in Liberia is about 28 percent (3) compared to other diseases in the country. Malaria is one of the leading causes of death in Liberia, and not only presents Liberian families with a burden of illness and disease but also presents a financial burden to families. The cost of treatment can be considerable, especially with payments for medicine and transport to a hospital or clinic. Illness may cause further losses because of an inability to work or a need to look after other family members, thereby preventing attendance at work. The effects of malaria on the community include substantial financial loss due to payment of treatment and consultation costs and vector control measures at the household level. Patients with malaria overburden an already over-stretched healthcare system.
Personal Experience

I was born and raised in Monrovia, Liberia. As a young child growing up, I was sick from malaria several times in a month causing me to regularly miss school for a couple of days. Although my family used insecticides every night, it did not prevent me from becoming infected. The insecticide only kept the mosquitos away for a couple of hours before the mosquitos would return. There were different types of antimalarial drugs used to treat me during that time. Antimalarial drugs like chlороquine, quinine, quinimax, and quinidine were some of the many drugs that I can remember taking to treat my malaria. Some of these drugs had some serious side effects on me. I remember symptoms like itching, delirium and rash. My parents had to pay for all my treatments from the little income they made. Some families did not have the financial means, so they had to use traditional herbs to help treat their loved ones.

Additionally, the communities around the capital of Monrovia, as I remember it, consisted of a lot of mangrove swamps and stagnant waters. After a rainfall, there would be an increase in the mosquito population for two or three days. I believe this was due to the stagnant waters and poor sanitary conditions of the area.

Location and Population

Liberia lies on the west coast of Africa (Figure 1). It is bordered on the northwest by Sierra Leone, on the north by Guinea, on the south by 300 kilometers (186 miles) of coastline on the Atlantic Ocean and on the east by Ivory Coast. Its land area is 111,370 square kilometers (43,000 square miles). The capital, Monrovia, is on the Atlantic coast. The name Liberia comes from the English word "liberty" and refers to the nation's origin as a colony of free Blacks repatriated to Africa from the United States in the early nineteenth century (3).
Figure 1. The political map of Liberia (www.lr.undp.org)

In 2001, the population of Liberia was estimated to be about 3.3 million (3). However, this projected estimate may be greater than the actual human population in Liberia due to the 14 year civil war that killed an estimated 5 percent of the population. The Kpelle are the largest ethnic group with 20 percent of the population, followed by the Bassa with 14 percent. The Kpelle tribal group is found across four counties in Liberia. All the other groups number less than 10 percent of the total.

**Brief History**

Most of the written history of Liberia begins in 1816, when an American-based organization called the American Colonization Society (ACS) was interested in finding a homeland for the emancipated slaves. By 1822, the first repatriated free men landed on Bushrod Island. More free slaves arrived over the years and by 1847 through the suggestion of the ACS
the colony declared its independence (3). In 1821, an agreement was signed between the ACS and local chiefs granting the ACS possession of Cape Mesurado. Shortly after the arrival of the freed slaves, a white American name Jehudi Ashman also followed and was very instrumental in forming the government and the digest of laws of Liberia. Socially, the ruling elite were drawn from the American settlers. The indigenous people were not included in the government; in fact, the state was based upon some 3000 settlers. The authorities in 1919 could not exercise any control past about 20 miles inland and were forced to transfer 2000 square miles of inland territory that it had claimed to France because the government could not control it. By 1912, Liberia got a loan of US $1.7 million for security and control of customs was given to the U.S. Since then the country has remained dominated by the United States. American-based companies own the two major export companies of rubber and iron ore. By the 1970s, after the death of the 19th president of Liberia, William V.S. Tubman, his vice president William R. Tolbert succeeded him. During this period, the government was very corrupt. Moreover, the price of rubber depreciated on the world market but Libya and Cuba were willing to pay more. As the 1980s rolled around, Tolbert became more interested in profiting from business with Libya and Cuba. He did not get the deal done before Samuel K. Doe killed him on April 14, 1980. Samuel Doe was the first indigenous president since independence in 1847.

The Samuel Doe government became increasingly more corrupt offering jobs only to members of his tribal group. Unemployment increased to about 50% and college graduates couldn’t find jobs. By 1989, the country was in a full scale civil war, very much along tribal lines. The rebel forces were led by Charles Taylor and Prince Johnson. The civil war lasted 14 years and some 100,000 people died.
Culture

Ethnic Groups

Liberia has many tribes that are divided into five major ethnic groups (4). The ethnic groups include the Mal that consist of the Gola and Kissi tribes; Kwa ethnic groups include the Dei, Bassa, Kru, Krahn, and Grebo. The other ethnic group is Mande-fu that includes the Kpelle, Gio, Mano, and Lorma; the Mande-ten consist of the Via, Mande, and Mandingo. The above ethnic groups are all indigenous African groups that comprise about 95% of the population of Liberia. The last group consists of the Americo- Liberian that make 5% of the population, the Congo that make up 2.5% and the Caribbean less the 1% (4).

Religion

Americo- Liberians and the Congo that were repatriated to Liberia in the 1800s brought with them cultures and traditions of the American Deep South that included the Christian faith. Most of the earlier settlers from America were of the protestant denominations, which consisted largely of the Methodist church. In 2002, it was estimated that about 40% of the population in Liberia considered themselves Christians. The Christian denominations include Lutheran, Baptist, Episcopalian, Presbyterian, Roman Catholic, United Methodist, African Methodist Episcopal (AME), and several Pentecostal churches (5). Islam makes up about 20% of the population, which is practiced mostly by the Madingo and Via tribes. The other 40% of the population practices traditional indigenous belief systems.
Language

The official language of the Republic of Liberia is English. English was first introduced to Liberia by free Black men from America in the 1820s. Other immigrant languages are spoken in Liberia including Fula, Arabic, Fante and others. Languages from the Eastern Maninkakan, Lebanon, and West Africa are some of the languages that are spoken in Liberia (6). The Bandi is spoken in the Northwest of Liberia in Lofa County and is found in Guinea. The Bassa language is found in central Liberia, in Grand Bassa county, Rivercess County, and Montserrado county. Bassa is also spoken in Sierra Leone. The Dan language is found in the north central part of the country in Nimba County. Gola is spoken in the West between the Mano and Saint Paul rivers and is also spoken in Sierra Leone. The Grebo language is found in the Southeastern region. The Kisi language is spoken in the Northwestern corner of Lofa County and is also found in Sierra Leone. Kpelle language is the largest in Liberia and is spoken in the central part of the country. The Krahn language is located in the Northeastern part of Liberia near the border with Ivory Coast. Loma is a language found in the Northwest of Lofa County. The Mano is spoken in Nimba County. Lastly, the Via language is spoken in Grand Cape Mount County.

Major Health Concerns

Malaria

Malaria poses the highest burden amongst all diseases in Liberia. Malaria is the leading cause of outpatient attendance and the number one cause of inpatient death in Liberia (7). According to the malaria indicator survey of 2011, about 33% of all inpatient deaths are due to malaria. Additionally, about 41% of all deaths among children under the age of five years are directly attributed to malaria. The fifteen years of civil war exacerbated the already poor health
care system in Liberia. Although malaria is a curable and preventable disease, it remains a major health issue in Liberia. The populations most affected by malaria are pregnant women and children (7).

**Cholera**

Cholera is an infection of the intestine that causes copious watery diarrhea, vomiting and leg cramps that could quickly lead to dehydration and death (8). Cholera is caused by poor sanitation and lack of clean drinking water. Figure 2 illustrates where most Liberians get their drinking water.

![Figure 2: Drinking water is taken from a well that is not treated.](image)

In 2003, the World Health Organization reported about 18,038 cases of cholera in Liberia, although the reported fatality rate was low (below 1%), the WHO still considers this outbreak a major epidemic (8). Again, in 2005, it was reported by the IRIN news that about 154 were killed by another outbreak of cholera in the southeast part of the country (9). The outbreak was near the diamond-rich town of Butaw about 30 kilometers from the city of Greenville. According to the health officials, this region has no clean drinking water and quality of life is deplorable. The town of Butaw has one healthcare facility to care for the entire population of about 3,892 people (9). Another limited outbreak was reported in 2012 by the New Democrat newspaper in the
Whein town community. Two people were reported dead and several others were seriously ill (10). The community blames the Monrovia City Corporation (MCC) for dumping garbage in their community that they allege created the cause for the recent cholera outbreak (10). The poor sanitation of Liberia and lack of safe drinking water had been the cause of many other diseases that has plagued this country. Figure 3 shows a cholera patient at a local cholera center near Monrovia.

![Cholera Patient](image)

Figure 3: A sick cholera patient in a hospital near Monrovia

**Measles**

Due to 15 years of civil war, Liberia is at risk for a measles outbreak as immunization coverage has dropped dramatically in the past years (11). Measles is known to be one of the biggest child killers in Africa. To avoid an outbreak in Liberia, the government and international partners are carrying out an emergency measles vaccination campaign (11) (Figure 4). The town of Tubmanburg near Monrovia marks where the first mass measles vaccination campaign began. The second campaign was held in Grand Cape Mount County where about 448 children were vaccinated and 207 children were also received vitamin A supplements (11).
Non-Communicable Disease (NCDs)

“Non-communicable diseases (NCDs), also known as chronic diseases, are not passed from person to person. They are of long duration and generally slow progression. The four main types of non-communicable diseases are cardiovascular diseases (e.g., heart attacks and stroke), cancers, chronic respiratory diseases (e.g., chronic obstructed pulmonary disease and asthma) and diabetes” (12, p.1) In 2008, an estimated 5.8% men and 6.8% women were reported to have died from NCDs. Figure 5 shows that the percentage of all deaths associated with NCDs for people under the age of 60 was 40.9% in males and 35.9% in females (12). Deaths associated with cancers per 100,000 people was reported as 91. Chronic respiratory diseases, cardiovascular diseases and diabetes were reported as 113.8 out of 100,000 in males and 65.9 out of 100,000 in females, 419.8 out of 100,000 in males and 454.2 out of 100,000 in females, respectively (12). There is not lot of data on behavioral risk factors; however, it is estimated that about 11.3% of males smoke tobacco daily.
Tuberculosis and Leprosy

The Liberia National Leprosy and TB Control Programs were established in 1989 to organize and coordinate all leprosy and tuberculosis (TB) control activities nationwide. The interruption of leprosy and TB service delivery during the civil war has contributed to the increased burden of leprosy and TB. In a bid to address this increase, Liberia endorsed and adopted the global Stop TB Partnership Strategy and the Directly Observed Treatment, Short-course (DOTS), the basic package that underpins the strategy and developed a 5-year strategic plan (2007–2012) aimed at reducing the national burden of TB (13).

Tuberculosis is still one of the major diseases affecting the population of Liberia. There is a lack of proper testing to detect the disease in its early stages before becoming fully manifested. However, the number of cases has increased since 2001 from 1771 cases to 5402 cases in 2011 (13). This increase in detection is due to the expansion of services to all parts of the country and an improvement in the capacity of the health system to diagnose and report new cases (13).
reporting of new TB cases has increased although there has been fluctuation in the cases reported (13). For example, the rate of cases reported in 2008 was 61% compared to 71% reported in 2010, while in 2006 the rate of cases reported was 64% compared to 63% reported in 2007. This figure is above the WHO recommended target of 70% because of an increase in reporting. However, sustaining and increasing access to treatment is still a great challenge. Since the beginning of improved testing, treatment rate has improved also. The success rate has increased from 67% in 2008 to 82% in 2010. Factors that led to the success in treatment are education of patients, dismissing myths associated with disease, and encouraging patients to continue treatment (13).

**Infant Mortality**

After the civil war in Liberia, about 300,000 internally and externally displaced people have returned to their homes (14). Although there has been national elections, state authority and rule of law is still in its infancy. Public health and social services are far below their pre-war status. Over half the population and an even higher proportion of the Liberian children live on less than a dollar a day. According to UNICEF, Liberia has the fifth highest infant mortality rate in the world. About 15% of infants and children under five years die before reaching their first birthday (14). Preventable diseases like malaria and measles are the leading causes of death amongst children (15). Malnutrition and respiratory infection killed an additional thousand children each year. About 40% of children suffer from growth impairment due to malnutrition. Infant mortality rate is a major health, social and economic issue in Liberia (15).
Risk Factors

Poor Drinking Water and Sanitation

In Liberia, nearly 40% of the population has no access to safe drinking water. This problem is the leading cause of outbreaks like cholera and polio (16). The WHO estimates that 11,900 people die every year due to poor drinking water and sanitation in Liberia. Along with UNICEF, the WHO also estimates that 2,600 children under the age of five die every year from diarrheal diseases in the country due to poor drinking water and sanitation (16). In November 2011, a Liberian journalist name Tecee Boley reported that the slum of West Point, Liberia is at risk of an outbreak of cholera because of the lack of safe drinking water. The residents of West Point get their drinking water from wells or by collecting rainwater. The water from both sources is contaminated and leads to death in women, children and the elderly (17). The Boley investigation ran by Pulitzer Center focused on the gap between the Liberian government’s stated intention of addressing the country’s water problem and the actual conditions experienced by the population. The result of the Boley Report shows that only 25% of the population has access to safe drinking water, while the government claims that they are working vigorously to address the water problem in the country (17). My visit to Liberia in 2012, gave me a first-hand look at the Boley Report. Although I did not travel the entire country, my observation of two of the largest cities that I visited showed that less than 25% of the population has access to any form of safe drinking water. This is one of the most alarming health risks I have been exposed to since the onset of the civil war in Liberia. And the fact that the present government is doing little to address this health risk is to me a neglect of their national duties to the people that have empowered them. Figure 6 illustrates how difficult it is to get any kind of water. Women and children have to walk miles to get water that is considered safe for drinking.
A report from Erstwhile Poverty Reduction Strategy (PRS) indicates that Liberia will need $93 million US dollars to meet its water and sanitation targets. Erstwhile PRS sought to increase Liberian access to safe drinking water from 25% to 50% by 2012; however, this target has not been met. Additionally, PRS sought to increase access to quality latrines from 15% to 40% (17). This projected target has since been reduced to 33%. According to Oxfam International, 22,000 Liberians have access to sanitation facilities out of 3.3 million; however, for Liberia to meet its
Millennium Development Goals (MDGs) by 2015, it will need to increase the current figure from 22,000 to 158,000 per year (17).

**Education System**

*Lack of Education*

The lack of education in Liberia is one of the major risk factors for contracting disease. Due to the 15 years of civil war in Liberia, human resource development was neglected, which led to a fall in the literacy rate below 32% (18). The Ministry of Education in collaboration with UNICEF conducted a study in 2003 that found 20% of schools had been destroyed, while the remaining ones are in dire need of repair (18). Moreover, most qualified teachers and educational managers were either killed or fled the country. Between 2000 and 2002, enrollment dropped dramatically due to the lack of qualified teachers (19). The gross enrollment rate for girls decreased from 72% to 35% and for boys from 73% to just 48% (19). Today large numbers of students in primary school are over-age. A recent census found that about 85% of the students in grade 1-6 were between 8-20 years old, with 50% of them being between 11 and 20 years old (19). For the secondary level, 45% of boys and 27% of girls are aged between 20 and 24 (19).

The two main universities in Liberia are the University of Liberia and the Cuttington University. The University of Liberia was founded in 1862 and is one of Africa’s oldest institutions of higher learning. The University was looted and destroyed during the war. Currently, the University is back to its prewar status. The Episcopal Church established Cuttington University college located in central Liberia in 1889 (19). Other colleges and universities that were established after the war, such as about five nursing schools are offering baccalaureate degrees and associate
degrees in nursing. Despite the slow recovery, the education system in Liberia is moving in the right direction.

**Political, Economic, and Social Structure**

*Governmental Structure*

Liberia is a unitary republic with a framework based on the model of the United States of America structure of government (20). The government of Liberia consists of three branches with equal power. The first branch of government is the executive branch headed by the president. The second branch of government is the legislative branch that is divided into two houses; the House of Representative and the House of Senates (20). The House of Representative has 64 seats elected by popular vote to serve a six year term, while the House of Senates has 30 seats elected by the people to serve for nine years. The House of Senates is the upper house while the House of Representative is the lower house. The third branch of government is the Judicial branch. The Judicial branch is comprised of a Supreme Court, criminal courts, appeals courts and magistrate courts (20).

The administrative divisions consist of the counties headed by superintendents appointed by the president and the district commissioners who head the districts and are elected by the people. Also there are paramount chiefs that are the head of tribal groups, the Clan Chiefs that head the clans and the Town’s Chief who is the head of a town that might consist of about 65-250 people. Liberia has a multi-party system. Presidential elections are held every six years. Currently the president of Liberia is Ellen Johnson Sirleaf of the Unity Party (20).
Economic Opportunities

The economic climate in Liberia is nothing close to a developed country or even close to developing countries like India and China. However, the economic climate provides a huge opportunity for local and foreign investors. The civil unrest in Liberia in the 1990’s has hampered the economics of Liberia. The destruction of many economic infrastructures like companies and local and foreign businesses resulted in a total breakdown in economic activities for almost 15 years. Now that the war has been over for eight years and security has been established over most of the country, economic activities are slowly returning to its pre-war status. Liberia is very rich in natural resources such as water, minerals, forests, and a favorable climate for agriculture, which has made this country a producer and exporter of basic products such as timber and rubber (21). Agriculture accounts for about 70% of the country’s labor force and 76.9% of its GDP (21).

The Liberian economy relies heavily on foreign aid. The United States is the largest donor of aid to Liberia followed by the EU, the World Bank, the United Kingdom, Germany, Japan, Denmark and Sweden. The People’s Republic of China and other developing nations donate less monetary funding but play a major role in the reconstruction and relief activities in Liberia (21).

Foreign investment in the country includes rubber, telecommunications, manufacturing, construction, timber, agriculture and mining. Firestone has operated one of the world’s largest rubber companies in Liberia since 1926 and continues to play a major role in the economic growth of the country (21). Arcelor Mittal is one of the largest steel companies in the world. In 2007 they increased their investment from $1-billion to 1.5- billion US dollars in new investments (21). Other new investments in the country includes a newly built five-star beach-
front resort near the capital of Monrovia by the founder of American company Black Entertainment Television (BET), Bob Johnson (21). Despite the economic growth, there is a tremendous demand for jobs in the country. Only 15% of the available workforce is currently employed and about 60% and 85% of people of working age are reported to be illiterate (21). There is a bright future for the population of Liberia as far as the economy is concerned; however, Liberia needs to be able to process most of its products in the country to increase employment opportunities. Additionally, the government needs to invest in higher education that emphasizes science and technology. Moreover, the government needs to invest in vocational training for ex-combatants and high school drop-outs to increase their potential as productive components of society.

**Current Healthcare Systems**

The healthcare system is one of the many basic resources that suffered a major impact during the Liberian civil war. Most of the hospitals and clinics were looted and destroyed by warring factions. The picture below (Figure 7) illustrates a hospital near Monrovia that was looted and destroyed during the war.

![A hospital destroyed during the civil war](www.rescue.org)

Figure 7: A hospital destroyed during the civil war (www.rescue.org)
The country’s healthcare system is now recovering from the brutal war as economic activities are rapidly expanding, with growth rate increasing to over 9% since 2007. The access to healthcare has increased from 26% in 2003 to 41% in 2008 (22). The fertility rate has decreased from 6.8% in 2004 to 5.2% in 2009 (22). The country still faces huge challenges in rebuilding the healthcare system. Currently, access to healthcare services in the country stands at 40%; however it may be lower in the rural areas (23).

There are about seven hospitals located in Monrovia. The John F. Kennedy Medical Center is the largest hospital run by the government of Liberia. The Eternal Love Winning Africa (ELWA) Hospital has been funded and run by American Missionaries since the 1960’s (24). The other hospitals include the Redemption Hospital run by the Seventh Day Adventist Church, the St. Joseph’s Catholic Hospital owned by the Catholic Church, Medicins Sans Frontieres (MSF) a non-governmental hospital and the E.S. Grant Mental Health Hospital, the only mental health hospital in the country (24). In addition, there are about nineteen other hospitals located around the country.

Doctors and Nurses Availability

The Health Minister of Liberia at the time, Walter Gwenigale, was quoted as saying that the country needs about 1,200 doctors to grapple with its post-war health situation in the country; however, there are currently only 120 available doctors and 70 of those doctors are with international non-governmental organizations and the WHO (25). He also mentioned the lack of trained nurses, midwives and laboratory technicians. Professionals in the healthcare system in
Liberia, like other civil service professions in the country, are underpaid, leading many to change professions or travel abroad for better employment opportunities (25).

**Educational opportunities**

At present, there is only one medical school in the country, which graduates about 6 to 12 students per year (26). There is no guarantee that even these graduates will ever take up assignment in the country. The medical college, which is a part of the University of Liberia, lacks modern educational materials to facilitate an appropriate learning environment, and there is a lack of electricity and running water in the student dormitories (25). Although there are reports of improvement at the medical college, it has yet to meet international standards.

**Malaria**

*Transmission*

Understanding the mode of transmission of a disease is the first step in preventing it or finding a cure for the disease. Malaria is transmitted through the bite of an infected female *Anopheles* mosquito and is not transmitted from people to people through casual contact like the common cold or flu. The *Anopheles* mosquitoes are the only type of mosquitoes known for the transmission of malaria (26). The *Anopheles* mosquitoes become infected with one of the *Plasmodium* parasites, in the case of Liberia the *Anopheles gambiae, Anopheles funestus, Anopheles melas or the Anopheles hancockt*, become infected from a previous blood meal from a person carrying *Plasmodium*. The parasites then grow and mature in the gut of the mosquito for a week or more (26). The mature parasites (“sporozoites”) then travel to the mosquitoes’ salivary glands and it infects the person it bites thereby completing the transmission process. The parasites then travel to the liver of the host, infecting the liver cells first, then the red blood cells.
In the blood, successive broods of parasites grow inside the red blood cells destroying them and releasing daughter parasites (“merozoites”) that continue the circle by invading other red blood cells (27) (Figure 8).

![Malaria transmission Process](image.png)

**Figure 8: Malaria transmission Process (WebMD.com)**

**Prevalence**

In 2007, the Center for Disease Control and Prevention in collaboration with the government of Liberia launched the President’s Malaria Initiative (PMI) program. This program was successful in reducing the malaria prevalence in the country (28). According to the CDC, the malaria prevalence in Liberia has been reduced especially among children under five years old, who are the more vulnerable. The prevalence rate of malaria decreased from 66% in 2005 to 32% in 2009 in the general population (28). Despite the decrease in cases, the Liberian Ministry of Health reported in 2011 an annual malaria tally of 1.8 million cases.

**Implemented Solutions**

**Community Solutions**

Most people within Monrovia and its suburb use multiple solutions to reduce the impact of malaria on their families including insecticides, bed nets, tree branches as traditional repellant,
and beating out mosquitoes. Some people in Monrovia use retail insecticides to kill the mosquitoes that cause malaria. Thirty minutes before bedtime, they spray the bedrooms in the house to kill mosquitoes. Others use the insecticide treated bed nets that are given out for free or for a very low price by non-governmental organizations. The mosquito coil is a very popular means of repelling mosquitoes and reducing the risk of getting malaria. The mosquito coil is a mosquito repelling incense that is usually shaped in a spiral form. It is made from dried pyrethrum powder. The typical mosquito coils measure around 15 cm in diameter and could last up to 8 hours. It is cheaper to use a mosquito coil as compared to the retail insecticides. There are also people that cannot afford the mosquito coils or the retail insecticides and do not have the opportunity to get one of the free bed nets; therefore they use traditional means, the tree branches. There is a belief that certain tree branches repel mosquitoes and are placed in the room at bedtime. The other method is beating out mosquitoes by using bed sheets or blankets to remove mosquitoes from the room just before bedtime. This is done by opening the door to the room, while keeping the windows closed and waving the bed sheet back and forth to get the mosquitoes out of the room. The door is then closed immediately to prevent mosquitoes from reentering the room. Based on personal experience, this method seems to be effective for only few hours.

Government and Non-governmental Organization Solutions

The government of Liberia in collaboration with the President’s Malaria Initiative (PMI) led by the U.S. Agency for International Development (USAID) and implemented together with the U.S. Centers for Disease Control and Prevention (CDC) launched the PMI in 2005 (29). The goals of the government and PMI are first to improve treatment by scaling up the availability,
accessibility and use of artemisinin-based combination therapy (ACT) as the first line of treatment. The second goal is to use an integrated Vector Management (IVM) approach. The third goal addresses malaria during pregnancy, and the final goal is to increase support for advocacy, health education and behavior change (29).

The PMI works with other national and international partners to reach its goals. Some of these partners include the World Health Organization, the World Bank, the Roll Back Malaria Partnership, the Global Fund to Fight AIDS, Tuberculosis and Malaria, the UK Department of International Development, and a host of other community groups and the private sector (29). The PMI focus on four interventions for malaria prevention in Liberia includes the insecticide-treated mosquito net (ITNs), the indoor residual spraying (IRS), the intermittent preventive treatment for pregnant women (IPTp) with Sulfadoxine pyrimethamine (SP), and diagnosis with rapid diagnostic tests (RDTs) or microscopy and treatment with artemisinin-based combination therapy (ACT) (29).

**Personal Plan**

After my assessment of the vulnerability that malaria poses to the residents of Monrovia and nearby communities, it is clear that there is a critical need for additional preventive measures. For any public health intervention to be successful, it has to depend heavily on the people or communities involved; therefore, community involvement is an important part of my plan (30). The proposed plan of action is based on the study published in the Journal of Tropical Medicine and International Health (31) that focuses on environmental management in addition to other existing preventive strategies to reduce and prevent malaria. The proposed plan consists of the Zambia Copper Mining Community Program launched in 1929. This program incorporated
environmental management strategies that encompassed vegetation clearance, modification of river boundaries, draining swamps, oil application to open water and outdoor latrine, and house screening (31). The plan will consist of three phases: education, implementation, and cost-effective maintenance phase. The success of this plan relies upon government and non-government organizations, as well as dedicated communities, and local, national and international volunteers and funding.

The first phase is to provide educational opportunities for the communities that will focus on behavior change as it relates to the transmission of malaria. Education will be centered around environmental factors that increase the risk of disease transmission (Figure 9). My first activity will be to meet with the community leaders and discuss my plan with them and make my case why I think this project will benefit the community financially. Once I can get the community leaders on my side, then we can plan different awareness and educational programs within the community. Awareness and teaching will be done at town hall meetings, in hospitals and clinics as patients are being discharged, and in school as part of the student health education. Posters, banners and bulletin boards will be posted all over the community to raise awareness and educate the people. We will recruit volunteers to go from door to door informing and educating the community. Once the communities understand that unclear vegetation, open outdoor latrines, and other elements are responsible for the rate of malaria incidents, the next step will be to teach them how to minimize these factors. Methods such as vegetation clearing once a week and applying oil to outdoor latrines will reduce the mosquito population. Additionally, proper disposal of trash and burning the community trash once a week will help reduce mosquito populations as well.
The next phase is implementation. This phase will require collaboration with local and international donors and volunteers. This phase will consist of draining swamps near residential areas, modification of river boundaries, and application of oil to open water and outdoor latrines. This phase will require special equipment and committed volunteers. The draining of the swamps will require water tankers that are equipped with a water pump machine. The five zones of Monrovia will require a total of five tankers that will drain swamps and open water twice a week during the rainy season and once every three months during the dry seasons. The modification of the river boundaries can be carried out by removing man-made or natural obstructions due to flooding so that the river flows more freely. When rivers are flowing freely the mosquito eggs or larvae have less chance of developing into adults or imagos. This can be done through community organizing were the community members go out to the rivers and remove objects and vegetation that are obstructing the flow of water. Standing water is ideal for the development of mosquitoes. Outdoor latrines are very popular on the outskirts of Monrovia. These facilities are infested with mosquitoes and other insects such as roaches and flies. By applying oil to these latrines twice a year, it will not only reduce the mosquito population that causes malaria but will also reduce the population of other insects that carry disease agents.
The implementation phase requires the most financial support, man-power, community commitment, and collaboration; therefore, it should only be pursued once the educational phase is successful. For the implementation phase to be successful over time, a comprehensive sustainable solution should be put into place within the community.

Maintainability is vital for the continuation of the project and is a major aspect of phase three. A project that is as cost effective to maintain as the environmental management can easily secure financial support from the government and non-governmental organizations. The 2001 study published in the Tropical Medicine and International Health Journal (31) shows that the environmental management of malaria is more cost effective than other malaria intervention methods currently in use. Therefore, it will cost less to maintain this project. Committees should be established to run different aspects of the project to ensure accountability and immediate response to problem areas. Additionally, with help from the government and non-governmental organizations like the WHO, a quarterly assessment of the mosquito populations and regular testing to see if the project is successful will be required. Moreover, malaria prophylaxis will be given to people diagnosed with malaria and to all members in the same home to prevent person to person transmission via the same mosquito(es).

My solution is based on the environmental intervention of malaria which embraces the community efforts, government cooperation, and the collaboration of national and international non-governmental organizations. Implementing this project will require all of the bodies to work together in all three phases for the project to be a success. My plan will help reduce the malaria burden on families in and around the capital city of Monrovia, while raising awareness of the environmental factors that increase the risk of contracting malaria.


31
   http://www.aho.afro.who.int/profiles_information/index.php/Liberia:Tuberculosis


   http://www.mnnonline.org/article/15295

   http://allafrica.com/stories/2012172220.html

   http://www.irinnews.org/printreport.aspx?reportid=64348

   http://www.bibl.u-szeged.hu/oseas_adsec/liberia.htm


   http://www.iss.co.za/af/profiles/liberia/LIBERIA1.HTML


   http://newsvote.bbc.co.uk/mpapps/pagetools/print/news.bbc.co.uk/2/hi/africa/7058701.stm

26. EmedTV. *Health Information Brought to Life*. Retrieved from
   http://malaria.emedtv.com/malaria_transmission.html

   http://www.cdc.gov/malaria/about/biology/

   http://www.cdc.gov/globalhealth/countries/liberia

   http://pmi.gov/countries/profiles/liberia_profile.pdf
