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Spirits and Syringes: Malaria as an Epidemic, a Spiritual Punishment, and an Act of War

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I would also like to extend my gratitude to my family and friends who have had to put up with me constantly talking about malaria for over a year now. You all have kept me sane, constantly encouraged me, reminded me to relax every once in a while, and have stood by my side throughout this long journey. Thank you!

You've Just Been Bitten: An Introduction

My foray into the world of global health was not subtle by any means. Over the course of a just few months during my junior year, I encountered the topic almost by chance and chose to dive in headfirst. At first, international health work was little more than a conversation topic in a class on Haiti and literature. The discussion lasted less than a week, but I was already hooked and craved to learn more.

Soon after this initial conversation, I received the opportunity to meet with several founders of medical nongovernmental organizations (NGOs). Over dinner, a small group of students and I learned about their career paths and visions for their organizations in the future. In talking with these visionaries, I could clearly see the passion behind their endeavors and remember thinking to myself, *I want that*. I want to be so deeply invested in and passionate about my work that I can't help but share my zeal with the world.

My first taste at doing such impassioned work came on a medical service trip to Ecuador in January of 2013. I was working as a student volunteer in mobile clinics throughout the Amazon Basin. This meant I was mostly doing the grunt work of recording patient histories, taking vitals, scribing for doctors, or counting pills in the pharmacy. Via these simple tasks, however, I began to see the true impact of the work we were doing.

On most days, upwards of 100 people filtered through our makeshift clinics, and even in the masses, the humanity of each patient was never forgotten. During the course of the week, I learned to take pulses and temperatures with almost mechanical efficiency in order to keep pace. Once I reached the point where I no longer needed to think about the technicalities of the processes, my mind was free to engage with the patients themselves. Through the words, gestures, and expressions we exchanged, I began to comprehend a tiny bit of their lives.

I don't know when it happened, but at some point that week I realized that this connection to our patients, this pure and uncensored human tie, was fuel for that passion I had wished for just months earlier. In that moment, I set my sights on working in global health. I have had ambitions of attending medical school for years. However, until my travels last year, a career in the field of medicine was a distant and comparatively vague plan. Now, armed with a cause, I have decided to focus my medical interests in international health, health equity, and public health; which brings me to this thesis.

In Ecuador, my conversations with patients would occasionally drift to topics outside the usual realm of medicine. I learned of a cleansing ritual performed using an egg to heal the body and spirit, which is often called *la limpieza*. This, among other types of ceremonial healing I encountered, aroused a number of questions. How do different cultures, especially those in low-income areas, view health and illness? How does this influence their views of foreign aid groups like us?

Since this experience, I have developed few more questions with regard to this interface between traditional and modern medicine: How do Ecuadorian cultural views on disease diverge from those of contemporary modern medicine? What are the consequences that result from a clash or coexistence of distinct interpretations of health? How can we use diverse perspectives on disease to better understand the illness itself and the delivery of medical care in international situations?

I will examine these questions through an in-depth study of one disease both in medicalized terms and in the cultural context of an endemic country. After combing through the plethora of diseases that plague low-income country in particular – where the Gross National

Income per capita is $1,035 or less – I selected malaria in the rural Amazon Basin as my focus.[1] Not only is malaria still a problem in many areas of the world, it also presents a wide range of symptoms and can at times have psychosomatic effects. Thus, malaria lends itself well to a variety of different interpretations based upon cultural context and biomedical literacy. Furthermore, the Amazon Basin is home to an extremely impoverished and isolated indigenous population. Many communities throughout the region lack access to basic healthcare from the government, and instead they rely on local shamans or more recently foreign NGOs for all healthcare.

The first section of this thesis will be a disease profile of malaria: its clinical presentation, treatment, and prevention. In beginning with a biomedical discussion of malaria, I seek to provide a sound basis through which the understanding of malaria held by the indigenous people of rural can be understood and analyzed.

Next, I will present a case study of malaria in rural Amazon Basin region of Ecuador including an introduction to the cultural background of the area, the local perspectives on disease, and how indigenous population interacts with healthcare providers. This section is meant to set up the conflict of perception that occurs when outside medical providers – either foreign or Ecuadorian – bring modern medicine into a community where pills, blood tests, and shots are completely foreign concepts.

Finally, I will end with an analysis of the challenges and advantages of this collision of medical cultures. In this section will including a series of recommendations for minimizing the negative effects and augmenting the benefits of a cross-cultural health clinic environment.

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[1] "How We Classify Countries." *The World Bank*. N.p., 2014. Web. 08 Jan. 2014.

Consequently, my case study of the Amazon Basin Ecuador can serve not only as one example of how divergent disease perceptions can affect efforts to combat disease, but can also act a model for strategies of cultural sensitivity that can be scaled up and used across varying cultures.

Malaria is a complex disease that delivers a multifaceted collection of symptoms. While this is one of the reasons I chose it as a focus for this thesis, it is also the reason I must begin with a disease profile. Understanding the epidemiological, cultural and environmental effects of endemic malaria in a community begins with understanding the biomedical basis of the disease. This includes the parasite lifecycle, the effects of malaria on the body, current prevention strategies and the treatments used in western medicine. From this foundation, the disease can be better understood in the specific context of the Amazon Basin of Ecuador

Malaria: A Disease Profile

Since 1957 in the United States, Malaria has existed only as a distant concern to all but travelers to the endemic areas of Sub-Saharan Africa, South America, or Southeast Asia. [2] In these endemic areas, however, it incessantly wreaks havoc in families, communities, and whole societies. Throughout the world, there are over 200 million cases of malaria annually resulting in over 600,000 deaths. About 80% of these deaths occur in just 14 countries and children and pregnant women are disproportionately affected. At one time, malaria was prevalent throughout the world, but now it is seen mostly in the subtropical areas of Africa, Asia, Central and South America. However, this still means that about almost half of the world's population (3.3 billion people) is at risk for the disease.[3]

Therefore, even though mortality rates for malaria have been falling since 2000, much work still remains to be done in order to get the disease under control. [4] While malaria, as one of the "Big Three" infectious diseases, has a healthy supply of funding from international sources such as the Global Fund, and private donors, such as Bill Gates, there remains debate on the best ways to use the available money. Additionally, the malaria parasites are becoming increasingly more resistant to some of the common antiparasitic drugs used today, necessitating further investment in the research and development of a new therapies.

Before we can look into treatment options being utilized around the world, we must understand how malaria infects its human host and is transmitted from one host to another.

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[2] Zucker, Jane R., MD. "Changing Patterns of Autochthonous Malaria Transmission in the United States: A Review of Recent Outbreaks." *Emerging Infectious Disease* 2.1 (1996): 37-43. *National Center for Biotechnology Information*. Web.

[3] Perkins, Douglas J., Tom Were, Gregory C. Davenport, James B. Hittner, and John M. Ong'echa. "Severe Malarial Anemia: Innate Immunity and Pathogenesis." *International Journal of Biological Sciences* 7.9 (2011): 1427-442. *National Center for Biotechnology Information*. US National Library of Medicine, 2 Nov 2011. Web.

[4] "Malaria." *World Health Organization Media Centre*. World Health Organization, 2013. Web.

Knowledge of the mechanisms of infection and transmission of malaria, though complex, is crucial for identifying targets for potential drugs, vaccines, or other therapies.

There are four malaria strains known to cause illness when transmitted to humans. They are *Plasmodium falciparum,* the deadliest and most common strain, *Plasmodium vivax*, another very common strain that is less well understood, *Plasmodium malariae, and Plasmodium ovale*. All strains of *Plasmodium* parasites are transmitted to humans via the vector of the *Anopheles* mosquito. Of the twenty different species of *Anopheles* mosquito most bite almost exclusively at night – hence the effectiveness of using bed nets to prevent malaria – and breed in standing water.[5] My focus will remain on *P. falciparum* and *P. Vivax* for the most part since they are the two most prevalent strains. These two stains are similar in many ways, so I will first explain the lifecycle, pathology, treatments, and complications of *P. falciparum*, which are more intimately understood. Then, I will highlight the differences that exist in the characterization and mechanism of *P. vivax,* as there are some very important ones.

Because the *Plasmodium* parasites rely on mosquitos as a vector, environmental conditions that affect mosquito survival also have an impact on the intensity and extent of malaria infections. Some of these factors include rainfall patterns, temperature and humidity, and seasonal changes.[6] Another influence on infection rates is the development of human immunity to malaria. In areas of moderate or high transmission, partial immunity and immunity to the common symptoms of malaria are built up over time due to repeat infections. This is why the most serious, life-threatening infections occur in children under 5 years old, those who are under nourished, or those who are immunocompromised. Though this adaptive immunity does provide

[5] Perkins, Douglas J., Tom Were, Gregory C. Davenport, James B. Hittner, and John M. Ong'echa. "Severe Malarial Anemia: Innate Immunity and Pathogenesis." *International Journal of Biological Sciences* 7.9 (2011): 1427-442. *National Center for Biotechnology Information*. US National Library.
[6] Ibid.

some protection for the individual from the effects of sever symptoms, it does stop transmission of the parasite.

The Lifecycle of the Malaria Parasite

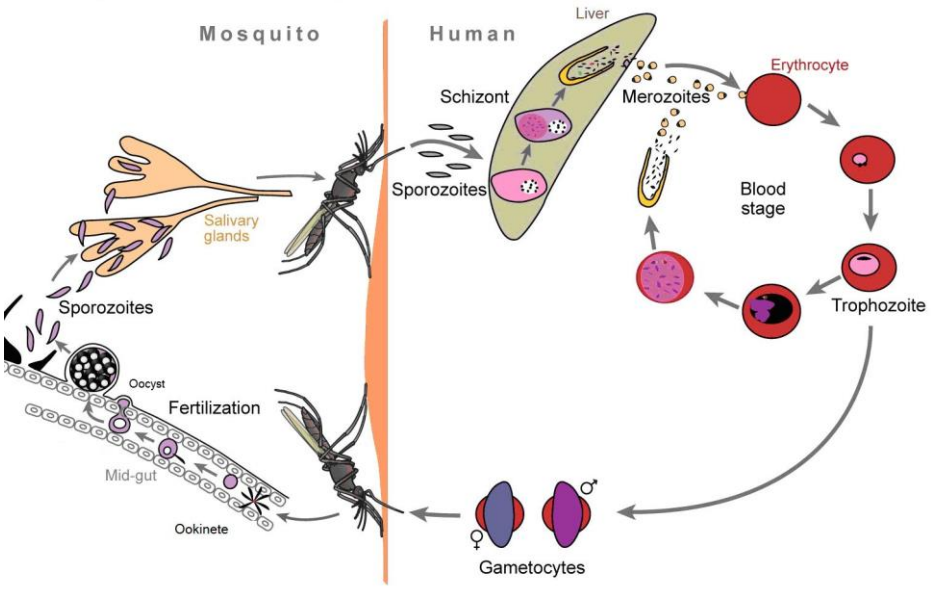
A malaria infection by begins with the injection of *P. falciparum* sporozoites, a spore-like stage of the parasite's lifecycle, into a human host by way of a female *Anopheles* during a blood meal. The sporozoites the briefly circulate in the bloodstream before entering hepatocytes or liver cells. Sporozoites will reside here for the next 7-15 days.[7] This is called the incubation period – the time between initial infection and the presentation of symptoms. While in the hepatocytes, *P. falciparum* grow, divide, and produce haploid merozoites, which are able to invade red blood cells – also called erythrocytes.

Once merozoite production causes hepatocytes to rupture and the parasites are dumped into the bloodstream, they begin infecting erythrocytes. Inside the red blood cells, the merozoites undergo a type of asexual replication called schizogony. In schizogony, merozoite undergoes nuclear division several times resulting in many daughter nuclei contained within the cytoplasm creating what is called a schizont. When the schizont cytoplasm divides, around 12-16 new merozoites are formed.[8] This asexual replication continues until the erythrocyte bursts and releases all the daughter merozoites into the blood, which can infect more erythrocytes continuing the cycle.

The classic malarial symptoms of cyclical fever and chills are associated with the periodic and synchronous release of merozoites, which signals the release of cytokines – cell

[7] "Malaria." *Life Cycle of the Parasite*. National Institute of Allergy and Disease, 3 Apr. 2012. Web.
[8] "Malaria" *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 08 Feb. 2010.

signaling molecules – TNF α and Interleukin–1 causing an inflammation response.[9] Another complication arises when erythrocytes that have been parasitized but not yet lysed are sequestered or adhere to the endothelial cells in the narrow capillaries of various organs.[10] Adhesion is thought to be a result of modifications to the erythrocyte membrane induced by the presence of the merozoites. Sequestration usually only occurs in advanced stages of infection and contributes to the fatality of severe malaria in affected individuals.



Parasite Lifecycle: There are two separate stages in the complete lifecycle involving both human and mosquito. Additionally, there is a sub cycle in the human blood stage causing the development of malaria[11]

Some merozoites break the blood stage cycle and instead, develop into sexual male and female gametocytes that circulate freely in the bloodstream and are injected by a new mosquito during a blood meal. These gametocytes are precursors to the sexual forms of *P. falciparum*

[9] Miller, Louis H., Michael F. Good, and Genevieve Milon. "Malaria Pathogenesis." *Science* 264 (1994): 1878-863. *Science Magazine*. AAAS. Web.
[10] Haldar, Kasturi, Sean C. Murphy, Dan A. Milner, Jr., and Terrie E. Taylor. "Malaria: Mechanisms of Erythrocyte Infection and Pathological Correlates of Severe Disease." *Annual Review of Pathology: Mechanisms of Disease* 2 (2006): 217-49. *Annual Review of Pathology*. Annual Reviews, 2007. Web.
[11] Fazekas, Balazs. "An Eradicating Vaccine for Plasmodium Falciparum: Possibility or Pipe-dream?" *Cambridge Medicine Journal* 37 (2011): n. pag. Web.

(gametes) that develop in the stomach of the mosquito and are carried again as sporozoites to the next human host. [12]

The traditional clinical presentation of malaria is best defined by its cyclical pattern of fever and chills driven by the erythrocyte stage of the infection. These symptoms can be accompanied by fatigue, nausea and headaches that vary in intensity. Treatment is most effective at this point in the infection, but in many malaria endemic regions is not usually easily accessible. If the infection becomes severe, a patient can develop hypoglycemia or low blood sugar; lactic acidosis – the buildup of lactic acid due to liver failure; anemia – a deficiency of healthy red blood cells to deliver oxygen and nutrients to body tissues; and altered consciousness.[13] Factors determining the development of severe malaria complications are complex and include interactions between the patient's immune responsiveness, parasite strain, environmental conditions, and age at infection among others.

Pathologies of Severe Malarial Complications

Cerebral malaria is the best-studied and most serious form of severe malaria mostly because it is a factor in a majority of malaria deaths. While there are many theories that deal with its causes, a main component of the development of this severe complication is likely the sequestration of parasitized erythrocytes in the brain, which causes obstruction of the small but vital blood vessels surrounding the brain. Although the relationship between sequestration in the brain and cerebral malaria remains indirect at the moment, it is thought that the obstruction of blood flow leads to hypoxia, reduction of metabolite exchange, and the release of inflammatory

[12] "Malaria." *Life Cycle of the Parasite*. National Institute of Allergy and Disease, 3 Apr. 2012. Web.
[13] Haldar, Kasturi, Sean C. Murphy, Dan A. Milner, Jr., and Terrie E. Taylor. "Malaria: Mechanisms of Erythrocyte Infection and Pathological Correlates of Severe Disease." *Annual Review of Pathology: Mechanisms of Disease* 2 (2006): 217-49. *Annual Review of Pathology*. Annual Reviews, 2007. Web.

mediators all causing damage to the surrounding tissue.[14] A diagnosis of cerebral malaria in practice is non-specific and based on the presence of systematic severe malaria symptoms along with altered consciousness, seizures, retinal changes and in the most extreme cases coma.

Clinically, those with cerebral malaria – most often young children – exhibit extremely high concentrations of parasites circulating in the bloodstream as well as elevated levels of TNF α and other inflammatory cytokines in cerebral tissues. These cytokines recruit immune cells to attack the parasite. However, in the process they also damage surrounding host tissue. A combination of this inflammatory stress and anoxia due to the adherence of erythrocytes to endothelial walls leads to the cerebral damage. Discernible signs of damage during a comatose state can be brain swelling, intra cranial hypertension, retinal changes and damage, and abnormalities in brain stem controlled functions such as posture, pupil size and reactivity, and respiratory patterns.[15] Additionally, systemic effects can include worsened anemia, metabolic acidosis, electrolyte imbalance, fever, hypoglycemia and some cases seizures. These symptoms are indicative of systemic shock due to both the presence of a pathogen in the blood as well as inflammation, oxygen depletion, and damage in the brain.

Without treatment, cerebral malaria is almost always fatal, and even when treatment is given, up to 30 percent of children who progress to the cerebral stage still die. Furthermore, in those who survive cerebral malaria about 10 percent are likely to be permanently disabled.[16] Since young children are those most likely to develop cerebral malaria and other complications,

[14] Mackintosh, Claire L., James G. Beeson, and Kevin Marsh. "Clinical Features and Pathogenesis of Sever Malaria." *Trends in Parasitology* 11.12 (2004): 597-603. *Science Direct*. Elsevier B. V. Web.
[15] Idro, Richard, Kevin Marsh, Chandy C. John, and Charles RJ Newton. "Cerebral Malaria; Mechanisms of Brain Injury and Strategies for Improved Neuro-Cognitive Outcome." *Pediatric Research* 68 (2010): 267-74. *Nature*. Nature Publishing Group, 2010. Web.
[16] Idro, Richard, Kevin Marsh, Chandy C. John, and Charles RJ Newton. "Cerebral Malaria; Mechanisms of Brain Injury and Strategies for Improved Neuro-Cognitive Outcome." *Pediatric Research* 68 (2010): 267-74. *Nature*. Nature Publishing Group, 2010. Web.

these permanent disabilities and loss of life can be devastating not only for a family, but also for the entire community.

Brain damage sustained by children who survive cerebral malaria can include blindness; ataxia – uncoordinated movement; central hypotonia – poor muscle tone; epilepsy; and impaired cognition, speech/language, and motor function.[17] These effects vary depending on the region of the brain in which sequestration occurs, severity of the inflammatory response, and other factors associated with individual variation in brains. Also, unfortunately, since cerebral malaria is so often fatal, few studies have focused on rehabilitation for children with malaria associated cerebral damage. If malaria treatment effectiveness improves, the need for rehabilitation through physical, occupational, behavior, and speech therapy in endemic regions will likely rise as well with more children surviving bouts of severe malaria.

Another major source of mortality within malaria infections is malarial anemia, which is generally defined as a reduction in hemoglobin (the oxygen carrying protein present in erythrocytes) levels below 11.0 g/dL.[18] Although it does have a lower case fatality rate than cerebral malaria – about 10 percent – its incidence rate is much higher. Especially in areas where nutritional and immunological deficiencies in infants, youth, and pregnancies are common, malarial anemia can be devastating. Additionally, in malaria endemic areas, blood transfusion, which can be life saving in the case of malarial anemia, are either unavailable, or not easily accessible.

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[17] Idro, Richard, Kevin Marsh, Chandy C. John, and Charles RJ Newton. "Cerebral Malaria; Mechanisms of Brain Injury and Strategies for Improved Neuro-Cognitive Outcome." *Pediatric Research* 68 (2010): 267-74. *Nature*. Nature Publishing Group, 2010. Web.

[18] Haldar, Kasturi, Sean C. Murphy, Dan A. Milner, Jr., and Terrie E. Taylor. "Malaria: Mechanisms of Erythrocyte Infection and Pathological Correlates of Severe Disease." *Annual Review of Pathology: Mechanisms of Disease* 2 (2006): 217-49. *Annual Review of Pathology*. Annual Reviews, 2007. Web.

Like in cerebral malaria, the precise mechanisms of malarial anemia are uncertain. However, two major causes are likely the lysis of uninfected erythrocytes along with infected ones and the decrease in formation of blood components due to the overexpression of cytokines.

The clearance of both uninfected red blood cells may be in part due to the deposition of parasite ligands on the surface of the unaffected cells by affected cells. This tagging then results in their clearance from circulation by sequestration in the spleen. Another proposed factor in erythrocyte clearance could be linked to oxidative damage or other subtle alterations to the plasma membrane of healthy cells.[19] It is also important to note that development and severity of malarial anemia is not only dependent on the concentration of parasites in the blood, but also on subtle effects such as these to healthy blood cells and individual immune strength.

The other major contributor to malarial anemia, especially in children, is suppression of bone marrow resulting in impaired erythropoiesis (generation of new erythrocytes). Loss of the ability to produce new erythrocytes then translates to an inability to compensate for the loss of infected red blood cells. Studies of patients with severe malarial anemia show significant structural damage to bone marrow, reduction of erythropoietic (erythrocyte precursor) production, and excessive growth of immature and abnormal erythroid precursors.[20] The combination of these findings demonstrates a link between the reduction of erythropoiesis due to bone marrow damage and the aggravation of malarial anemia.

Damage to bone marrow as a result of a severe *P. falciparum* infection has not been completely pinned down to a single source, but an imbalance of inflammatory signals appears to

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[19] Haldar, Kasturi, Sean C. Murphy, Dan A. Milner, Jr., and Terrie E. Taylor. "Malaria: Mechanisms of Erythrocyte Infection and Pathological Correlates of Severe Disease." *Annual Review of Pathology: Mechanisms of Disease* 2 (2006): 217-49. *Annual Review of Pathology*. Annual Reviews, 2007. Web.

[20] Perkins, Douglas J., Tom Were, Gregory C. Davenport, James B. Hittner, and John M. Ong'echa. "Severe Malarial Anemia: Innate Immunity and Pathogenesis." *International Journal of Biological Sciences* 7.9 (2011): 1427-442. *National Center for Biotechnology Information*. US National Library

play a major role. During the immune response to *P. falciparum* infection, the body produces an abundance of both pro- and anti- inflammatory mediators including cytokines, chemokines, growth factors, and effector molecules as an attempt to control parasitemia. The release of these inflammatory factors is extremely time sensitive, and can either successfully regulate parasite levels, or conversely, can induce damage in host tissues including bone marrow.

Both cerebral malaria and malarial anemia are major contributors to the death toll of *P. falciparum*. While experts don't completely understand the mechanisms behind why severe malaria complications develop only in some patients, they do have an idea of the general factors involved. The main contributors to both cerebral malaria and malarial anemia seem to be parasitemia or very high concentration of parasites in the blood, and the effects of excess cytokine release, which causes damage to host cells but is unable to summon a sufficient immune response

Malaria in Pregnancy

There are several reasons malaria is exceptionally dangerous to pregnant women as well as young children. One of the biggest involves their need for extra resources in order to support the healthy growth of the fetus. Many times in low-income areas, they are malnourished which leaves them more vulnerable to disease. Therefore, pregnant women are often affected by severe malarial complications for very different reasons than young children who are the other main victims of serious disease. In general, pregnant women, have a higher incidence of anemia or insufficient amounts of erythrocytes in the blood. This preexisting anemia results in a higher likelihood of succumbing to severe malarial anemia if infected.

Additionally, a malarial infection during pregnancy presents the risk of sequestration of parasite-infested erythrocytes in the placental blood vessels. Such an even then can result in fetal growth retardation and premature delivery in addition to a decline in maternal health.

Treatments

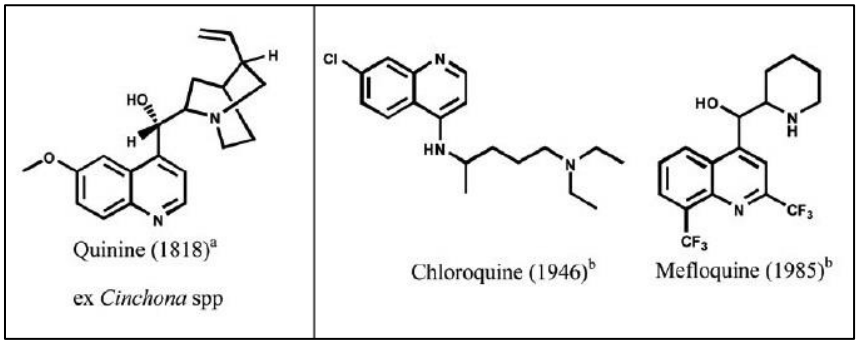
The first widely used effective treatment for malaria was quinine, a compound naturally found in the bark of cinchona tree and first discovered by the Quechua people of Ecuador, Peru and Bolivia.[21] Quinine was subsequently the antimalarial drug of choice until the 1940's when new drugs, such as the quinine derivative, chloroquine, harboring less unpleasant side effects began replacing it in treatments. However, in critical situations, such as severe and cerebral malaria, quinine is still used. In general, quinine is an antipyretic, meaning it is used to prevent or reduce fevers, and an analgesic or pain reliever that can be given in oral form or as an intramuscular injection.[22]

Initially, the Quechua used ground bark of the cinchona trees mixed with sweet water, which produced what we now know as tonic water, in order to halt shivering.[23] After they introduced European explorers to this treatment, it was brought back to Europe and first officially used to treat malaria in 1631.[24] Though the connection originally made between the shivers quinine was originally used to treat and the shivers occurring as a symptom of malaria was incorrect, quinine was still successful as a treatment. Then, in the 1930's a derivative of

[21] Toovey, Stephen. "The Miraculous Fever-Tree. The Cure That Changed the World." *Travel Medicine and Infectious Disease* 2.2 (2004): 109-10. Print.
[22] "Quinine (DB00468)." *Drug Bank*. The Metabolomics Innovation Centre, 2013. Web.
[23] Flückliger, Friedrich A., and Daniel Hanbury. *Ptharmacographia: A History of the Prinicpal Drugs of Vegetable Origin Met with in Great Britain and British India.* London: Macmillan and Co. 1879.
[24] Toovey, Stephen. "The iraculous Fever-Tree. The Cure That Changed the World." *Travel Medicine and Infectious Disease* 2.2 (2004): 109-10. Print.

quinine called chloroquine quickly became the preferred antimalarial drug. Though still toxic at higher doses, it is slightly safer than pure quinine.

Interestingly, it is the oldest of the known treatments for malaria, the mechanism of action for quinine and its derivatives against *P. falciparum* are still unknown. The most widely agreed upon model involves quinine acting as an inhibitor of heme breakdown inside the parasite. Due to the fact that its structure contains multiple amines – in the figure below, these are the two nitrogens (N) in each compound – quinine preferentially accumulates in the lysosomal compartment of the parasite where it inhibits proper heme breakdown by the parasite leading to the accumulation at toxic levels of bilirubin, partially degraded heme. This buildup then ultimately stimulates apoptosis or programmed cell death.[25]



Quinine and Derivatives: Chemical structure for the antimalarial compound quinine, which was isolated from the cinchona tree, is depicted on the left. Two of its synthetic derivatives are on the right[26]

Unfortunately, as mentioned earlier, quinine in therapeutic doses has the potential to cause serious adverse side effects. The main complication sited in conjunction with quinine treatment is the development of cinchonism, which is a syndrome caused by the accumulation of toxic levels of cinchona alkaloids in the body. Its symptoms can range from mild blurred vision,

[25] "Quinine (DB00468)." *Drug Bank*. The Metabolomics Innovation Centre, 2013. Web.

[26] Dolabela, Maria Fâni, Salma G. Oliveira, José M. Peres, José M.s. Nascimento, Marinete M. Póvoa, and Alaide B. Oliveira. "In Vitro Antimalarial Activity of Six Aspidosperma Species from the State of Minas Gerais (Brazil)." *Anais Da Academia Brasileira De Ciências* 84.4 (2012): 899-910. Print.

nausea, weakness, and vertigo to more serious hypotension, premature ventricular contractions and in the most severe cases cardiac arrest.[27] Due to these potentially serious side effects, once new medications based on a different herbal derivate artemisinin were discovered to be more effective with less of the severe side effects, quinine was relegated to treatment of only the most severe malaria. Even the safer derivatives of quinine – namely chloroquine, which was until the 1990's the most widely used malaria treatment – are now used only sparingly compared to newer treatments.

Since the early 2000's the gold standard for malaria treatment worldwide has been artemisinin based combination therapy (ACT), which combines several antimalarial drugs in order to prevent the development of drug resistance. The core component of the treatment is artemisinin, is isolated from *Artemisia annua*, a sweet wormwood herb that has been used for over two thousand years in traditional Chinese medicine. Its effectiveness against malaria was discovered as part of a 1972 study including the evaluation of over 5000 traditional Chinese medicines. Artemisinin was found to be not only effective, but also able to clear malaria parasites from the body faster than any known drug.[28] One concern with the drug however, was its potential structural instability.

The effectiveness of artemisinin is derived from its structure, however. The chemical is a sesquiterpene with a rare peroxide bridge – a direct bond of two oxygens to one another, which is the cause of its unique antimalarial qualities. The endoperoxide linkage between oxygens acts a trigger for the molecule to explode in the presence of infected erythrocytes. One major proposal for the activation of artemisinin is reduction by iron contained within the malaria parasites.

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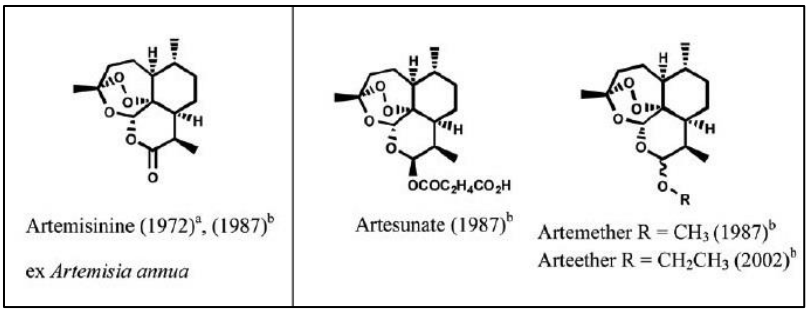
[27] "Quinine Side Effects." *Drugs.com*. N.p., 2013. Web.

[28] Miller, Louis H., and Xinzhaun Su. "Artemisinin: Discovery from the Chinese Herbal Garden." *Cell* 146.6 (2011): 855-858. *Science Direct*. Elsevier B. V., 16 Sept. 2011. Web.



Artemisinin and Derivatives: The chemical structure of artemisinin is on left, and the structures of two of its synthetic derivatives are on the right

When the peroxide bridge comes in contact with iron (II), it is cleaved and releases highly reactive radical oxo-iron species, which then proceed to destroy the parasite through disruption of redox homeostasis. Artemisinin targets only erythrocytes infected by malaria because these cells have a sustained pool of iron (II) that were once a part of hemoglobin. During the invasion of an erythrocyte, malaria merozoites consume and digest hemoglobin releasing the heme (iron) group. These iron atoms are then able to directly reduce the peroxide bond causing the activation of the artemisinin "bomb" and subsequent oxidative damage.[29]

Despite the many structural advantages to using artemisinin for malaria treatment, one significant obstacle was the compound's poor solubility in both water and oil. This property severely limited deliverability of the drug. Therefore, instead of using pure artemisinin, treatments today utilize derivatives of the compound that still maintain the crucial peroxide bridge, but also have improved bioavailability.[30] Another branch of research is currently looking into synthetic products with similar antimalarial properties as artemisinin.

One of those synthetics is called artesunate. It is a water-soluble derivative of artemisinin. This means that it can be given as an intravenous injection, which are more effective and faster acting than a pill form of the drug. Artesunate has been shown to be more effective at preventing

[29] Brown, Geoff. "Artemisinin and a New Generation of Antimalarial Drugs." *Education in Chemistry* (2006): *Royal Society of Chemistry*. Royal Society of Chemistry, July 2006. Web.
[30] Brown, Geoff. "Artemisinin and a New Generation of Antimalarial Drugs." *Education in Chemistry* (2006): *Royal Society of Chemistry*. Royal Society of Chemistry, July 2006. Web.

deaths from severe malaria than quinine through several randomized control trials, It has quickly become the recommended first line treatment for severe in adults and is currently being tested in children.[31]

In structural terms, the major difference between artemisinin (along with many of the other artemisinin derivatives) and artesunate is the addition of a succinic acid to the lactone ring. This addition of a hydrophilic (water-loving) side chain allows the drug to mix well with water and travel through the blood effectively. This is a major breakthrough in malaria treatment as the insolubility of antimalarial compounds has been one of the biggest challenges in the fight against malaria.

In order to combat drug resistance in *P. falciparum,* all types of artemisinin treatments often contain other antimalarial compounds. Artemisinin, as the fastest and most effective antimalarial, acts quickly to eradicate a majority of the parasites. Then, the other slower partner drugs eliminate any remaining parasites. This ensures that if by chance the artemisinin-based drug doesn't kill a few parasites, they don't survive to reproduce and create more resistant parasites.

The Emergence of Drug Resistance in P. falciparum

Though significant efforts have been made to minimize the development of drug resistance in malaria strains through the use of combination therapies and strict treatment regimens, the problem is a very real one. Since the introduction of chloroquine (CQ) as the main antimalarial treatment in the 1950's, a CQ resistant mutant of *P. falciparum* has been spreading

[31] Dondorp A., F. Noston, K. Stepniewska, N. Day, and N. White. "Artesunate Versus Quinine for Treatment of Severe Falciparum Malaria: A Randomised Trial." *The Lancet* 366 (2005): 717–725. Print.

rapidly through malaria endemic regions.[32] Resistance developed so quickly due to the practice of monotherapy or using only one drug to treat patients. For this reason, the World Health Organization (WHO) now recommends combination therapies for treatment of malaria.

While most strains of *P. falciparum* are still sensitive to the artemisinin-based drugs are more expensive to manufacture making the wide distribution necessary to fight the spread of the disease challenging and imposing large societal costs in the process. Even more concerning is the fact that in several countries in the Greater Mekong sub-region of Southeast Asia, artemisinin resistance of *P. falciparum* have been detected.[33] The spread of such resistance to other endemic areas could mean the loss of recent, hard-earned gains in the fight against malaria. This is because as of yet, there are no alternative antimalarial medicines available, and furthermore, it will be at the very least a few decades for the development, testing and approval of a new treatment if one can be found.[34]

Therefore, a public health driven movement to avoid the development of resistance to our best treatment option has also been in progress. This movement utilizes a combination of disease ecology, epidemiology, genetics, and evolutionary biology in order to track the evolution of the parasite and the dynamics of its spread throughout populations.[35] Hopefully, such an effort will prevent the need to search for novel drugs to fight malaria and the focus can stay on utilizing the tools we have in the most effective ways.

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[32] Kim, Yuseob, and Kristin A. Schnieder. "Evolution of Drug Resistance in Malaria Populations." *Nature Education Knowledge* 4.8 (2013): *Nature*. Nature Publishing Group, 2013. Web.
[33] "Malaria." *World Health Organization*. World Health Organization, 2013. Web.
[34] Kim, Yuseob, and Kristin A. Schnieder. "Evolution of Drug Resistance in Malaria Populations." *Nature Education Knowledge* 4.8 (2013): *Nature*. Nature Publishing Group, 2013. Web.
[35] Kim, Yuseob, and Kristin A. Schnieder. "Evolution of Drug Resistance in Malaria Populations." *Nature Education Knowledge* 4.8 (2013): *Nature*. Nature Publishing Group, 2013. Web.

Prevention

On the other side of the fight, there are two major forms of prevention, which are used in most countries where *P. falciparum* is endemic. The first is the use of insecticide-treated mosquito nets. They have been touted as a miracle for the cost effective prevention of malaria, and if used properly can be just that. These nets are most often provided for free or for a small fee to those in high-risk areas and are effective at keeping the *Anopheles* mosquitos, which are usually most active in the evenings and at night, at bay. The other widely used prevention strategy is indoor spraying with residual insecticides. This method can be very effective if at least 80 percent of the houses in an area are sprayed, and can last for up to 9-12 months in some cases.[36] Both of these prevention methods are in use in many endemic areas, but full coverage is proving to be quite challenging due to the inaccessibility of some at risk populations and the difficulty of ensuring complete and proper compliance regarding the use of these prevention strategies.

The difficulty of full utilization of current prevention techniques has also contributed to a push to find a vaccine that could produce immunity to the *P. falciparum* parasite. This approach has not been without its own obstacles, however, many of which are derived from the complexity of the parasite life cycle. Unlike many bacterial or viral infections, parasites have many different forms they take on in the human body and its life cycle in the human body is also less well understood. This makes it challenging to develop a vaccine that will correctly elicit the immunological memory, which will allow the body to recognize and fight *P. falciparum* before it takes hold in the erythrocytes.

[36] "Malaria." *World Health Organization*. World Health Organization, 2013. Web.

Scientists have been in search of a viable vaccine since the early 20th century. Many early attempts mimicked those used to create the first vaccines to bacteria and viruses involving the injection of malaria sporozoites, which had been inactivated by formalin, a 40 percent formaldehyde solution.[37] Although these sporozoites are the form in which the body first encounters *P. falciparum* in a natural infection, it failed to produce immunity in tested subjects. In retrospect, this vaccine was developed before in was known that the parasite had a liver stage and that the liver stage was crucial for triggering the immune response.

Since we have learned more about the intricate life cycle of *P. falciparum*, research on a malaria vaccine has shifted in order to better activate the immune system in the same way the virus would. Research has also diverged into two camps as techniques for creating more advanced and safer vaccines have arisen in the past 30 years.

One branch has pursued the creation of a subunit vaccine against malaria. A subunit vaccine is one made up not of an entire pathogen, but rather, only of the specific antigens on that pathogen that elicit the best immune response.[38] In this case, an antigen is most often a specific protein bound to the surface of the pathogen, which immune cells will bind with and recognize as foreign starting a cascade of responses. Any pathogen will have many different antigens on it with eliciting stronger immune reactions than others. These subunit vaccines reduce the chance of any adverse reaction and completely eliminate the chance of contracting the disease from its vaccine.

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[37] Good, M. F. "Pasteur Approach to a Malaria Vaccine May Take the Lead." *Science*341.6152 (2013): 1352-353. Print.

[38] "Vaccines." *National Institute of Allergy and Infectious Disease*. U. S. Department of Health and Human Services, 3 Apr. 2012. Web.

Currently, the best candidate of many subunit vaccines being tested is called RTS,S, which is based off the protein coat on the sporozoite that initially infects humans.[39] Researchers hope that with the use of this vaccine, immunized patients will develop antibodies for the specific proteins present on malaria sporozoites. Then, if infected, their immune system will recognize the proteins on the sporozoite coat and elicit a stronger and quicker response to the parasite than an unimmunized patient would. This vaccine is currently in phase III clinical trials in various malaria endemic countries in Africa and is showing promise. However, this approach is far from perfect. Two caveats for the RTS,S vaccine are its efficacy and the duration of protection.

First of all, its efficacy is only 30 – 50 percent, meaning only that percentage of subjects who received the vaccine was protected against a later challenge infection. Additionally, the protection delivered by the RTS,S vaccine appears to last at maximum only 3 months.[40] While this is does mean that some people who received the vaccine would indeed be protected for a time, it is uncertain whether this relatively low protection rate is worth the time, money, and man power needed to distribute the vaccine through endemic regions.

The other branch of malaria vaccine research is revisiting an approach that was initially developed over 30 years ago in 1967. This original approach used irradiated sporozoites from the salivary glands of irradiated mosquitoes to induce an immune response in mice without the acquisition of malaria by the mice.[41] The irradiation inactivated the parasites without altering the structure of their surface proteins like other methods of inactivation such as heat or chemicals do.

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[39] Good, M. F. "Pasteur Approach to a Malaria Vaccine May Take the Lead." *Science*341.6152 (2013): 1352-353. Print.
[40] Good, M. F. "Pasteur Approach to a Malaria Vaccine May Take the Lead." *Science*341.6152 (2013): 1352-353. Print.
[41] Good, M. F. "Pasteur Approach to a Malaria Vaccine May Take the Lead." *Science*341.6152 (2013): 1352-353. Print.

This allows for an immune response to develop against antigens, as they are present on the live parasite.[42] Findings were promising, but the approach was soon abandoned due to the rise in popularity of the safer subunit vaccine.

Now, researchers revisiting the irradiated sporozoite method have added a slight twist to the method in hopes of eliciting an even stronger immune response. In addition to irradiating both the mosquitoes and sporozoites to ensure safety of the vaccine, researchers are obtaining the sporozoites through careful manual dissection of mosquito salivary glands and preserving them via cryopreservation or cooling to sub zero temperatures to maintain the viability and effectiveness of the sporozoites.[43] Also, in addition to the typical intradermal and subcutaneous injections, they tested the effectiveness of intravenous injections of the vaccine. It turns out that the intravenous injections provided a superior antibody and T cell responses including the development of memory T cells, which is the critical component to adaptive immunity against a pathogen.

T cell response was also correlated with protection from a challenge infection induced three weeks after immunization. In those who were given the highest doses of irradiated sporozoites, all volunteers were protected and showed the highest levels of antibodies and CD4 and CD8 T cells. In the group given the next highest dose, six out of the nine volunteers were protected and had slightly lower but still significant levels of antibodies, and both types of T cells.[44] These encouraging results highlight the major advantage of using whole parasites as

[42] National Institute of Health. *Radiation-Killed Bacteria Vaccine Induecs Broad Immune Response in Mice*. *National Institute of Allergy and Infectious Disease*. National Institute of Health, 25 July 2006. Web.
[43] Good, M. F. "Pasteur Approach to a Malaria Vaccine May Take the Lead." *Science*341.6152 (2013): 1352-353. Print.
[44] Good, M. F. "Pasteur Approach to a Malaria Vaccine May Take the Lead." *Science*341.6152 (2013): 1352-353. Print.

opposed to just protein subunits. Basically, all 1,000+ antigens expressed on the surface of the malaria parasite become potential targets for an immune reaction.

The irradiated sporozoite method is not without its drawbacks, however. One major downside is that in the study, more than 600,000 sporozoites per subject were required to induce complete immunity.[45] This, combined with the fact that each infected mosquito contains at most a few hundred thousand sporozoites means that mass production of the vaccine could be tricky and time intensive. Furthermore, the effectiveness of the vaccine against multiple different strains of *P. falciparum* as well as the duration of immunity both remain to be tested. Without these statistics, it is impossible to effectively and efficiently implement a vaccine centered prevention strategy. Finally, since the vaccine must be given intravenously for maximum success, concerns exist about compliance in areas where it is hard enough to get people to come to health clinics in the first place.

A proper vaccine could dramatically shift the tide in the fight against malaria especially if executed in conjunction with already proven prevention methods. However, while there are multiple promising avenues being explored in development of a malaria vaccine, operational and successful implementation of such a prevention strategy is at least a decade or more away.

Plasmodium vivax: What's so different about it?

Now to switch gears a little, there is another species of malaria that is particularly relevant to the global fight against the parasite. Although it has at times been called the "benign malaria", *Plasmodium vivax* is nothing to be taken lightly. In fact, this minimization of the disease has likely done more harm than good. Although *P. falciparum* does deserve a great deal

[45] Good, M. F. "Pasteur Approach to a Malaria Vaccine May Take the Lead." *Science*341.6152 (2013): 1352-353. Print.

of attention due to its lethality – 90 percent of malaria deaths worldwide are due to *P. falciparum* – the costs of neglecting research and development on *P. vivax* are becoming ever more apparent as we inch closer to the possibility of the eradication of malaria.[46] In numerous studies conducted over the past few years, as the overall number of cases of malaria begins to fall in a certain region, the proportion of cases due to *P. vivax* increases.[47][48] This suggests that there is likely something different about the infection strategy of *P. vivax*, which could prove potential problematic for the campaign to eradicate malaria. If we continue to use the same strategies that don't appear to be working against *vivax*, we may end up with a very different situation in a few years.

It is estimated that around 2.6 billion people per year are at risk for contracting *P. vivax* malaria.[49] This large number is partially due to the fact that unlike *P. falciparum*, which is carried by only a limited number of mosquito species, *P. vivax* is carried by at least 71 species. A number of these species are quite comfortable in temperate climates as well as more tropical climates meaning that they have the potential to spread to areas such as Europe and the United States. Additionally, many of these species are active during the day as well as at night, negating some of the beneficial aspects of prevention strategies such as bed nets.[50] So, while this species of malaria may not have the eye-catching kill times or overwhelming lethality rates, it certainly is a problem in very different ways.

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[46] Vogel, Gretchen. "The Forgotten Malaria." *Science* 3426159 (2013): 684-87. *Science Magazine.* American Association for the Advancement of Science, 8 Nov. 2013. Web.
[47] Vogel, Gretchen. "The Forgotten Malaria." *Science* 3426159 (2013): 684-87. *Science Magazine.* American Association for the Advancement of Science, 8 Nov. 2013. Web.
[48] *World Malaria Report: Ecuador*. World Health Organization, 2013. Web.
[49] "P. Vivax: The Disease." *Plasmodium Vivax*. N.p., 2008. Web.
[50] Vogel, Gretchen. "The Forgotten Malaria." *Science* 3426159 (2013): 684-87. *Science Magazine.* American Association for the Advancement of Science, 8 Nov. 2013. Web.

In many ways, both *P. falciparum* and *P. vivax* are very similar. The main acute symptoms of both are fever and chills, headache, and vomiting. Both also attack and eventually lyse erythrocytes leading to anemia in their victims. Finally, though they share the same general life cycle of merozoite to trophozoite to gametocyte in the mosquito and back to merozoites again in a different human host, there are a few major differences that set *P vivax* apart from *P. falciparum*.

One major difference exists in the cells invaded by the two species. *P. vivax* will preferentially invade reticulocytes, or immature red blood cells making *P. vivax* infections harder to diagnose since reticulocytes are present at much lower concentrations in the blood than adult erythrocytes. This selection of reticulocytes over mature erythrocytes in the infection stage could help to explain some of subtler and delayed symptoms of *P. vivax* in comparison to *P. falciparum*.

Another defining factor that separates *P. vivax* is that the red blood cells remain pliable unlike in a *P. falciparum* infection where they becomes rigid leading to accumulation in the capillaries or segregation.[51] Since accumulation of infected cells is one of the major contributors to the development of cerebral malaria, the lack of accumulation could contribute to the lower lethality of *P. vivax*.

Most notably, though, the life cycle of *P. vivax* includes a dormant hypnozoite stage in the liver.[52] Therefore, in addition to producing a similar acute blood infection to that of *P. falciparum*, *P vivax* parasites also have the option of remaining in the liver for a time then reemerging later resulting in a relapse of symptoms. These relapses can come anywhere between months and years after symptoms from the initial infection have disappeared and with no

[51] Vogel, Gretchen. "The Forgotten Malaria." *Science* 3426159 (2013): 684-87. *Science Magazine.* American Association for the Advancement of Science, 8 Nov. 2013. Web.
[52] P. Vivax: The Disease." *Plasmodium Vivax*. N.p., 2008. Web.

evidence of reinfection.[53] A relapse is not to be confused with recrudescence, which is a return of malaria within days or weeks of treatment and is a result of inadequate clearance of the parasite from the blood.

These hypnozoites are a key characteristic of *P. vivax.* They are usually 5 μm in diameter (the equivalent of five thousandths of a millimeter), are visible at about 36-40 hours after sporozoite inoculation and will remain fundamentally unchanged throughout their dormancy stage.[54] One of the biggest reasons the hypnozoite is such a problem in *P. vivax* infections is because almost every major antimalarial medicine in use today, is designed to attack the blood stage parasites. Since in *P. vivax* infections, there are some parasites that stay hidden in the liver during the initial infection, they will be able to reemerge and begin a relapse episode at a later time, likely after the patient has already gone through treatment and recovered. This cycle can keep happening in those with *P. vivax* infections leading to complications such as susceptibility to other diseases or malnutrition related deficiencies, chronic anemia, and can affect ability to work.

Additionally, each successive relapse comes with the possibility of a strengthened parasite. With its time in the liver, where it is effectively hidden from the immune system, *P. vivax* has the potential to take a greater hold in the body with each relapse that occurs.[55] This adds support to the saying acknowledged by many in the public health community that "*Falciparum* kills you fast while *vivax* kills you slowly".

To add to the complications of controlling and treating *P. vivax* malaria, this species of the parasite is able to population the blood stream before symptoms begin to show at around two

[53] P. Vivax: The Disease." *Plasmodium Vivax*. N.p., 2008. Web.
[54] P. Vivax: The Disease." *Plasmodium Vivax*. N.p., 2008. Web.
[55] Vogel, Gretchen. "The Forgotten Malaria." *Science* 3426159 (2013): 684-87. *Science Magazine.* American Association for the Advancement of Science, 8 Nov. 2013. Web.

weeks post bite.[56] This means that by the time a case is noticed and reported, *P. vivax* could already be endemic in the area, especially if the area of concern is a small close community.

All of these subtle but crucial differences between *P. falciparum* and *P. vivax* can help to explain why they exhibit such different infection strategies and can also give us a window into how to combat the lesser known but equally dangerous *P. vivax.*

Treatments for P. Vivax

Until recently there has not been much of a focus on understanding or combatting the so-called "slow killer" since the 1950's. Nevertheless, developments have been made in creating drugs to destroy the hypnozoite and in finding better ways to track the prevalence rates of *P. vivax* infections as separate from *P. falciparum*.

Firstly, blood stage *P. vivax* infections are completely treatable. This parasite, when in the blood, acts in a way similar to that of the *P. falciparum* parasite. Therefore, the same artemisinin based drugs can be used to treat both species of parasites.[57] The problem with *P. vivax* is that these drugs are not effective against the hypnozoite liver stage of the parasite.

There is a drug currently in use called primaquine that was developed from quinine in the 40s and 50s, which has been found effective at killing *P. vivax* hypnozoites.[58] However, this drug must be taken religiously for 14 days. Such a rigorous schedule can prove challenging to enforce especially for patients who don't feel ill since they don't have the active blood infection. Additionally, and admittedly the more worrisome concern about primaquine is that if taken by a patient with a genetic condition glucose-6-phosphate (G6P) deficiency it will cause hemolysis or

[56] Vogel, Gretchen. "The Forgotten Malaria." *Science* 3426159 (2013): 684-87. *Science Magazine.* American Association for the Advancement of Science, 8 Nov. 2013. Web.
[57] P. Vivax: The Disease." *Plasmodium Vivax*. N.p., 2008. Web.
[58] Vogel, Gretchen. "The Forgotten Malaria." *Science* 3426159 (2013): 684-87. *Science Magazine.* American Association for the Advancement of Science, 8 Nov. 2013. Web.

the bursting open of red blood cells.[59] Therefore, since there is no quick, easy field-test possible to check for G6P deficiency, the broad treatment of an affected region with primaquine in the hopes of destroying the latent liver stage parasites could be dangerous. The exact reason why the drug causes such a reaction in the erythrocytes of people with G6P deficiency is unknown, which leads to the last concern with this treatment. The mechanism by which it works is not well understood, nor does much data exist on dosage recommendations, efficacy, or resistance.

There is hope, however, in a new drug called tafenoquine, currently in clinical trials, which would be a single dose treatment to kill the liver hypnozoites. It is the first new drug that has been developed for *P. vivax* specifically in the past half century.[60] In fact, it was originally developed in the 70s and shown to be safe for treatment, but due to a loss of interest in treating *P. vivax*, it was abandoned until recently. Unlike primaquine, this new drug would only require a single dose in combination with drugs to ensure the treatment of the blood stage parasites. Furthermore, in clinical trials for effectiveness against the standard treatment of primaquine preformed in Brazil, India, and Thailand (all places where *P. vivax* malaria is endemic) showed that 90 percent of those receiving tafenoquine were relapse free after 6 months compared to 24 percent of those receiving primaquine.[61] However, for the same reasons as primaquine, it cannot be used in anyone who has G6P deficiency.

Thus, even though during the past half century there has been a lack of research and investment in the treatment and prevention of *P. vivax*, there have many some encouraging

[59] Vogel, Gretchen. "The Forgotten Malaria." *Science* 3426159 (2013): 684-87. *Science Magazine.* American Association for the Advancement of Science, 8 Nov. 2013. Web.
[60] Vogel, Gretchen. "The Forgotten Malaria." *Science* 3426159 (2013): 684-87. *Science Magazine.* American Association for the Advancement of Science, 8 Nov. 2013. Web.
[61] Vogel, Gretchen. "The Forgotten Malaria." *Science* 3426159 (2013): 684-87. *Science Magazine.* American Association for the Advancement of Science, 8 Nov. 2013. Web.

developments in recent years and a renewed enthusiasm for pursuing the eradication of *P. vivax* along with *P. falciparum*.

Why is all this important?

Malaria is a complex parasitic disease that affects hundreds of millions of people each year. The more we can understand about how it works inside the human body and in the outside environment, the more effective our treatments and prevention strategies can become. This is not the whole story though. In many areas where malaria is endemic, the understanding of this disease is very different from the biochemical and medical driven view of the higher income countries creating a problem in situations where international aid groups are attempting to treat a population.

One way to bridge these diverging views on disease and illness is to understand the root of what is happening in affected patients. This understanding can then be applied to the symptoms described by patients and provide a better background for interpreting their perspective of the disease. Therefore, instead of dismissing a different culture's understanding of a disease because it is not "medically correct", there can be communication and new insight on both sides about what the disease is and how best it can be treated.

In fact, without communication between those who come from different cultures and have diverse understandings of disease, we may not have developed the medications currently available to treat malaria. Both quinine and artemisinin were herbal remedies used for hundreds of years by the native people of the lands they come from before being introduced to European explorers during the 15^{th} to 18^{th} centuries.

With this perspective, in this next section, I will be delving into in depth case studies of a malaria endemic region: the Amazon Basin of Ecuador. So as to understand the dynamics of the disease and the populations it is affecting in the fullest way possible, I am beginning the case study with an introduction to the history, socioeconomic climate, and healthcare situation of Ecuador itself. Each of these factors plays a role in the understanding, acceptance, and management of a disease such as malaria.

Throughout this case study, I will focus especially on the healthcare available to malaria patients through the avenues of governmental organizations, local healers or medicine men/women, and foreign aid groups. In many ways, the relationship between these caregivers and their patients is a two way street. The types of care available to patients help determine their understanding of disease. However, the perception of malaria by the patient also contributes to his or her opinion of healthcare organizations/workers and his or her acceptance of their care. Each of these entities is pursuing a unique mission, encounters different challenges, and holds a distinct place in the opinions of their patients.

I realize that the region I selected is not commonly thought of as a hotspot for malaria, this is intentional. Malaria in the Amazon Basin is quite different from the disease in Sub-Saharan Africa, which is so often under the spotlight. From the strain of parasite, to the treatment available, to the local perception of the disease, malaria in Ecuador is a very unique situation.

From this unique situation though, I hope to use a specific perspective of the disease – and the challenges it creates – as a framework for investigating general themes of cross-cultural medicine. It is then from these themes that we can work towards creating more generalized guidelines and advice for appropriate interactions between international or governmental aid initiatives and their patients. In order to make such guidelines, one must fully comprehend the

condition of those affected. This means looking not only into the disease, but also the living conditions, social and political climate, and perspectives on health, illness and medicine of the patient involved.

Ecuador: A Case Study

Background: The Social and Political Climate of Ecuador

The republic of Ecuador is one of many divisions. Its 15 million people represent five main ethnic groups and numerous subsections within these groups. Geographically, it has three main regions. There is the Costa, which encompasses the land between the Pacific Ocean and the Andes Mountains. Slightly further east and consisting of the two major chains of the Andes is the Sierra. Finally, the Oriente, which contains about half of Ecuador's land, is composed of the Andean piedmont and the eastern lowlands of the Amazon Basin.[62] The geographic divisions serve as a metaphor for the numerous societal partitions and factors, which combine to set the stage for socio-cultural, economic, and healthcare disparities as well. These factors are the intense stereotyping of the rural, indigenous population, the political and economic instability of the country as a whole, and the limited public healthcare system.

Map of the Amazon Basin: About half of Ecuador's land is considered part of the Amazon Basin and is characterized by a majority indigenous population and extreme poverty.

There exists a sizeable gap between the income levels, living situations, and healthcare accommodations of Ecuadorians living in Quito and those, many of whom are of indigenous heritage, living in the remote Amazon Basin. However, due to the averaging of data for country

62 "Ecaudor." *Central Intelligence Agency*. Central Intelligence Agency, n.d. Web.

level reports, the disparities between urban and rural settings and colonist and indigenous groups is often masked. For example, though Ecuador has made some great progress in health outcomes such as the reduction of maternal and infant mortality and childhood malnutrition, the chance of mortality for the indigenous population is 30 percent higher and the child malnutrition rate is two times higher than that for nonindigenous Ecuadorians.[63,64] Discrepancies such as these are paralleled in the economic, social, and political situations of the indigenous and colonist groups in Ecuador. While to some, they may be counted as a byproduct of the society; these inequalities have much deeper roots.

Inequalities in Ecuador date back to the early 20th century along with the birth of the Ecuadorian Republic, which gained independence from Spain in 1830. During this time, the colonists and natives in the Sierra region coexisted. The highland natives were "considered capable of cultural transformation (i.e. overcoming their "Indianness")."[65] In the eyes of colonists, these "Indians" were not responsible for their race and thus, received the pity and assistance of the state. The natives of the Amazon Basin – or lowlands – were a different story, however. They were perceived as savage, meddlesome, and a completely backwards society incapable of redemption in the way that their mountain dwelling counterparts were.

Since that time, many Ecuadorian intellectuals and politicians have tried to argue that racism in the country has died out. Empirical studies of Ecuadorian society suggest otherwise though. Numerous studies conducted throughout the 1990s observed the structural racism

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[63] *Ecuador Country Cooperation Strategy*. Issue brief. World Health Organization, May 2013. Web.

[64] Pan, William Kuang-Yao, Christine Erlien, and Richard E. Bilsborrow. "Morbidity and Mortality Disparities among Colonist and Indigenous Populations in the Ecuadorian Amazon." *Social Science & Medicine* 70.3 (2010): 401-11. *Science Direct*. Elsevier B.V., Feb. 2010. Web.

[65] Beck, Scott H., Kenneth J. Mijeski, and Meagan M. Stark. "*¿Qué Es Racismo?*: Awareness of Racism and Discrimination in Ecuador." *Latin American Research Review* 46.1 (2011): 102-25. *Project Muse*. Johns Hopkins University, 2011. Web.

against the indigenous through mass media, education, and in public spaces. Additionally, the indigenous population's public activism against this racism, and its campaigns for equality have earned native Ecuadorians the labels "disrespectful Indians" and "suddenly violent Indians".[66] The perpetuation of these negative views on the humanity, morals, and personal qualities of the indigenous people of Ecuador demonstrates the degree to which this discrimination has been normalized.

While not every Ecuadorian may be actively enforcing these harsh stereotypes, a majority of them are keenly aware of racial distinctions. This awareness is possibly most notable in Ecuadorian Spanish where there are numerous words for those of mixed heritage depending on how "white" or "Indian" a person appears. Those who are labeled "mestizo" or "mestizaje" have a lighter skin tone and these names come with a more positive connotation. On the other hand, designations such as "longo", "cholo", "guangudo", or "indio" are reserved for people of mixed race who are of a lower class and who have darker skin.[67] These qualities, skin tone and social class, are not necessarily always linked, but due to the stratified nature of the Ecuadorian society and the structural reinforcement of such social divisions, they are often seen as connected.

Though Ecuador does have a representative government in which the indigenous population has been taking on an active role, the instability of leadership has contributed to the countries overall poverty and hardship. The country's leadership has changed hands 13 times since 2000.[68] Along with the fact that many major industries within the country including the petroleum industry, the export of which makes up one third of Ecuador's overall GDP, are under

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[66] Beck, Scott H., Kenneth J. Mijeski, and Meagan M. Stark. "*¿Qué Es Racismo?*: Awareness of Racism and Discrimination in Ecuador." *Latin American Research Review* 46.1 (2011): 102-25. *Project Muse*. Johns Hopkins University, 2011. Web.

[67] Roitman, Karem. *'Longos' and 'cholos': Ethnic/"racial Discrimination among Mestizos in Ecuador*. Working paper. Centre for Research on Integrity, Human Security, and Ethnicity, 2008. Web.

[68] Krieger, Rob. "Ecuador Profile." *FRONTLINE/WORLD*. PBS, n.d. Web.

state control, this volatility in the government has contributed to the extensive poverty and economic stagnation throughout the country. Due to the mishandling of several economic downturns and the fall of petroleum prices in the 80s and 90s, Ecuador has spent the last decade rebuilding it's economy and therefore, leaders have had little time or resources to devote to public health or indigenous rights.[69]

Deeply ingrained stereotypes along with political turmoil have contributed to the disparities in healthcare, resources, and representation experienced by the indigenous people living in the rural Amazon Basin. With language that so separates indigenous from colonists, it is much easier to minimize and ignore the inequalities and struggles faced by the disadvantaged population. Additionally, since issues of the economy consume those in power there has been little focus on assisting the poorest of the poor who reside in the rural Amazon Basin.

The Amazon Basin: The States of Health and living

The inequalities confronting many rural inhabitants begin in many areas, with a lack of access to basic amenities. For example, in the rural areas of Cotopaxi, which comprise about 2/3 of the province, almost 70 percent of people live in houses with dirt floors, 30 percent have no access to a toilet or latrine, and 90 percent still burn wood for cooking. Along with less than modern living conditions, the demographic of rural populations in Ecuador is strikingly different than that of the urban environments. The age distribution in these areas mirrors that of developing countries with a majority of the population in the younger age brackets and less than 20 percent over the age of 40. Finally, 40 percent of those interviewed from Cotopaxi indicated that they had to travel an hour or more to reach a health center, which forces many to rely

[69] Gerlach, Allen. *Indians, Oil, and Politics: A Recent History of Ecuador*. Wilmington, DE: Scholarly Resources, 2003. Print.

primarily on self-care or family member care.[70] While these statistics may draw from only one region of Ecuador, they represent the plight of many who live in the rural Amazon Basin where limited access to resources and high poverty levels are domineering factors in the determination of their standard of living.

Since many communities in the Amazon Basin are extremely isolated, travel to the nearest town with a medical center may take up to a day. Therefore, because of their remoteness, patients often turn to a village medicine man or shaman for medical treatment. In fact, according to a 2009 estimate by the WHO, around 80 percent of people living in developing countries depend on traditional medicine for primary healthcare.[71] Shamans or medicine men are members of the community who are usually well known and trusted. Their knowledge of traditional remedies ranges from ritual cleansing ceremonies to medicinal plants to the use of amulets for healing and protection. Most treatments are preformed with the goal of restoring balance between the patient and his or her surroundings.

Because local shamans are an integral part of their communities and in most cases heavily respected, patients place a great deal of trust in their opinions and treatment recommendations.[72] Their knowledge, which has been passed down through generations is also entrenched in local spiritual beliefs giving it even more authority.[73] However, the intense trust

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[70] Puertas, Benjamin, and Marita Schlesser. "Assessing Community Health Among Indigenous Populations in Ecuador With A Participatory Approach: Implications For Health Reform." *Journal of Community Health* 26.2 (2001): 133-47. *Springer Link*. Springer Science + Business Media. Web.

[71] Chelala, Cesar. "Health in the Andes: The Modern Role of Traditional Medicine (Part I)."*The Globalist*. The Globalist, 2009. Web.

[72] Biermann, Olivia, Bringer Forsburg, and Martin Eckhart. *Perceptions of a Non-governmental Organisation and Its Health Care Services by a Marginalized Population in Rural Ecuador*. Thesis. Karolinska Institute, Sweden, 2012. N.p.: n.p., n.d. *Convibra Health Congress Online*. 2012. Web.

[73] Roumy, Vincent, et al. "Amazonian plants from Peru used by Quechua and Mestizo to treat malaria with evaluation of their activity." *Journal of ethnopharmacology* 112.3 (2007): 482-489.

patients often have in local medicine men can become problematic if a remedy they are recommending is not helpful or may even be harming the patient further.

Since the utilization of local traditional medicine for healthcare is a result of a community lacking access to health clinics or hospitals, exact data on the number of people utilizing these authorities for health problems, how hard resources are to come by, and how well treatments actually work is sparse. Nevertheless, from what we do know about local traditional medicine providers, we can clearly see two important characteristics, which dramatically affect the their utilization. The first is that patients have extremely high levels of trust in local shamans because people of the community know and respect these medicine men. Additionally, the medicine men understand the local culture, spiritual beliefs, and social climate allowing them to better understand their patients' ailments. Both of these factors contribute to a preference for local care in many remote villages and higher rates of compliance with recommended treatment plans than is seen in either government or NGO clinics.

The other two major healthcare providers in the Amazon Basin region bring in modern medical care to a portion of rural communities. The first is funded by and under the control of the Ecuadorian government and is called the Ministry of Public Health (abbreviated MSP for the Spanish name: Ministerio de Salud Pública). The other major healthcare providers are international aid groups, which set up clinics and bring physicians from their home countries to exam patients. Within this subsection of medical providers, there exists a large range of operational strategies. Some groups will come for a short time bringing medicines and physicians and then leave. Others will set up long term clinics offering basic services and assistance in order to help fill in the gaps in local and national health care services. Still others use a combination approach with physicians and medical supplies being sent down at regular intervals, but also a

team remaining in the country to assist with referrals to hospitals, training of community health workers, and assessment of the needs of the communities.

After a brief overview of the Malaria in the Amazon Basin and the Quechua perception of the disease, I will investigate these outside healthcare providers more in-depth taking into account their treatment strategies for malaria. Additionally, for the purposes of remaining succinct, I will be focusing on just one aid organization, Foundation Human Nature. This organization follows the combination model with both periodic clinic visits and sustained on the ground support.

Malaria in the Amazon Basin

The status of the malaria epidemic in rural Ecuador is rather hard to fully understand owing to the limited number of cases that are accurately reported. Since a large portion of the rural population is isolated from hospitals or clinics that have the ability to diagnose a malaria infection, there are likely more infections than official reports suggest. Additionally, the major malarial strain present in the Amazon Basin is *Plasmodium vivax*, which is characterized by recurrent episodes of symptoms after the initial infection subsides. Therefore, the treatment of malaria as a one-and-done disease neglects the social, personal, and lifestyle effects that a resurgent infection can cause for patients and populations leading to a mischaracterization of the burden of disease caused by this parasite.

However, despite these critiques, knowing the reported data about infection and treatment rates can be helpful in assessing the status of the disease. In 2010, there were an estimated 2,222

cases of malaria in Ecuador.[74] This number has been dropping steadily over the past decade, though. In 2007, the number of malaria cases stood at 9,863.[75] Thanks to a diligent effort through programs by the National Center for Malaria Education (NCME) there has been an increased focus on preventative measures such as the spraying of DDT and presumptive treatment. These actions, along with greater education about safety measures, have proven effective in drastically reducing reported infection rates.

While the number of cases is nowhere near the 1.4 million in India, this does not negate the malaria problem in Ecuador. There exist several challenges unique to the area, which create a situation that is about more than just case numbers. The first of these challenges deals with a phenomenon in disease transmission called hypoendemicity.[76] When a disease is hypoendemic, it has an incidence rate – the rate of development of new cases – that is consistent but still too low for a population to develop any immunity to the disease. In contrast, within the malaria endemic regions of Sub-Saharan Africa, malaria is so common that since it is generally a survivable disease (except in young children, pregnant women, and immunocompromised individuals), most people have had the disease and thus have developed partial immunity against future infections lowering the burden of recurrent adult infections. In Ecuador, however, malaria affects a decent percent of populations, but not everyone. Hence, there are still individuals from every age group who can become infected for the first time, creating a bigger disease burden for adult infections in the Amazon Basin.

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[74] "Malaria Cases: Estimated Cases." *Global Health Observatory Data Repository*. World Health Organization, 2013. Web.

[75] "Malaria Cases: Estimated Cases." *Global Health Observatory Data Repository*. World Health Organization, 2013. Web.

[76] Sebastián, Miguel San, Ricardo Játiva, and Isabel Goicolea. "Epidemiology of Malaria in the Amazon Basin of Ecuador." *Revista Panamericana De Salud Pública* 7.1 (2000): 24-28. *Sci Elo Public Health*. Pan American Health Organization. Web.

Secondly, a great number of malaria cases are likely not reported or even known to be malaria. Since the Amazon Basin is a vast geographical area, many of the people who live there are isolated and are either unable or unwilling to travel to a clinic for treatment. When surveyed, over half of the people living in these remote villages said they were more likely to enlist the help of a family member or care for themselves in lieu of traveling to see a physician or nurse.[77] This resistance to engage in services offered by either the government or aid groups could be due to a number of different factors including inability to travel the distance to the clinic, preference of being treated at home by family or a local healer, or the inability to treated at clinics due to overcrowding or staff incompetence. Without appropriate infrastructure in place and advertisement of services, these people will continue to rely on the people and treatment methods they have always trusted.

The final main issue paying into the complicated nature of malaria in Ecuador is the fact that the most prominent and active strain here is *P vivax*, which makes up over 90 percent of the reported cases.[78] Because *P. vivax* preferentially invades liver hepatocytes delivering subtler and sometimes delayed symptoms, infections are harder to recognize and characterize leading to an underestimation of disease burden. Also, the tendency for relapse in *P. vivax* infections creates new complications because individuals assumed to be cured of infection might still exhibit symptoms or have complications involving other opportunistic or endemic infections. These factors, along with inconsistent use of government medical facilities combine to make the actual burden of malaria difficult to determine and total treatment even more difficult to complete.

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[77] Puertas, Benjamin, and Marita Schlesser. "Assessing Community Health Among Indigenous Populations in Ecuador With A Participatory Approach: Implications For Health Reform." *Journal of Community Health* 26.2 (2001): 133-47. *Springer Link*. Springer Science + Business Media. Web.

[78] Sebastián, Miguel San, Ricardo Játiva, and Isabel Goicolea. "Epidemiology of Malaria in the Amazon Basin of Ecuador." *Revista Panamericana De Salud Pública* 7.1 (2000): 24-28. *Sci Flo Public Health*. Pan American Health Organization. Web.

So, while malaria in Ecuador may not get as much publicity or notice as that in parts of Sub-Saharan Africa or India, it is equally relevant both to this discussion of disease perception and to the international health community.

Perception of Malaria by the Quechua People of the Amazon Basin

In the western world, we are taught to think of infections and disease in terms of germ theory where disease originates from microorganisms that invade the human body and affect normal body function causing outward symptoms. In a community with no access to technology such as microscopes to see these disease causing microorganisms with, the concept of illness and medicine take on a new meaning.

For the Quechua of the Ecuadorian Amazon Basin – the largest indigenous groups in the Americas who span Peru, Bolivia, and Ecuador – illness in the traditional understanding, represents a disruption of the soul and its relation with others.[79] It relies on the detection of physical symptoms instead of blood tests or pathogen cultures.

Here, instead of the categories of viral, bacterial, fungal, or parasite infections, there are only three types of illness. The first is called *Unkay*. This category of illness is due to natural causes such as dampness, too much heat or cold and is used to describe most general physical ailments. Next, there is *Pahu*, which is due to supernatural origins such as mythical or spiritual entities that have been disturbed. Finally, there is *Wiruti*. Literally, this word is the name of a blowgun dart used for hunting. Fittingly, this type of illness is thought by the Quechua to be a

[79] "Indigenous Peoples of the World — The Quichua." *Peoples of the World Foundation*. Peoples of the World Foundation, 2014. Web. 10 Apr. 2014.

physical manifestation of shamanistic wielding power with the intent to harm another as a consequence of underlying conflicts between villages or ethnic groups. [80]

Where an illness falls within these classifications is based upon the observed symptoms and will determine the appropriate treatment. Therefore, it is not uncommon for two afflictions that would be considered just different types or stages of a single disease in the modern medical world to be considered completely different illnesses for the Quechua people because they exhibit diverse symptoms.

Consequently, malaria is actually characterized as two very different diseases by Quechua shamans depending upon the severity and the types of symptoms exhibited.[81] In fact, this dual characterization of malaria based on symptoms displayed is quite common in isolated communities throughout the world who are affected by endemic malaria. When the malaria infection is nonlethal it is considered *chukchu unkay* or "shaking illness" in Kichwa (the language spoken by the Quechua). However, if malaria causes death, it is placed in a different of the three main categories - *wiruti*.[82]

In the case of *chukchu unkay*, malaria is thought to be caused by an excess of cold, a natural and personal cause, and is treated thought medicinal plants.[83] On the other hand, *wiruti*, because of its severity, is attributed to outside forces – spiritual in origin or a shaman from another village – and predatory intentions. This distinction of an external cause results in very different treatments from those of *chukchu unkay*. For *wiruti* there are two possible interventions.

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[80] Roumy, Vincent, et al. "Amazonian plants from Peru used by Quechua and Mestizo to treat malaria with evaluation of their activity." *Journal of ethnopharmacology* 112.3 (2007): 482-489.

[81] Roumy, Vincent, et al. "Amazonian plants from Peru used by Quechua and Mestizo to treat malaria with evaluation of their activity." *Journal of ethnopharmacology* 112.3 (2007): 482-489.

[82] Roumy, Vincent, et al. "Amazonian plants from Peru used by Quechua and Mestizo to treat malaria with evaluation of their activity." *Journal of ethnopharmacology* 112.3 (2007): 482-489.

[83] Roumy, Vincent, et al. "Amazonian plants from Peru used by Quechua and Mestizo to treat malaria with evaluation of their activity." *Journal of ethnopharmacology* 112.3 (2007): 482-489.

The first is to conduct a search for a ritual interpretation, which often involves a ceremony preformed by a shaman to call upon spirits for an answer to the illness. Another option is political intervention, often meaning war, if the illness is judged to be the result of a malicious attack by outsiders from another village.[84] Such a reaction can be seen throughout the history of the region in the coincidence between malaria outbreaks and sociopolitical tensions escalating to violence.

The existence of such a wide variety of treatments for illness in the Quechua medical culture pays homage to their complex and holistic views of health. For the Quechua, the concept of wellbeing encompasses not only the relationship between individuals and their bodies, but also social relationships with both human and non-human entities.[85] This inclusive definition of health and wellness, then influences the way the Quechua culture perceives illness as well. They are very aware of the world around them – both physical and spiritual – and as a result, can be very sensitive to changes in their body and environment.

Everything about the way disease is described in Kichwa revolves around the feelings and experience of being sick. Most translations of symptoms are very literal as opposed to the medicalized terms used in modern medicine. For example, fever is *rupa* meaning simply "hot sensation"; weakness is translated as *shunku nanay* meaning "hurting heart" because for the Quechua, the heart is considered the locus of the soul and source of energy; and weak or darkening vision is *yana rikurin*, which literally means "it looks dark".[86] The Quechua look at illness through the lens of experience because that is what they know. They have no way to

[84] Roumy, Vincent, et al. "Amazonian plants from Peru used by Quechua and Mestizo to treat malaria with evaluation of their activity." *Journal of ethnopharmacology* 112.3 (2007): 482-489.
[85] Roumy, Vincent, et al. "Amazonian plants from Peru used by Quechua and Mestizo to treat malaria with evaluation of their activity." *Journal of ethnopharmacology* 112.3 (2007): 482-489.
[86] Roumy, Vincent, et al. "Amazonian plants from Peru used by Quechua and Mestizo to treat malaria with evaluation of their activity." *Journal of ethnopharmacology* 112.3 (2007): 482-489.

connect the feelings that accompany sickness to underlying microbial causes as modern medicine does through immunology or microbiology.

Such an interpretation of illness is far from incorrect. In fact, both the Quechua and western perspectives tell complementary sides of the same story. Yes, the Quechua may understand symptoms by experience and thus possibly misattribute the cause of a symptom that occurs in many different diseases. However, their very detailed perception of feelings may allow them to more accurately describe the type of pain they feel when in western medicine the many diverse feelings associated with pain are often lumped into only one or a few categories. If taken together however, these two perspectives could give valuable insight for both parties on a more complete picture of the disease works and is affecting the patient.

The benefits of diverse perspectives on disease do not end at description and diagnosis. Great potential for new malaria treatments lies in the experience and knowledge of Quechua medicine men and women. For centuries, they have used medicinal plants to treat malaria symptoms, and one of these original plant based remedies is in fact the root of the first major antimalarial drug, chloroquine.[87] Additionally, 11 of the 15 drugs currently on the market to treat malaria have direct connections to natural products.[88] With drug resistant strains of malaria looming on the horizon, the need for new and unique antimalarials is growing. Since cinchona bark – from which quinine was derived – is only one of many medicinal plants commonly used in Quechua medicine, scientists have begun to analyze other plants used in traditional malaria remedies for bioactivity against both *Plasmodium* species.

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[87] Toovey, Stephen. "The Miraculous Fever-Tree. The Cure That Changed the World." *Travel Medicine and Infectious Disease* 2.2 (2004): 109-10. Print.

[88] Bourdy, G., M.l. Willcox, H. Ginsburg, Ph. Rasoanaivo, B. Graz, and E. Deharo. "Ethnopharmacology and Malaria: New Hypothetical Leads or Old Efficient Antimalarials?" *International Journal for Parasitology* 38.1 (2008): 33-41.*Science Direct*. Elseier B.V. Web.

In the case of drug development to avoid resistance, the world of traditional medicinal plants offers much to be hopeful about. Worldwide, there are over 1,000 plant species that have been used for their suspected antimalarial properties for centuries.[89] While not all of these plants will lead to the development of a new safe and effective drug for malaria, they can provide researchers with a strong chance to find at least a few more drugs that can prevent the explosion of new cases that comes with the development of drug resistance. And in order to start analysis on these plants, researchers must start by talking with those who use them so as to understand the natural conditions, dangers, and potential of these traditional medicines.

Through comparison of the Quechua perception of disease above to the western medical perspective from the disease profile, it is obvious that the two diverge on many counts. If each perspective remained contained within its own sphere, their differences would not pose a problem. However, the Quechua do not live in isolation from the rest of Ecuador nor the rest of the world. They come in contact with outsiders regularly, often in the form of medical brigades or clinics. Encounters like these give ample room for a clash of perspectives, which can have an effect on the care outside groups are trying to provide and the overall relationship between the Quechua and these outsiders. However, before delving into the effects of divergent perceptions, lets take a look at the different circumstances – specifically those concerning malaria – under which groups of indigenous people come into contact with the outside world

Government Interventions and Healthcare

Initiatives for malaria treatment in the Amazon Basin can be at best described as a patchwork of efforts through the three main healthcare entities: state services, international

[89] Karunamoorthi, Kaliyaperumal, Shanmugavelu Sabesan, Kaliyaperumal Jegajeevanram, and Jayaraman Vijayalakshmi. "Role of Traditional Antimalarial Plants in the Battle Against the Global Malaria Burden." *Vector-Borne and Zoonotic Diseases*13.8 (2013): 521-44. *Liebert Publishers*. Mary Ann Liebert, Inc., 2013. Web.

organizations, and local healers. Even so, there are still areas that remain without access to treatment.[90] It is widely known both in Ecuador and throughout the international healthcare community, that the government sponsored healthcare system has many gaps that the state seems unwilling to fill. Their unwillingness to improve malaria treatment programs is due to both a lack of available funds and a still persistent bias against the indigenous and mestizo people of Ecuador who make up a large majority of the people affected by malaria.

Nevertheless, government efforts do play an undeniable role in the fight against malaria in Ecuador. Currently the main government program is the NCME (National Center for Malaria Eradiation). This program constitutes a national effort to improve malaria protection via increasing the use of controlled strategic spraying of DDT, more accurate case detection, and presumptive treatment.[91] Government run hospitals and clinic facilities scattered throughout the region in province capitals provide such services. These major towns usually house a population of less than 1 million individuals, so are still quite small.[92]

At NCME centers, patients are seen by doctors, nurses, or other health workers depending on the availability of providers. These facilities provided passive detection of malaria through Rapid Detection Tests (RDTs). Such tests are useful in remote and resource poor locations, as they do not require microscopes or skilled laboratory technicians to interpret. RDTs can use blood from a finger-stick and rely on the reaction of the test strip with components that

[90] Pinault, Lauren L., and Fiona F. Hunter. "Malaria Knowledge, Concern, Land Management, and Protection Practices among Land Owners And/or Managers in Lowland versus Highland Ecuador." *Malaria Research and Treatment* 2011 (2011): 1-12. *Hindawi Publishing Corporation*. Hindawi Publishing Corporation, 2011. Web.
[91] Sebastián, Miguel San, Ricardo Játiva, and Isabel Goicolea. "Epidemiology of Malaria in the Amazon Basin of Ecuador." *Revista Panamericana De Salud Pública* 7.1 (2000): 24-28. *Sci Flo Public Health*. Pan American Health Organization. Web.
[92] "Ecaudor." *Central Intelligence Agency*. Central Intelligence Agency, n.d. Web.

are present at abnormal levels in malaria parasites compared to normal human blood.[93] These RDTs are fast, cheap and easy making them ideal for use at clinics in the resource poor Amazon Basin especially when used in conjunction with a physical examination. While not as accurate or sensitive as traditional microscopic analysis, they are for practical purposes effective enough for field treatment. Most times, patients arrive at clinics after progressing to the symptomatic stage of the disease when the parasite concentration in their blood is likely above the threshold needed for detection by RDT.[94]

The other main services provided by NCME centers are treatments in the form of antimalarials for those who test positive for the parasite, preventative treatment for high-risk groups such as pregnant women and children if supplies are sufficient, and DDT spraying for surrounding communities.[95]

Unfortunately, because of the difficult terrain and isolated population, the government facilities are not easily accessible to a majority of people residing in the Amazon Basin region. Only those who live close to a major town or have access to reliable transportation are able to benefit from government programs meaning that a significant number of people never come into contact with government treatment and prevention efforts.

If a significant portion of Amazon Basin residents can't access Ecuadorian government healthcare facilities, this also means that the government estimates of the malaria infection rate is severely inaccurate. In a study conducted over the span of 4 years in the 1990s, data confirmed

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[93] Shiff, Clive J., Cristina Stoyanov, Cornelius Choobwe, Aniset Kamanga, and Victor M. Mukonka. "Measuring Malaria by Passive Case Detection: A New Perspective Based on Zambian Experience." *Malaria Journal* 12.1 (2013): 120-28. *Malaria Journal*. Springer Science + Business Media, 2013. Web.

[94] Shiff, Clive J., Cristina Stoyanov, Cornelius Choobwe, Aniset Kamanga, and Victor M. Mukonka. "Measuring Malaria by Passive Case Detection: A New Perspective Based on Zambian Experience." *Malaria Journal* 12.1 (2013): 120-28. *Malaria Journal*. Springer Science + Business Media, 2013. Web.

[95] Sebastián, Miguel San, Ricardo Játiva, and Isabel Goicolea. "Epidemiology of Malaria in the Amazon Basin of Ecuador." *Revista Panamericana De Salud Pública* 7.1 (2000): 24-28. *Sci Flo Public Health*. Pan American Health Organization. Web.

that the cases of malaria confirmed by the NMCE made up less than half of the overall reported cases, which in turn represent an undetermined portion of all malaria cases in Ecuador.[96] This underestimation of the malaria endemic by the Ecuadorian government not only instills a false sense of security in regards to malaria risk, but also results in an inappropriate amount of funding being directed toward malaria control.

All services provided by the NCME centers are funded through the Ecuadorian government. Thus, due to inaccurate estimations of disease prevalence, this funding, while reliable, is not necessarily sufficient to meet the needs of the areas NCME centers serve. Shortages of staff, medicines, and testing supplies are common, and there has been little if any movement within governing bodies to increase funding for the program.

For patients that are able to come to and receive treatment at the NCME facilities, opinions of the healthcare provided are mixed. A study conducted in 2012 on the perceptions on healthcare facilities of rural Ecuadorian residents, found that most were grateful for the opportunity to get correct and helpful medicine, but were dissatisfied with the quality of service at clinics.[97] Many patients, especially to those who had had contact with western doctors working with international NGOs, expressed that the doctors at government clinics overall had negative attitudes and seemed younger and inexperienced.

The attitudes and experience levels of doctors in these rural settings is likely a direct result of a mandatory program in Ecuadorian medical education where first-year physicians (who would be first-year residents in the United States system) are required to spend a year serving in

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[96] Sebastián, Miguel San, Ricardo Játiva, and Isabel Goicolea. "Epidemiology of Malaria in the Amazon Basin of Ecuador." *Revista Panamericana De Salud Pública* 7.1 (2000): 24-28. *Sci Flo Public Health*. Pan American Health Organization. Web.

[97] Biermann, Olivia, Bringer Forsburg, and Martin Eckhart. *Perceptions of a Non-governmental Organisation and Its Health Care Services by a Marginalized Population in Rural Ecuador*. Thesis. Karolinska Institute, Sweden, 2012. N.p.: n.p., n.d. *Convibra Health Congress Online*. 2012. Web.

one of these rural clinics.[98] Often, these young doctors are on their own as the only medical professional working at the clinic. Their U.S. equivalents, on the other hand, work under and learn from a team of experienced, senior doctors for a few years after graduating from medical school.

The practice of placing new and inexperienced doctors that have never practiced medicine before alone in an isolated setting to learn on the job while treating patients is representative of the governments attitude towards rural health overall. They provide some services, but efforts to improve conditions are only half-hearted, still leave behind many gaps in healthcare coverage, and even those who do have access to services are often denied medicine or examinations due to insufficient funding and staffing of government run rural hospitals and clinics.

The State of Outside Aid

The other category of modern medicine providers in the Amazon Basin region of Ecuador is international NGOs. These organizations range from small, with have fewer than 100 people involved, to enormous multinational strategists like the WHO or the Pan American Health Organization (PAHO). The exact number of organizations with a sustained presence in Ecuador is difficult to determine. There is not much regulation or documentation by the government or otherwise of what international groups are currently active within the country. The regulation that does exist is enacted mostly through political interest. In 2012, Ecuador's Secretariat for International Cooperation revoked operation permits for 26 foreign NGOs and tightened restrictions on 15 others because, according to president Rafael Correa, these groups were

[98] Biermann, Olivia, Bringer Forsburg, and Martin Eckhart. *Perceptions of a Non-governmental Organisation and Its Health Care Services by a Marginalized Population in Rural Ecuador*. Thesis. Karolinska Institute, Sweden, 2012. N.p.: n.p., n.d. *Convibra Health Congress Online*. 2012. Web.

"extremely right wing" and attempting to "replace the government and impose their politics".[99] It was not clear exactly how many, but at least a handful of the banished NGOs were preforming health services. Additionally, in the past, the Ecuadorian government has been known to shut down NGOs accused of supporting indigenous protest against mining and drilling projects. Since most health NGOs work with indigenous communities, and some have asserted that resurgence of malaria may in part be caused by the environmental effects of rainforest destruction, some of these shutdowns inevitably left whole communities without medical care.

On the issue of malaria, many of the NGOs working in Ecuador are simply implementing the recommendations of larger multinational initiatives including Roll Back Malaria – the result of the partnership of many international health organizations primarily the WHO. These larger organizations are able to dedicate time and money to fund research on malaria treatment and prevention, which they then use to develop action plans specified to the different areas of endemic malaria. This way, individual NGOs can focus on the best way to optimize implementation in their specific area while the larger organizations focus on ways to optimize the treatments that are given.

Since Ecuador is considered a low transmission area primarily infected with *P. vivax*, the strategy recommended by the Roll Back Malaria initiative stresses the use of prevention methods such as vector control through insecticide spraying is touted since transmission in the Amazon Basin is seasonal and intimately linked to the mosquito population. Roll Back Malaria also advises the implementation of localized and early diagnosis through parasitological exams and RDT. Little immunity to malaria exists within communities of the Amazon Basin causing infections to be devastating to those who contract them. As for treatment, they recommend the

[99] AQ Online. "Ecuador Shuts Down 26 Foreign NGOs." Web log post. *Ecuador Shuts Down 26 Foreign NGOs*. Americas Quarterly, 6 Sept. 2012. Web. 10 Apr. 2014.

use of a 14-day regimen of chloroquine in combination with primaquine.[100] Unfortunately, because *P. vivax* in most areas of the Ecuador has developed resistance to chloroquine, the treatment regimen has been altered to recommend artemisinin-based combination therapy (ACT) instead, which is more expensive.[101]

These recommendations are then carried out by smaller NGOs targeting specific areas for which to provide care. Foundation Human Nature (FHN) is one such NGO. Established in 2003, after a severe outbreak of cerebral malaria, FHN serves about 6,000 people in village of La Y de la Laguna and surrounding areas that would otherwise have to walk up to 10 hours to reach the next nearest health clinic.[102] La Y lies in northern Ecuador and technically at the far western edge of the Amazon Basin. However, its population is extremely poor and isolated similar to many communities in the east – which is better known as part of the Amazon Basin. Also, though the region is slightly higher in elevation, its climate is still more similar to that of the rainforests than the sierra. FHN is based in Germany and provides funding for the Ecuador initiative, which they call the Minga Foundation.

When the organization first came to the area of La Y, there was no official map, travel into and out of the region was exceedingly difficult – this was part of the reason there was only marginal government support for the people living here. A majority of the population of the region consists of people of mixed, African, and indigenous decent. Additionally, outside of the village of La Y, the people have no access to clean drinking water, garbage disposal, electricity or educational facilities.[103] In terms of health risks, the region is plagued by a high susceptibility

[100] "Part III Regional Strategies." *Global Malaria Action Plan: The Americas*. Roll Back Malaria Partnership, n.d. Web. 10 Apr. 2014.
[101] "Malaria." *Pan American Health Organization*. Pan American Health Organization, n.d. Web.
[102] "History." *The Minga Foundation*. Foundation Human Nature, n.d. Web.
[103] "Ecuador." *Foundation Human Nature*. Foundation Human Nature, n.d. Web. 10 Apr.2014.

to malaria as well as dengue fever, typhoid, and intestinal parasites.[104] Due to their extreme isolation, these people had been neglected in all public health outreaches by the Ecuadorian government.

FHN has sought to improve both health and living conditions in La Y and surrounding regions through an Ecuador-focused project called the Minga Foundation. Their mission is to help communities to achieve better socioeconomic and health conditions through partnerships and the empowerment of community members to invest in the future of their own community.[105] The Minga Foundation places emphasis on the training of local individuals as community health workers (CHW), and recruits doctors and nurses from Ecuadorian medical schools in order to achieve collaboration on many levels. In fact, "Minga" is an indigenous Quichua term that means "collaborative work through which friends and neighbors volunteer time, effort, and resources to achieve a shared goal for the betterment of the community."[106]

Services provided by the Minga Foundation are centered on El Subcentro de Salud. The facility provides a medical clinic staffed by Ecuadorian doctors and nurses in their year of rural service; a training program for CHWs; workshops for local people on topics such as hygiene, family health, vaccination campaigns, first aid, and domestic violence; a waste management project; a medicinal plant garden; the region's first library; and periodic medical brigades to smaller communities with foreign volunteer medical staff.[107] Specifically for malaria diagnoses, the health clinic has been able to offer RDT testing, antimalarials, and community workshops for malaria education.

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[104] "History." *The Minga Foundation*. Foundation Human Nature, n.d. Web.
[105] "Our Mission." *The Minga Foundation*. Foundation Human Nature, n.d. Web.
[106] "History." *The Minga Foundation*. Foundation Human Nature, n.d. Web.
[107] "History." *The Minga Foundation*. Foundation Human Nature, n.d. Web.

Until 2010, FHN and the community jointly managed El Subcentro's daily operation and special initiatives. However, since then, the clinic's daily functions has been independently run and financed by the community. FHN still provides financial and organizational support for special projects and medical brigades, allowing for the expansion of services in this high need area. This also creates space for greater community ownership of and investment in their own healthcare. Ultimately, these two qualities will hopefully allow El Subcento de Salud and the rest of FHN's projects to be sustainable.

Overall, FHN has had an overwhelmingly positive effect on the community health care in La Y and the surrounding areas by providing doctors, nurses, testing, medicine, health education, and public services that they otherwise would have not had access to. Also, malaria, which was once a major cause of death in the area, has now been controlled through robust testing, treatment and community education. The real test, however, remains the acceptance of this care by the community. In a 2012 study, the community of La Y was surveyed about their experiences at the health clinic and their satisfaction with FHN and its services. In general, most patients expressed gratitude for the organization and the people working there both international and Ecuadorian. They appreciated that services were offered free of charge and liked the fact that medical brigades periodically trekked out to further communities bringing doctors and medicine with them.[108] The overall attitude towards the organization and the health clinic was overwhelmingly positive.

However, as with any project, people did express some complaints or suggestions of what they wanted to see from the NGO. The biggest complaints by residents of La Y and the surrounding areas were not enough medical brigades or doctors, misunderstandings of who funds

[108] Biermann, Olivia, Bringer Forsburg, and Martin Eckhart. *Perceptions of a Non-governmental Organisation and Its Health Care Services by a Marginalized Population in Rural Ecuador*. Thesis. Karolinska Institute, Sweden, 2012. N.p.: n.p., n.d. *Convibra Health Congress Online*. 2012. Web.

and runs the health center, misunderstandings of the role of CHWs, and foreign doctors didn't spend enough time in the community to understand the culture and health situation there.[109] Given the fact that FHN is an international organization, many of these complaints are expected, as there are troublesome language and cultural barriers that must be navigated for maximal understanding on both sides.

So, while they are not perfect by any means, FHN and their Ecuador project, the Minga Foundation, have been implementing some great strategies for distributing health care, educating the population they serve about malaria among other health concerns, and working with the government of Ecuador and the local communities to insure the correct, sustainable, and effective use of medical resources.

The healthcare situation, specifically in regards to the treatment of malaria, in the Amazon Basin of Ecuador results from a complex slew of geographical, historical, cultural, economic, and international factors. Each individual branch of Ecuador's current rural health system has its strengths and weaknesses, and thanks to recent initiatives especially in the fight against malaria, collectively they have begun to reach more people in the rural, isolated Amazon Basin. However, there is more that can be done, and there is more that needs to be done in order to continue the trend of reaching more patients and successfully treating them.

[109] Biermann, Olivia, Bringer Forsburg, and Martin Eckhart. *Perceptions of a Non-governmental Organisation and Its Health Care Services by a Marginalized Population in Rural Ecuador*. Thesis. Karolinska Institute, Sweden, 2012. N.p.: n.p., n.d. *Convibra Health Congress Online*. 2012. Web.

A Collision of Perspectives: An Analysis

Thus far, I have covered two very distinct characterizations of the same disease. One, the dominant perspective taken in the modern medical world, emphasizes the mechanisms of the malaria parasite and their specific effects on various body systems. The other, Quechua medical tradition, focuses on the experience of the illness. Here, symptoms, severity, and a patient's connection to the world around them dictate the Quechua understanding of this same disease. Both approach the disease from different angles, with different a base of knowledge, and armed with different treatments. And yet, both methods of diagnostics and treatment are effective in their own ways.

At times the nature of how modern medicine and science attempt to understand the world can cause us to lose the big picture or key points in pursuit of intimate details. We are so obsessed with finding out every aspect of how a disease progresses and affects every system of the body that we sometimes forget there is a subjective component to disease as well. This personal experience of illness, which the Quechua base their medical system on, can affect treatment and prognosis as much as much as antimalarials via factors such as early diagnosis through subtle symptom detection, holistic treatment, and the provision of unique and possibly revolutionary medicinal plants.

If an international aid group attempts to impose a certain medical perspective on patients who have lived their whole lives through a different perspective, they will encounter more problems and resistance than successful treatments. For the most part, people will not blindly follow treatments, especially if their own medical knowledge is contradictory. In order to actually benefit the community, they must be involved in the decisions about their care. The only true way to achieve this is through collaboration. Therefore, after examining and validating the

unique strengths and weaknesses of each viewpoint, I now present my case for the benefits of a cooperative approach to understanding and treating malaria around the world through mutual education and receptivity.

First, however, it is important to remember that bringing together two vastly different perspectives will always result in a collision of sorts. Both sides will be confronted with information and opinions they have no way to process, which can be extremely stressful and intimidating. Because of the innate stress of this process, some individuals on either side will also likely resist the bridging of perspectives. Therefore, it is important to acknowledge that full collaboration will take time and that on the way to achieving this goal, there will first be damage that must be repaired and trust that must be built.

Collateral Damage

Collisions, unless you are talking to a nuclear physicist trying to create nuclear fusion, most often carry with them a negative connotation. The meeting of two opposing forces creates conflict, damage, and the upheaval of stability. Similarly, in situations where outside aid – either from the Ecuadorian government or international – is brought into an Amazon Basin community, both doctors and patient are coming to the clinic with different understandings. The more different these views are from one another, the more possible complications misunderstandings, low compliance, and breaks in communication are.

Misunderstandings were some of the most commonly cited complaints from surveys of community members in La Y de la Laguna. In many cases, people were hearing information about the health center and FHN from secondary sources because FHN didn't have clear methods of broadcasting messages to the communities. Therefore, information about the center

becomes vulnerable to the telephone effect where slight misconceptions are be amplified with each retelling eventually resulting in completely false information. The breakdown in communication over time between the health center, FHN, and the community lead to this confusion of leadership and could ultimately have some more dramatic effects in terms of patient trust of the medical providers and community involvement in and support of the health center.

If patients don't know who they are receiving care from, they are less likely to have trust in the doctor and the treatment that he or she prescribes. This lack of trust can then lead to low patient compliance, which is a major problem especially in the treatment of diseases such as malaria that require a regimen of a strict determined length to fully cure the disease. The problem of reduced compliance is not just an issue for international NGO initiatives. It can also be seen in government health clinics as well. Here, studies have shown that of those who came to government clinics, for every three fully compliant patients, there were two at least partially non-compliant patients.[110]

A second hurdle commonly encountered by NGOs like FHN is low patient compliance to treatment. When surveyed, Ecuadorian patients' reasons for not taking antimalarial medicine usually fell into two main categories. The first group included those who stopped taking antimalarials due to side effects of the drugs including nausea, vomiting, dizziness, and also those who saw symptoms disappear quickly but were not completely parasite free when they stopped treatment. The other major reason people stopped treatment was because they underestimated the severity of the disease.

[110] Yepez, Martha C., Denis Zambrano, Fernando Carrasco, and Rodrigo Yepez. "Factores Asociados Con El Incumplimiento Del Tratamiento Antipalúdico En Pacientes Ecuatorianos." *Revista Cubana De Medicina Tropical* 52.2 (2000): 81-89. *Sci Elo Public Health*. Pan American Health Organization, 2000. Web.

Both segments of the noncompliant population cite reasons that could potentially be mediated by better education and communication by healthcare providers. First of all, it makes sense that patients would stop taking a drug that is making them feel sick if they don't know that is a normal reaction for some people and that it is much better than the consequences of malaria itself. Patients should not be expected to just blindly obey instructions given to them, especially if they don't understand fundamental aspects of the treatment such as what to expect in terms of side effects, under what conditions the drugs should be taken, or – in the case of malaria – that it is essential to keep taking the drugs even after symptoms subside in order to fully clear the infection.

For those who cited underestimated the severity of the disease as a reason for not taking antimalarials, a general education campaign about malaria could help improve compliance. It seemed that in those surveyed, those who were told they had *P. falciparum* had a compliance-to-noncompliance ratio of 2:1. On the other hand, those patients who were told they had *P. vivax* had a ratio of 1.5:1, and those who were told only that they had malaria in general terms had a compliance ratio of 1.3:1.[111] This trend in compliance vs. noncompliance mirrors perceptions concerning malaria that are quite prevalent in the Amazon Basin.

Most people in rural Ecuador know that *P. falciparum* malaria is very different than *P. vivax* both from the experience of seeing someone suffer from it and from the severe symptoms if they have had it. Since *P. falciparum* is the flashier of the two strains, it is perceived as much more dangerous, and therefore, patients are likely to follow treatment regimens. Conversely, *P. vivax* is less virulent – has less intense and sudden symptoms – and thus, is seen as less dangerous and more survivable. Finally, those who are told only that they have malaria and not

[111] Yepez, Martha C., Denis Zambrano, Fernando Carrasco, and Rodrigo Yepez. "Factores Asociados Con El Incumplimiento Del Tratamiento Antipalúdico En Pacientes Ecuatorianos." *Revista Cubana De Medicina Tropical* 52.2 (2000): 81-89. *Sci Elo Public Health*. Pan American Health Organization, 2000. Web.

the specific strain are likely ill informed about many aspects of the diagnosis and treatment process. Whether due to a misunderstanding between patient and doctor, a language barrier, or just an apathetic care provider, there is important information that is not being conferred to the patient.

Stepping back into the shoes of the Quechua, remember that their understanding of diseases, including malaria, are based upon observation of symptoms and the disturbance of the relationship between the body and the world around it. Consequently, wouldn't it seem natural for a patient who is having adverse side effects to a drug to immediately think that he or she is just getting sicker because of the drug? And wouldn't a patient whose symptoms have disappeared think he is cured even if he still has a few days left in his treatment regimen?

So the problem is not that these patients in the Amazon Basin just don't want to get better or aren't concerned with their own health, quite the opposite actually. They just see health and illness through a different context than the world of modern medicine. Therefore, they don't need to be monitored while taking medicine in order to increase compliance. Instead they need to be part of a conversation. They need a conversation where their opinions and views can be heard and understood instead of assumed ignorant of medical knowledge. They also need a conversation where they are taught about their condition in terms they can relate to instead of just given instructions in a void of context.

A final complication encountered by international NGOs fighting malaria in Ecuador is a lack of cooperation with the government health system. Communication is not only important between patient and doctor or between an aid organization and the people they are helping; it is also essential for cooperation between aid groups working in the same area. One of the biggest criticisms of Ecuador's public health system and its response to malaria is its patchwork

organization. Governmental initiatives only serve a small portion of people, and even for those people, there is limited funding. They rely on foreign and domestic NGOs to fill in the gaps. However, since there is little to no organization of NGOs working in Ecuador, it is difficult to know which areas are well covered, which need more care, and what care is needed by individual communities.

All of these organizations, bringing with them doctors, supplies, and funds that are desperately needed throughout the Amazon Basin, are coming in to the country blind to what other organizations are already in place. While new NGOs may at least know that the area they serve has no other access to healthcare, they don't know if there is another groups in the general area with whom they could partner to make more efficient use of resources or coordinate outreach into remote communities. Thus, without communication between aid groups serving in the Amazon Basin, there exists a very real problem of uneven treatment, and the squandering of already scarce resources.

In brief, the collision of diverse perspectives on disease, health, and aid can cause some devastating instances of misunderstanding especially if the time is not taken for both sides to openly talk and listen to one another's thoughts, feelings, and opinions. Unfortunately, the breakdown of communication within Ecuador's system of public health allows us to see these consequences very clearly. However, much as there is never just one perspective to a relationship, there are not only negatives that can come from a collision. As trust is built and information shared, there are incredible benefits that begin to arise.

Impacts and Innovation

The word collision may inherently bring to mind negative thoughts, but what if I was to use impact instead? It still can be used to describe the meeting of two very different forces or viewpoints, but also implies a change to both parties because of their convergence. Impacts happen in brainstorming sessions, at schools, and in reformations. They allow us to uncover revelations and novel solutions. They breed understanding, tolerance, and inspiration. Finally, they can signal the start of a new effort for collaboration, which is exactly what is needed in the Amazon Basin.

One of the largest revelations from the clash of modern and traditional medicine in rural Ecuador is the discovery of new resources for antimalarial drug development. While the modern medical world has only 15 drugs to treat malaria – many of which belong to just two main classes – the Quechua have been using over 100 unique medicinal plants for centuries for malaria treatment. Now, their vast knowledge of medicinal plants is being tapped by top ethnopharmacologists, who study cultures and their use of drugs. They are learning about the efficacy, dangers, and traditional preparation of such plants from those who know them best in order to utilize this knowledge in laboratories and potentially create then next new weapon against malaria.

Their research has been promising as well. Of the plants sampled so far, there are a number that show some definitive antimalarial properties that could serve as a new base for the next class of drugs much as quinine and artemisinin did many years ago. Additionally, this conformation of antimalarial activity can serve as validation for the Quechua medical knowledge for those who might be quick to write them off as uneducated in medicine because of their spiritual beliefs regarding illness or ignorance of certain modern medicines.

Another benefit from the convergence of different perspectives can be seen in the outcomes of FHN's clinic in La Y, Ecuador. This clinic began as a joint effort between the community and an international organization, which encouraged community participation in healthcare. Then, once it became established and secure, management was transferred completely to the community allowing them to utilize the new resources and strategies brought in by FHN along with their own knowledge of the community and judgment to continue sustainably offering basic healthcare for the area.

Self-sufficiency is the ultimate goal for any aid operation. The ability to give a service to a certain region is great. However, it requires the constant input of funds, personnel and resources. If instead, an NGO can teach and enable a community to provide that service themselves, they can not only, become self-sufficient, but also create more jobs, empower more members of the community, and address specific community concerns better. It also allows the NGO to focus their efforts on a different challenge to further help that area or to bring their service to a whole new area. For example, FHN in Ecuador has now expanded its efforts to collect regional health and census data so that needs in other isolated communities similar to La Y can be recognized and addressed in the future.

The truth is that collisions and impacts are one in the same. There will always be both good and bad sides in the meeting of diverse perspectives and the sooner we realize this, the sooner we can begin to reap the benefits of these clashes as well as focus on remediating the negative effects.

From Perception to Action: What's the next step?

Observations in their own right are good and useful. However, their impact is limited if just taken at face value. In order to truly utilize this information on disease perception and healthcare, these newfound connections must be applied through progressive changes. In this situation, the changes that need to be made are systematic, and in order to change the structure of a broken system, you need a partnership.

While the Ecuadorian government, organizations working in rural Ecuador, and indigenous people they are helping do not currently fit the traditional definition of a partnership; they have the potential to achieve monumental gains in health and international cooperation by working towards functioning as one. The key to a smooth cooperative partnership is to make sure all participants are informed, empowered, and receptive. Such a relationship starts with communication.

In order to efficiently spread healthcare throughout the population, there must be organization of care providers. Such organization can only come as a result of communication. At the very least, there needs to be better communication between the government of Ecuador and each of the NGOs currently caring for communities in the Amazon Basin and the rest of rural Ecuador. This would allow groups to coordinate plans, pool resources, and ensure that all areas are accounted for and either being treated or will be treated in the future.

Large partnerships of NGOs already exists including Roll Back Malaria, and Malaria No More, which coordinate efforts of individual organizations for research, resource acquisition, and strategizing for treatment. Therefore, it is not unreasonable to suggest the formation of such a partnership between healthcare focused NGOs in Ecuador. Furthermore, creating an alliance of healthcare NGOs might facilitate communication with the Ecuadorian government.

The other major area where improved communication is needed is in the relationship between healthcare providers and the communities they serve. For aid groups, improving communication means increasing transparency and dispelling rumors or misconceptions about the organization. It also entails listening to the concerns and questions of their patients. Open, two-way communication can help to reduce misunderstandings and lead to a more trusting relationship between the two parties. Ultimately, better communication can help increase the efficacy of treatment plans. Patients will understand their conditions and why they are given a particular treatment leading to better compliance with treatment. On the other side, doctors will understand the perspectives and living situations of their patients and then will be able to adapt treatment to give them the best chance of success.

Patient-doctor conversations in rural Ecuador could also benefit from a technique currently being implemented by a health center in the predominantly indigenous city of Otavalo. The health center is called Jambi Huasi and was founded in 1994 by a local NGO in order to meet the unique health needs of the indigenous community. Their philosophy asserts that health needs can only be addressed properly in the context of their own social and cultural context. Consequently, the health center at Jambi Huasi offers not only a full spectrum of modern medical treatments but also have two full-time traditional healers on staff whose services are utilized by around half of the 1,000 patients per month who come to the clinic.[112]

Jambi Huasi's success, they believe, stems form their integration into the cultural traditions and value systems of their clients. They have built a medical system that respects and provides treatments that abide by the indigenous concept of holistic health, which sees the patient not only as an individual, but as biologically, socially, and spiritually linked to their

[112] Hinrichsen, Don. "Working with Indigenous Communities in Ecuador: Jambi Huasi - a Model for Community Empowerment." *United Nations Poulation Fund*. United Nations, 2006. Web. 10 Apr. 2014.

social and natural environment.[113] Furthermore, even modern medicine practitioners integrate traditional medical concepts into their work by using them to help explain a diagnosis or treatment to a patient. When an unfamiliar idea such as a diagnosis is placed in familiar terms such as the traditional understanding of a conditions origin, the patient has a much greater likelihood of understanding important information the doctor is attempting to deliver.

International NGOs could learn a great deal from the model by which Jambi Huasi operates. By legitimizing and providing traditional medicine as well as employing its concepts to convey a diagnosis, international groups could improve relations with indigenous communities, build trust, still reach potential patients who might be weary of modern medicine, and also improve health literacy.

Along with conversations between patients and their doctors, communication in health clinics can be made more effective through pubic health education programs for the entire community. Programs on such basic topics as hygiene, common diseases in the area and their remedies, and general healthy lifestyle tips could go a long way. They would not only improve health literacy and understanding of treatments patients might be given, but also possibly preempt future visits for avoidable conditions.

An education program could then be expanded into a community health worker (CHW) training class. This would allow those interested in healthcare to continue learning how to care for ill members of their community, and allow for members of villages further away from the health clinic to bring care back to their neighbors who may not be able to make the journey to the main health center. Additionally, the training of CHWs allows community members to become

[113] Chelala, Cesar. "Health in the Andes: The Modern Role of Traditional Medicine (Part I)." *The Globalist*. The Globalist, 2009. Web. 10 Apr. 2014.

involved and invested in their own healthcare ultimately lessening reliance on outside organizations and creating a more sustainable healthcare system.

Finally, increase receptivity to the cultural knowledge of local people can lead to immense benefits not only in a single community, or all of Ecuador, but in the worldwide fight against malaria. Local knowledge of medicinal plants made be the key to unlocking the next big class of malaria drugs. Moreover, locals can help give receptive medical providers a sense of the community climate, which can aid in the way they approach exams, interact with patients, and develop treatments.

These six recommendations, all centered on improving communication and respect for cultural differences, could help to organize and concentrate the efforts of combatting malaria and of providing basic health care in the rural Amazon Basin region of Ecuador. They highlight the importance of partnership among all players, empowerment of those in need, and receptivity to new ideas on all sides. These factors are crucial in allowing for equal participation in changes and developments throughout the system. For in order to effectively change a system you need to involve people living inside the system who intimately know its effects and people looking in from afar who can easily spot structural flaws that may be hidden from those inside.

But why stop at the borders of the Amazon Basin? These principles of communication and respect for culture can be translated into terms that apply to any collaborative medical aid effort whether they are in South America, Africa – where malaria is an even more prominent focus of medical aid, or really anywhere in the world. Every country constantly faces its own public health challenges, and even within a country, there exist many individuals with their own unique perspectives on health based on their experiences, culture, and environment. All of these

perspective are not only valid, but also essential to understanding the disease and the social burden it places on a community.

The Aftermath: A Few Closing Thoughts

As human beings, we all have some concept of what health and wellness means. No matter our culture, we know the experience of illness and have some way of coping with that experience. We do not, however, all have the same concept of health. It is a concept influenced by our environment as well as our reactions to that environment, which very not only from culture to culture, but also from individual to individual. Each individual experience of a disease contributes a line to the definition of that disease. One perspective alone can neither describe it completely, nor treat it effectively.

For example, in Ecuador, the Quechua understanding of disease is derived not from germ theory, but instead from their astute perception of symptoms and their interpretation of health as a holistic quality. They see a person's wellness as a product of their biological, social, psychological, and spiritual connections to the environment. This characterization, however, is also a stereotype in the sense that not all individuals within Ecuador and even within the Quechua peoples understand health in this exact way. While it may be true for a portion or even a majority of individuals, there still exists much more variety in perceptions than it is possible to describe.

In the world today, international aid is widespread. There are thousands of organizations and thousands of causes they represent. Through these organizations, culture collision is inevitable, and depending upon how the collision is addressed by both parties, it can be a true wildcard factor in the success or failure of the aid initiative.

Due to the extreme variation in individual perspective of health and the ubiquity of international aid, a need exists for generalized principle with which to address the cultural interface. Two of these principles are increased communication between parties and general

respect and receptivity of a patient's culture, social context, and personal knowledge. Even though they have been assembled from our case study of Ecuador, they are more like basic principles of respectful human interaction. Therefore, it follows naturally that such principles can be scaled up and applied in a variety of different cultural contexts around the world.

While it may seem unnecessary emphasize the need for respect and communication in interpersonal interactions, often these principles are forgotten in pursuit of a seemingly bigger goal such as the eradication of malaria for example. However, it is only through mutual cooperation in these international efforts that progress can be made. And so I will end with the Quechua translation of a critical principle in the world of global health.

Tukuy kay pachaman paqarimujkuna libres nasekuntu tukuypunitaj kikin obligacionesniycjllataj, jinakamalla honorniyojtaj atiyniyojtaj, chantaqa razonwantaj concienciawantaj dotasqa kasqankurayku, kawsaqe masipura jina, tukuy uj munakuyllapi kawsakunanku tian.

All human beings are born free and equal in dignity and rights. They are endowed with reason and conscience and should act towards one another in a spirit of brotherhood.
(Article 1 of the Universal Declaration of Human Rights)