MALARIA: A Cause and Effect of Poverty

Frequently Asked Questions

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The noise was deafening.

I found it difficult to believe that less than ten minutes ago I was sitting comfortably in my uncle’s SUV, chuckling at his light-humored joke, marveling at the East African savannah scenery that melted past us. Little did I know then that in moments I would be forcing my way through a dense crowd of people who were all shouting, pleading words of desperation in a language unknown to me. Shielding my eyes from the searing sun, I passed through mothers wearily carrying exhausted, limp children in rags, and dozens of outstretched hands reaching for a hope that has always been out of their grasp.

My uncle was shouting something urgently over his shoulder as we hurried through the swarm, but his voice was drowned among the uproar that surrounded us. I don’t know how he could have spoken, let alone shouted; my mouth was so dry from panic that all I could do was mechanically nod and continue snaking through the dense horde on my own haphazard trail.

Shortly, we came to a bleached-looking cement building with a patched tin roof, where a group of familiar volunteers were briskly tearing open crates of pristinely packaged white netting. If I was not mistaken, the crowd had become even more relentless, a mass that embodied human survival in its most raw form. In a spur of the moment, I grabbed pieces of spare tarp and lined them up so that they led to the volunteers. Catching onto my idea, my uncle ordered everyone to stand on the tarp and follow the forming line. But even with the crowd immediately hushed, something was still unsettling; perhaps it was the unmoving, carried forms that began to stifle strained, dry sobs, or the perfunctory manner of 600 people moving in a line; or maybe it was my thoughts echoing ‘Why? Why them?’ answered with a helpless derision, ‘That’s just the way it is.’

Even with the numb silence, the noise was still deafening.

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What is Malaria?

Malaria is one of the most common infectious diseases our world faces today and is prevalent in 109 countries.\textsuperscript{10, 13} The term comes from the Medieval Italian \textit{mala aria}, meaning \textit{bad air} suggested by early 18\textsuperscript{th} century Italian explorers.\textsuperscript{10} Malaria is not caused by breathing the “poisonous vapours of swamps” but by protozoan parasites, very small, single-cell blood organisms that harm their host.\textsuperscript{10} The parasite can harm any animal with red blood cells, however some strains have evolved to thrive in specific species.\textsuperscript{10} It is widespread in tropical and humid climates, including parts of the Americas, Africa and Asia.\textsuperscript{10}

Before antibiotics in the early 20\textsuperscript{th} century, patients with syphilis were purposely infected with malaria to create a fever, which surprisingly alleviated most of the effects of syphilis.\textsuperscript{11} By precisely controlling the fever with quinine, the anti-malarial drug of choice until the 1940s, the effects of both syphilis and
malaria could be diminished. However, some patients died from malaria, but at the time it was preferable to the very likely death from syphilis.

The parasite itself is from the genus *Plasmodium*, which represents a broad category of more specific strains: *Plasmodium falciparum* (the most serious of which causes 80% of all human malarial infections and 90% of the deaths); *Plasmodium vivax* and *Plasmodium ovale* (two rarely fatal, reoccurring forms of the disease), and *Plasmodium malariae* (also known as “benign malaria”).

**How is Malaria spread?**

People get malaria by being bitten by a female *Anopheles* mosquito that must have been transmitted through previous contact from an infected person. When a mosquito bites an infected person, a small amount of blood is taken, blood that contains the microscopic malaria parasites. When the mosquito bites again, these parasites mix with the mosquito's saliva and are injected into the person being bitten. Also, Malaria can be spread by any exchange of blood with an infected individual; for example, through organ transplant, blood transfusion or the shared use of needles contaminated with blood. Malaria may also be pass on from a mother to her infant before or during delivery ("congenital" malaria).

**What is the life cycle of the parasite? Once it has infected a host, does it always remain in the body?**

First, the parasite infects the liver. Immediately after being biten, sporozoites, or undeveloped parasites, infiltrate into the liver cells and undergo repeated replication. Then, merozoites, or ‘daughter cells’ of the replicating parent, are released into the blood stream. Depending on the strain, the parasites may remain dormant in the liver and release merozoites weeks or even years later, triggered by unknown reasons. Only when these parasites are released in much higher numbers into the blood, symptoms occur, marking the clinical stage of the disease. Merozoites invade red blood and degrade our protein responsible for oxygen transport, hemoglobin, so it can obtain essential amino acids for its growth;
incidentally, haemoglobin is broken down into two parts; haem and globin. Haem is toxic to the malaria parasite, so it produces a chemical which converts the toxic heme into a non-toxic product.

The most serious strain of the parasite, *Plasmodium falciparum*, has a special feature of developing sticky knobs in red blood cells, which then adhere to the average cells in our blood vessels, to avoid being cleared in the spleen. The adhesive characteristic of the red blood cells may cause cerebral malaria, a form of the disease that prevents oxygen from being efficiently delivered to the brain.

**Is it an issue that the average person has to worry about?**

Generally, you are only at risk of contracting Malaria if while living in or traveling to an endemic area; however since about half the world’s population lives in Malaria endemic regions, it is a concerning issue of which the average person needs to be more aware. Overwhelmingly, there are approximately 515 million cases of malaria *each year*, killing between one and three million people, the majority of whom are young children in Sub-Saharan Africa. In addition, 10,000 travellers become ill with malaria after returning home. Even the strong and healthy can contract this deadly disease, but it can be even made worst for the elderly, young children, and the immunocompromised with existing health problems such as AIDS.

**What are the symptoms and medical implications of Malaria?**

The symptoms at first are not always dramatic and can often be dismissed as something important. Within the first 7-30 days, there may be flu-like symptoms such as headache, nausea, fever, and vomiting. Moreover, warning indications may appear at what may seem like random intervals. Cyclic symptoms are caused by the life cycle of the parasites as they develop, mature, reproduce and are released into the blood stream to reinfect even more blood and liver cells.

In the case of the most serious and common strain, *Plasmodium falciparum*, which can lead to Cerebral Malaria, symptoms include impaired consciousness, seizures, neurological damage, and coma. Without
the knob binding complexes, which is an exclusive feature of *Plasmodium falciparum*, red blood cells do not stick to the walls of blood vessels, and infected individuals do not experience symptoms such as cerebral malaria.\(^\text{10}\) Also unique to this strain is the 48 hour life-cycle, which causes fever on day one, then next on day three, and so on.\(^\text{3}\) This intermittent fever cycle differentiates Malaria from Typhoid Fever which is marked with a continuous fever.\(^\text{3}\)

**What are the medical implications if not immediately treated?**

Ultimately, if left untreated, malaria can lead to fever marked with intense shivering leading to delirium, coma, and death.\(^\text{9}\)

However, not all strains are virulent but still need immediate medical attention nevertheless.\(^\text{9}\) Some of the more severe stages of the disease have characteristics that include kidney failure, abnormal liver function (replication of the parasite in its initial life-cycle), anemia (degrading of red blood cells), an accumulation of fluid in the lungs (“pulmonary edema”), and a condition known informally as "Black water fever", so called because of dark urine that results from the massive destruction of red blood cells destroyed by the parasite.\(^\text{9}\)

The parasites live inside cells, quite a clever adaptation since they are essentially hidden from our immune response.\(^\text{10}\) However, infection with malaria tends to *suppress* the immune system, rather counterintuitive to believing that the parasite would trigger some immediate kind of alarm signal in our body.\(^\text{10}\) Dendritic cells, one of the cell types driving our immune system, need a specific threshold of signalling with infected cells to mature properly and eliminate those cells.\(^\text{10}\) Once they interact with Malaria-infected cells, however, Dendritic cells do not receive a sufficient signal (yet another shrewd adaptation for the parasite) and are rendered virtually incapable of protecting our liver from rapidly replicating parasites.\(^\text{10}\)
Another medical implication is full recovery, depending on the aggressiveness of the parasitic strain, and even some long-term immunity against Malaria.\textsuperscript{10} This is because infected cells directly stick to and activate our B cells, which in turn pump out proteins called antibodies.\textsuperscript{10} The antibodies will bind specifically to the parasite in such a manner that it will not be able to reinfect our cells again.\textsuperscript{10} On the other hand, the Plasmodium species tends to mutate very quickly, changing one aspect of itself that makes it unrecognizable to those antibodies.\textsuperscript{10}

\textit{How can the spread of the disease be prevented?}

Ultimately, research toward effective vaccines and insecticides is an invaluable component to the prevention of Malaria.\textsuperscript{13} However, something as simple as draping mosquito netting over your bed would prevent the majority of most cases.\textsuperscript{9} Also, it is best to avoid being out at dusk, wear light-coloured clothes that cover most of skin, apply mesh screens on doors, and have citrus-type essential oil, or citronella oil in a vaporizer.\textsuperscript{9} For travelers, it is also advised to avoid high-risk Malaria zones (such as the wilderness), and to take anti-malarial drugs.\textsuperscript{9} Also, it is best to avoid used needles, and receiving an organ or blood from a person who has Malaria.\textsuperscript{9}

Unfortunately, daily or weekly preventative drugs and insecticides are often not feasible for residents living in endemic areas.\textsuperscript{9}

\textit{What are the treatments of Malaria and how do they work?}

The anti-malarial drug of choice until the 1940s was called Quinine, and it is worth noting because today it is an ingredient found more commonly in foods then we think.\textsuperscript{11} Quinine acts by inhibiting what’s called \textit{hemozoin biocrystallization}, or the parasite’s way of making the by-products of red blood cell destruction less toxic for itself.\textsuperscript{11} Thus, this drug facilitates an accumulation of cytotoxic heme.\textsuperscript{11} The amount of toxic free heme builds up in the parasites, leading to their death.\textsuperscript{11} The problem with increased cytotoxic heme is our own immune response to it, which parallels to a severe if not fatal fever
reaction when the parasites unnaturally lyse are cells. The Quechua Indians of Peru were the first to take the bark of the cinchona tree and use it for malaria treatment. Today, it happens to be the flavour component of tonic water and bitter lemon. As maintained by tradition, the bitter taste of anti-malarial quinine tonic led British colonials in India to mix it with gin, consequently creating the gin and tonic cocktail.

However, Quinine was soon replaced with more efficient drugs such as Primaquine and Chloroquine. Chloroquine is used in either the treatment or prevention of malaria. It mildly suppresses the immune system and works similarly to Quinine by preventing the organism from rendering its metabolic waste to be non-toxic to the parasite. Thus, the organism drowns in its own metabolic products. With a slightly suppressed immune system, our body will not react as vigorously to this increase in metabolic products, decreasing the likelihood of a deadly fever and delirium.

Primaquine, on the other hand, is not used in the prevention of malaria, only in the treatment. It is most often used following treatment with chloroquine. Primaquine acts by specifically thwarting the parasite’s mitochondria, an organelle that is dependable for supplying it with energy. Without energy, the parasite dies. This stops the infection from continuing and allows the person to recover.

Is there a vaccine available?

Unfortunately, there is no vaccine is available. Preventive drugs decrease the risk of infection but are seldom affordable for most people living in endemic areas. Many people living in high-risk regions have some partial long-term infection, which tends to recur, and may have partial immunity; even with some immunity to the parasite, they may become susceptible to severe malaria if they leave endemic regions for a long period of time, then return.

There are many reasons as to why no vaccine has been developed. First, the plasmodium species as a whole replicate at a very high rate, much faster than actually needed to guarantee transmission in its life cycle. Also, pharmaceutical treatments work beautifully in decreasing the reproduction rate
but not halting it completely; for this reason, it is likely a vaccine will be produced that would diminish at least the severity of malaria for children living in endemic areas.

The parasites then adaptively ‘upgrade’, so to speak, their ways of evading our body defences, favouring the development of resistance. Evolutionary change is an important concept to consider when researching for potential vaccines. Because of resistance, a potential vaccine can be rendered useless, a weighty investment gone to waste in the eyes of most pharmaceutical companies.

Is it possible to be born with complete, long-term immunity to Malaria?

Everyone is susceptible to getting Malaria, even those who have been exposed to it before, but there is essentially one exception: those with rare, genetic blood disorders, most notably “sickle-cell anemia”. Sickle-cell anemia is an inherited, lifelong disease that is passed down if a child receives one copy of the sickle-cell gene from each parent. Normal red blood cells are shaped like doughnuts without holes and last about 120 days in the bloodstream. Sickle red blood cells are shaped like a “C”, die after only about 10 to 20 days, and are physically not built to carry oxygen efficiently. Red blood cells are essential for supplying oxygen to our organs and removing carbon dioxide, and a lower number of functional red blood cells can lead to life-long fatigue and serious complications.

If sickle-cell anemia is so maladaptive, then why has it been, evolutionarily speaking, “selected” to be passed on generation after generation? It so happens that the Plasmodium parasite cannot breakdown the uniquely shaped haemoglobin from sickle red blood cells, and thus cannot infect these individuals. Following this logic, it should not be surprising that the highest incidence of sickle cell anemia is in endemic regions for malarial infections.

What is the economic impact of Malaria?
When considering the economic impact of Malaria, it is important to look at the disease as both a cause and an effect of poverty and a major strain on economic development.\textsuperscript{14} There is a noticeable gap in prosperity between countries with malaria and countries without malaria that has become wider every year.\textsuperscript{14} A comparison, or rather more of a contrast, of average per capita GDP in 1995, modified for equivalence of purchasing power, between countries with malaria and countries without malaria has a striking fivefold disparity ($1,526 USD versus $8,268 USD).\textsuperscript{10} Between 1965 and 1990, the average per capita GDP has risen only 0.4\% per year in countries where malaria is common, compared to 2.4\% per year in other countries.\textsuperscript{8} For example, during the late 19th and early 20th centuries, it was a major factor in the slow economic development of the American southern states! \textsuperscript{3} Even though mostly tropical regions are affected, malaria can reach some temperate zones with extreme seasonal changes.\textsuperscript{14} The possibility of Malaria affecting southern USA today, even with extreme weather changes, is unlikely because of our advanced healthcare practices.\textsuperscript{14}

Poverty is seen as a cause of malaria, as well as infectious diseases in general, since the poor are financially unable to prevent or treat the disease.\textsuperscript{14} The lowest income group in Malawi, for example, carries the burden of having 32\% of their annual income used on this disease compared with the 4\% of household incomes from low-to-high groups.\textsuperscript{10} As a whole, the economic impact of malaria has been estimated to cost Africa $12 billion USD every year.\textsuperscript{10} This expenditure includes costs of health care, lost working days due to sickness, days lost in education, a decline in productivity due to brain damage from cerebral malaria, and an underdeveloped tourism industry since investors and traders are not inclined to travel and invest in endemic areas.\textsuperscript{10} Local farmers also plant subsistence crops rather than more profitable manual-labouring cash crops because of malaria’s effect on workers during harvest season.\textsuperscript{14} In some countries with a heavy malaria burden, the disease may justify for as much as 40\% of public health expenses, 30-50\% of inpatient admittance, and up to 50\% of clinic visits.\textsuperscript{14} Creating ways to encourage government subsidies and ensuring that public healthcare providers are closer to all of the people in a town are effective ways to lessen the cost of treatment for the poor and all social classes. Equal accessibility and distribution of treatment is key here.\textsuperscript{10}
In addition, families are often unable to buy insecticide treated mosquito nets (ITNs), doctors' fees, anti-malarial medication, transport to health facilities, support for the patient as well as for a family member during hospital stays. Malaria also hampers children's education and social development through both non-attendance and enduring neurological effects of the disease.

**What is being done locally for the fight against Malaria?**

Most undertakings toward combating malaria are done through internationally networked NGOs such as TamTam Africa, and also a notable project funded by the Bill Gates Foundation, the latter of which was even commended by Tony Blair at the World Economic Forum as an endeavour that will ultimately bring “a long-term solution to malaria control.”

An example of a locally-based project is Mission Against Malaria Society (MAMS), a registered Canadian charity that aims in the prevention and awareness of Malaria in the heart of Tanzania, Africa. What is particularly specific about this campaign is the focus on immediate prevention of malaria and long-term awareness, while taking into account women’s rights and gender-specific obstacles in obtaining access to malaria treatment. For this reason, their efforts are aimed primarily towards children in boarding schools, women and large families. MAMS is also planning infectious disease awareness programs in Tanzanian boarding schools; the vision for this next project is for students to put themselves in a new perspective, in the place of someone who would treat or prevent the disease rather than be the one treated. This would foster an atmosphere of being proactive and ultimately a generation of leaders who extend their awareness back into their community.

**What are the political and developmental challenges that impact the effort to fight Malaria globally?**
Teams of countries are coming together to implement band-aid strategies for an illness that already has a cure and sound preventative approaches. So why aren’t those measures consistently being taken? This leads me to perhaps the most important question of all: Why are up to three million people dying of Malaria each year if there are already efficient tools to control it? In other words, Why them?

There are three major obstacles in carrying out a successful malaria control strategy. First, we need to change the common perception that insecticide control can only be done by a large corporate institution. The private sector would be invaluable in this area, as it can boost community and government relations and support research and development of new treatments for malaria. It is also advantageous in marketing and PR to aid public education campaigns.

The second major constraint is the reduction in central budgets. The World Health Organization lacks the funds, and some major benefactors are uneasy about investing in what may seem like a bottomless pit.

Another concern is the lack of effective vector control in developing countries or tracking of emerging strains. It is essential for research of vaccines, the successful prevention of mortality and reduction of morbidity. Drug-resistant parasites and insecticide-resistant mosquitoes is a concerning issue, especially in regions that were safe in the past. We are becoming less well equipped to deal with malaria and the current mortality trends will remain if new ways of control are not created. Malaria is causing an increasing load on both the economic stability and progression of public health in the countries where the disease is endemic. Our global priority? Make more diverse treatment options and research on prevention strategies and vaccines.

Sources:


