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Baccalaureate Honors Program/Health Administration Minor Capstone Project

Submitted 12-10-2021

A Review on the Etiology, Treatment, Administration, and Challenges of  
Neglected Tropical Diseases in the Democratic Republic of Congo: Onchocerciasis  
and Four Other NTDs treated by the United Front Against Riverblindness

The Democratic Republic of the Congo is a country that takes up much of Central Africa, rich in natural resources such as copper and cobalt with a complicated, bloody history. Formerly known as Zaire, the DRC is the second-largest in the continent of Africa and 11<sup>th</sup> largest in the world. The Congo's population is approximately 92,000,000. Inhabited originally by the Central African foragers 90,000 years ago, the Congo began to see European expansion in the 1870s when Henry Morton Stanley explored the Congo Basin for Belgium. Leopold the II of Belgium claimed the territory in 1885 as his own, as European explorers had a habit of doing, and named it the Congo Free State.

The Europeans proceeded to exploit the Congolese for their labor and resources, forcing them to produce rubber, leading to the death of millions due to exploitation and disease. The Congo became independent of Belgium in 1960, run as a dictatorial one-party state under Joseph-Désiré Mobutu, who renamed himself Mobutu Sese Seko. Joseph-Désiré Mobutu came to power through a coup d'état in 1971. The Rwandan genocide of 1994 began the destabilization of this governmental system, when the Rwandan invaded in 1996, leading to Mobutu's descent from power.

The next president changed the name of the country to the Democratic Republic of the Congo, as we know it today. However, due to tensions between this new president and the Rwandan and Tutsi presences in the Congo, the Second Congo War erupted in 1998 and lasted until 2003. Over 5,400,000 people died, devastating the country. In fact, conflict within the Congo has been the deadliest of all in history since World War II<sup>17</sup>. The president, Kabila, was assassinated in the night and succeeded by his son. Under Joseph Kabila, human rights were under attack at all times. According to Human Rights Watch<sup>17</sup>, Kabila and his family stole

hundreds of millions of dollars from the copper and cobalt industry. Devastatingly, the immense wealth radiating from the rich, fertile grounds of this country could be key to ending poverty in the DRC. However, it is unlikely that any profit from this industry would end up anywhere except in the secret accounts of the rich and powerful, particularly of those who do not even reside in the country, as will be discussed later.

President Joseph Kabila abused his power to critical levels, delaying elections that would get him removed from power. His use of “violence, repression, and corruption”<sup>17</sup> furthered the vice-like grip he has on the country. Although he was forcefully removed from power due to a constitutionally mandated two-term limit, his power will extend beyond his reign. The methods Kabila used on the DRC endorsed rewarding those most responsible for suffering and impoverishment. This includes accounts of rape, massacres, and decapitation, displacing over 200,000 people for fear of arbitrary imprisonment and forced disappearances.

Mass corruption in the Democratic Republic of the Congo has led to the death of millions, more than anything seen since the second World War, a crisis that is often ignored or deemed unimportant by anyone who is capable of helping. The people of the Congo continue to suffer for the actions of their leaders, who show no regard for human life but instead for the weight in their own pockets. Often, victims of this crisis are denied medical care, in violation of the Convention Against Torture of which the Congo belongs to<sup>17</sup>.

Population displacement, violence, and the destruction of infrastructure along with human health services has been devastating to the overall populations’ health. A survey conducted by the Médecins Sans Frontières<sup>18</sup> looked into mortality rates, access to healthcare, vaccination coverage, and violence exposure. Particularly high mortality rates were concentrated

in front-line zones due to malnutrition and infectious diseases. Acute need for humanitarian services becomes more vital every moment as rural areas that were directly affected by the conflict in the country are disproportionately affected. It has been estimated that 2,700,000 people were displaced in the Congo in the past few decades<sup>18</sup>, and this combined with infrastructure destruction has been devastating to a population that is two-thirds the population of Western Europe.

Out of 191 countries surveyed by the World Health Organization in 2000, the Democratic Republic of the Congo ranked 179<sup>th</sup> in terms of overall health of the country. Congolese authorities invested so little into the health system that salaries have gone unpaid, along with “dilapidation of health centres and hospitals and poor distribution of essential medicines and supplies”<sup>18</sup>. The DRC has a birth mortality rate of 48.9 out of every 1,000 births<sup>19</sup>, along with a maternal death rate of 1,289 out of every 100,000 mothers<sup>19</sup>. Sadly, since achieving independence, health conditions have not improved. If anything, conditions continue to decline. Access to drinkable, clean water is limited, conditions for living are poor, and food availability is low. Health services in the DRC are only accessed 0.15 times per inhabitant of a household per year<sup>19</sup>, indicating highly limited access to such resources and a possibility of distrust for the services. Transmissible diseases are rising in incidence, even when considering diseases that have been controlled within reason in the past few years; along with nontransmissible diseases, such as diabetes, systemic arterial hypertension, cancer, and sickle-cell anemia<sup>19</sup>. With the health of the Congo in shambles, it is vital to turn our attention to diseases that can be controlled now that will have a lasting impact on the improvement of the economy and health systems. In fact, the ideal outcome is that the treatment process reveals to us new ways of treating diseases.

President Joseph Kabila of the Democratic Republic of the Congo. Kabila overstayed his presidency for over two years past the constitutionally mandated two-term limit. He was president from January 2001 to January 2019 after inciting mass violence and human rights conflicts in the country.

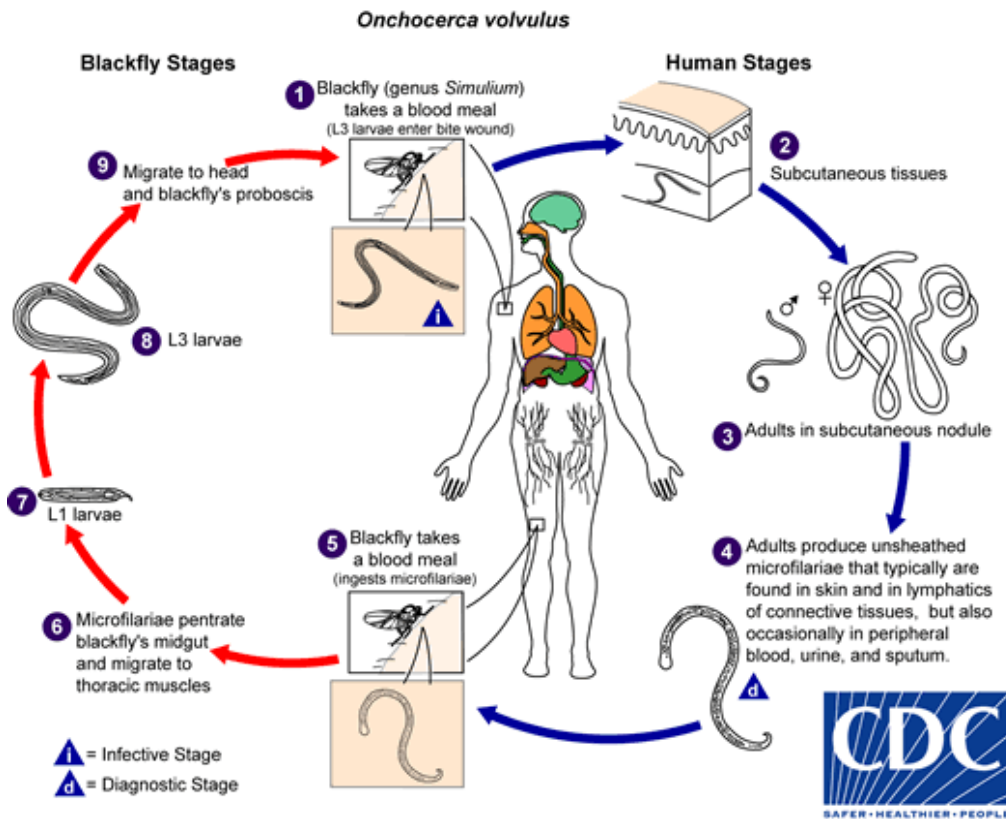


All of this being said, there are a plethora of tropical diseases plaguing the Congo that are very serious for many reasons. With a health system that fails to reach out and treat, many are being left to die of their illnesses without ever knowing that there was ever a cure or a treatment. A term used to describe diseases of this sort is “neglected tropical diseases”, or NTDs. These are diseases that affect primarily the poorest people of the world and are not given much attention when they would probably be considered devastating and top-priority to treat in developed countries. This paper will focus on a few of the NTDs that the United Front Against Riverblindness focuses on, including onchocerciasis and several others. Onchocerciasis is a disease that originates in Africa, caused by the parasitic worm *Onchocerca volvulus* that is

spread by the bites of the *Simulium damnosum* black fly. Onchocerciasis, known more commonly as river blindness, is one of the most common preventable causes of blindness in the world via infectious means. It causes tissue damage and scarring, eventually leading to blindness in many cases, as well as dermatologic symptoms such as eczema-like rashes and raised papules.

*Onchocerca volvulus* find their hosts in humans. During their larval stages, they grow in the *Simulium damnosum* black fly. The growth cycle of the parasitic worm is critically important to its spread, with the following information from Gyasi, Okonkwo, and Tripathy<sup>1</sup> detailing this cycle. The life cycle starts with the microfilariae larvae, considered stage L3, being injected into a host. Within 6-12 months, they develop into adult worms residing in subcutaneous nodules (fluid-like bumps under the skin), with 2-3 microfilariae per nodule. These nodules are a notorious symptom of river blindness, causing an intense sensation of itchiness under the skin and general discomfort. These adult female worms can produce 1,000-1,500 microfilariae daily, and they live 10-15 years<sup>2</sup>. In an infected host, there can be millions of these baby worms, moving subcutaneously and lymphatically. The black fly ingests these baby worms, L1 microfilariae, through feeding from infected hosts, and develop over a few weeks into the L2 larval stage. They then enter the L3 larval stage and migrate into the salivary glands to be transferred into a human when the black fly bites. It takes multiple, repeated bites by these black flies to infect a person. The larvae inside of the human host enter the L4 stage for one year working towards maturation.

**Figure 1: Life Cycle of *Onchocerca Volvulus***



This figure demonstrates the life cycle of the *Onchocerca Volvulus*. Some key parts of the life cycle include time spent maturing within a blackfly and time spent in a human being. Photo Credit: Center for Disease Control, 2019.

There are risk factors identified for contracting onchocerciasis. The people at risk for developing river blindness are those who live alongside streams and rivers, where the blackfly lives and breeds. There, the symbiotic relationship between the blackfly and the microfilariae can flourish, as the people who live and work along the river will be bit by flies that already have the parasite or pass the parasite on to “innocent” flies who can then pass on their newly acquired parasite to a new host. Being a male can lead to an increased prevalence of contraction, along

with not taking the drug used to treat onchocerciasis, ivermectin, and being older than the age of 35.

Onchocerciasis is an endemic disease in 31 sub-Saharan African countries, along with the Arabian Peninsula and some presence in Latin America, introduced during the slave trade, though 90% of the disease is prevalent in Africa<sup>1</sup>. The World Health Organization estimates that 25,000,000 people have been infected worldwide, with 90,000,000 at risk of developing the infection. The Global Burden of Disease Study estimates that 14,600,000 of infected peoples have the skin disease with 1,150,000 having some form vision loss. Worldwide, there is ongoing mass drug administration (MDA) of ivermectin (more on this drug later in this paper) to reduce the symptoms and spread of river blindness<sup>3</sup>

*O. volvulus* infection results in skin itching and sight problems. The itching in the skin is a result of migrating microfilariae from the nodules that form subcutaneously. As raised papules in the form of rashes evolve into chronic dermatitis, the victim may experience “lichenification, development of papules, atrophy, and depigmentation”<sup>6</sup>. Lichenification leads to thickened skin, hyperpigmentation, and exaggerated lines of cleavage in the skin, and atrophy is the shrinking of muscles due to disease or disuse. The skin issues get significantly worse if not treated promptly. Onchocerciasis can also cause edema of the peripheral limbs, or fluid retention, along with swelling of the lymph nodes (lymphadenopathy) and “hanging-groin”—or elephantiasis of the male genitals. The female worms while in the host human can induce an inflammatory response that leads to granuloma formation, which is a small nodule. Eventually this develops into a subcutaneous nodule, called more specifically an onchocercoma, or the subcutaneous nodules that contain the parasites.



**Figure 2:** Depigmentation of the Skin in Onchocerciasis Infection



A Cameroonian man demonstrates depigmentation by way of onchocerciasis infection. This type of depigmentation is frequently called “leopard skin,” as a result of a combination of inflammation and scratching to the point of damaging the skin. Photo Credit: Helen Keller International/Yaobi Zhang

Besides aggravating skin conditions, onchocerciasis can lead to severe visual impairment. In fact, river blindness is the second most common preventable cause of infectious blindness<sup>7</sup> in the world. When *O. volvulus* invades, the host’s initial reaction to the infiltrating microfilariae is to initiate corneal scarring as well as sclerosing keratitis. The blindness caused by onchocerciasis is the primary issue of the disease, and one that will be a focus point of this paper.

The pathophysiology of onchocerciasis is still being studied. While the route of entry is known to be through bites of the black fly, where it goes from there is less clear. How the

parasite gets from the entry site to the eye is proposed to be through the bloodstream, nerves, cerebrospinal fluid, and even the sheath of the optic nerve<sup>4,5</sup>. While onchocerciasis causes painful skin lesions and nodules, the most debilitating aspect of the parasite is how it affects sight. What researchers found is that the “host’s reaction to the infiltrated microfilariae initiate corneal opacities or punctate keratitis that can develop into corneal scarring and a sclerosing keratitis<sup>6</sup>.” Punctate keratitis is when small groups of cells on the corneal surface become apoptotic. This develops into sclerosing keratitis, which is the inflammation and injury of the interior adjacent layer. Corneal scarring prevents light from passing through the cornea, causing clouding. Both of these contribute to blindness in the host. Through a series of parasite-host interactions, *O. volvulus* release a myriad of molecules that directly interfere with host cell functions, of which the host’s defense mechanisms have little success in fending off, making it more successful in invading the body.

River blindness has played a critically important role in societal structure in the Congo. Not only does it affect the individuals who go blind, but that individual’s family and village as well. Blindness renders one essentially useless in a society that requires people to be moving to survive, in which everyone has to contribute with their hands and physical labor in some way. These people become outcasts, rejected by others, useless to their village, and tend to live without shelter or sustenance. Those who are fortunate enough to be kept by their families have now become a burden. Not only do they have to be cared for without providing anything themselves, but frequently, the children are left in charge of their elderly parents or grandparents. This much time commitment requires children to drop out of school, forfeiting what little education they would be able to receive, leaving them uneducated and at a riskier place when it

comes to solidifying a successful future. The strain the people with river blindness put on their families and their villages is one that cannot be ignored and can be fixed with treatment.

There are some improvements in this area, with steps being taken to create useful positions for blind people, so that they may be of use and even make a living so they do not cause such a strain on their societies. For instance, one man was a rich merchant who went blind due to onchocerciasis had instruments to turn agricultural crops into powdered versions for baking and cooking and anything else powder could be useful for (from an interview with Dr. Daniel Shungu, 2021). Advances such as this one provide a hopeful future for those who cannot be treated by medication, which leads us to our next challenge.

The search for a cure for onchocerciasis was on. The story of a drug derived from the avermectin family of compounds is almost a miracle: in 1970, Japanese scientist Satoshi Ōmura isolated an unusual bacterium of the *Streptomyces* family while along a golf course at the southeast coast of Honshu, Japan. From here, Ōmura sent the bacterium to William Campbell, an Irish-American scientist who worked at Merck, an American multinational pharmaceutical company based in New Jersey. Campbell discovered that a bacterial culture could be used to cure *Heligmosomoides* (round worm)-infected mice<sup>12</sup>. Campbell then decided to isolate the active compounds from the unusual bacterial culture, naming them “avermectins”, meaning literally “without worms” (a/vermis) for the cultures potent ability to clear mice from worms.

At this time, Merck & Co laboratories marketed ivermectin as a veterinarian antiparasitic as of 1981. It was the bestselling veterinarian medication in the world. Then, another Merck scientist named Mohamed Aziz decided in collaboration with WHO to test if ivermectin was safe to use in humans to fight onchocerciasis<sup>13</sup>. Determining it to be safe, Merck registered ivermectin

for human use under the name Mectizan in 1987. The CEO of Merck, Roy Vagelos, pledged that Merck would donate all of the ivermectin necessary to eradicate river blindness from the face of the planet, a move that has since changed the course of history of the Democratic Republic of the Congo along with so many other countries for the better. In 2015, Campbell and Ōmura won a Nobel Prize in Physiology and Medicine for discovering avermectin.

The way ivermectin works is, as the name implies, by killing the parasite by interfering with the nervous system and muscle function. It does this by enhancing inhibitory neurotransmission. The drug is directly effective against the larval stage, microfilariae, of *Onchocerca volvulus*, paralyzing them. Ivermectin does not kill the female worms, but does seem to paralyze the reproductive tract and cease the release of microfilariae. This makes the drug highly effective in reducing microfilarial load<sup>14</sup>.

Merck & Co committed to donating Mectizan in 1987, for as long as needed for the effort to end river blindness. Merck's decision to donate Mectizan brought with it some challenges, specifically that these diseases affect the poorest of people, in weak health infrastructure countries. Merck thus established the Mectizan Donation Program (MDP), a partnership that operates out of Atlanta, Georgia, to assist with these issues in 33 endemic countries. The MDP coordinates technical and operational issues between Merck, the endemic countries, and WHO.

Some specific challenges the MDP seeks to tackle start with clearly defining a target population, in order to set operational priorities with the goal being to treat the most severely affected first and foremost. Those with the highest risk factors, mentioned earlier, were set as the initial target population, but at some point, researchers also realized that treating everyone equally was probably the most efficient way for distributors to give out the drug.

The next challenge is one that this paper will focus heavily on, and that is the issue of reaching out and involving the community. During the initial stages of ivermectin distribution, a mobile-team approach was used on a small scale. There was a great deal of attention invested in weighing patients for their individually correct dosage along with active surveillance for reactions that may turn adverse. Eventually, when ivermectin was proven to be relatively safe and effective, more leeway was granted in the way of distribution. Something else to consider is that in these endemic-ridden countries, many people are malnourished and underweight, so distribution had to be adjusted to account for height as opposed to weight (Figure 3). With these situations accounted for, the next problem was staffing. As the organizations could scale up distribution, they needed more of a health staff to do so. A group of non-governmental development organizations (NGDOs) addressed the problem of field involvement and communication regarding mass treatment.

**Figure 3:** Heights of the people in the four dosing categories for ivermectin

**Table 2: Heights of people in the four dosing categories for ivermectin**

No. of tablets	Height (cm)					No. of people
	Minimum	25th percentile	Median	75th percentile	Maximum	
0	90	97	99	103	119	43
1/2	92	110	116	123	139	1310
1	109	136	145	151	173	1575
1 1/2	135	155	160	165	185	3109
2	150	166	170	174	188	336
Overall	90	133	153	162	188	6373

This table demonstrates the height/dose measurements to be followed when administering ivermectin to the population. The four dosing categories receive either ½ a tablet, 1 tablet, 1 ½ tablets, or 2 tablets. Height increases

by roughly 15 cm in the minimum height percentile for each upward dose. Photo credit: *Bulletin of the World Health Organization*<sup>15</sup>.

The MDP is disease-specific donation program, focusing on distributing Mectizan in remote areas in which health services are hard to come by, reaching over 400,000,000 people in affected areas. Mectizan is also donated for the purpose of treating lymphatic filariasis, another neglected tropical disease (NTD).

With Merck's donation program, Mectizan (ivermectin) can be distributed far and wide throughout the Democratic Republic of the Congo. However, it can be argued that bringing in a group of white doctors from the United States to throw medicines at the Congolese people might be problematic and may not go well. The question then remains: how can this problem be avoided while still providing the Congolese with proper treatment?

Before we go any further, we are going to turn our attention to one of the non-governmental organizations that is working towards the elimination of onchocerciasis along with several other neglected tropical diseases. This organization, the United Front Against Riverblindness, was founded in 2005, registered in the US and the DRC as a nonprofit by Dr. Daniel Shungu. Dr. Shungu was born in the Congo and sponsored by a Christian church in the Congo to go to college in the United States. He became a naturalized US citizen and went to medical school at Temple University in Philadelphia, specializing in clinical laboratory medicine. Dr. Shungu began working at Merck & Co laboratories. When his son received a financially-generous scholarship to attend Duke University, Dr. Shungu took time off from Merck to go back to the Congo. There, he spoke to the Minister of Health, Dr. Eteni Longondo, about what he could do to give back to his community, citing his Christian faith as motivation to

do good for the country that his heart belongs to. Dr. Longondo begged Dr. Shungu to take on the project of river blindness, emphasizing the terrible impact the disease has had on the country.

Dr. Shungu embraced the challenge, establishing UFAR in Kasongo after seeing firsthand the effects of onchocerciasis when given a trip into the field itself. As UFAR became actively involved in the fight against the disease, there were 21 separate community-directed treatment with ivermectin projects (CDTI) including UFARs in the Maniema province. CDTIs are strategies relying on trained volunteers in the community to help administer ivermectin to the population. There will be more on this vital concept in a later section. Within its first year, UFAR distributed ivermectin to over 1,000,000 Congolese people in the Kasongo province.

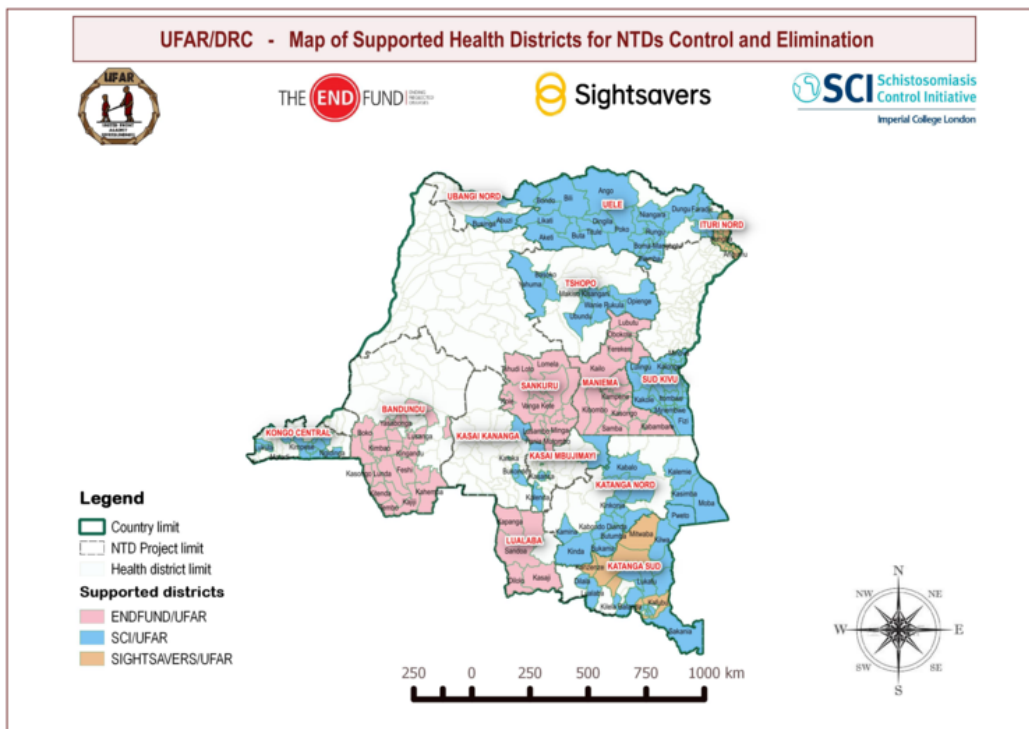
The United Front Against Riverblindness has been integrating mass drug administration campaigns annually to control and eliminate river blindness, successfully treating 27,800,000 people in 2021, up from 25,400,000 in 2020 (UFAR data sheets). UFAR is partnered with several other organizations that assist in the strong establishment of successful agreements that expand river blindness treatment in the Democratic Republic of the Congo. UFAR partners with END Fund, Sightsavers, and the Schistosomiasis Control Initiative Foundation (SCIF). UFAR now covers a third of the DRC with the help of their partners (Figure 4). Another partner of UFAR initially was the World Health Organization (WHO), who contributed heavily with finances in the beginning of the project. UFAR would contribute 20-25% of the annual budget, while the minister of health would contribute 5%, and WHO would contribute the rest of the 70-80%.

Financial issues come with being a nonprofit NGO, including finding transportation for CDDs. For instance, it is vital for CDDs to have bicycles, motorcycles, canoes, even motor

vehicles in order to reach far, remote villages. Part of the annual budget goes to buying transportation, much of this money being raised through fundraising.

Some challenges that came with starting a nongovernmental organization that operates in a third world country includes the use of cash-only transactions. CDDs were required to write receipts for every transaction, a task that has proved tedious and difficult to organize, although throughout time, the process has become more streamlined. However, the previously mentioned challenge of determining how best to distribute ivermectin to the Congolese people was still a question.

**Figure 4:** Map of Supported Health Districts for NTDs Control and Elimination



This map demonstrates what sections of the DRC are covered by UFAR and its partners. The pink areas indicate places covered by ENDFund and UFAR, including Sankuru, Bandundu, Maniema, and Lualaba. Blue areas indicate areas covered by SCI and UFAR, including Kongo Central, Kasai Kananga, Kasai Mbuji-Mayi, Katanga Nord, Sud



Kivu, and Maniema. Yellow areas indicate those covered by SightSavers and UFAR. This includes Sud Katanga and Ituri Nord. Not included are areas covered by GiveWell, a newer NGO partner of UFAR.

Now, after some background on UFAR, it is time to focus our attention again on how exactly it is that NGOs such as UFAR manage to treat the Congolese people in the most effective manner. The solution lies in community-directed distributors. These “foot soldiers” are vital in the control of neglected tropical diseases. Empowering the people to take their healthcare into their own hands was the chosen strategy. In the effort to eradicate onchocerciasis, the community itself must be involved to build trust and partnerships between the healthcare services and communities. These work together to strengthen and develop existing national health systems that are, as previously discussed, already heavily lacking in the Democratic Republic of the Congo. Involving people in the fight against onchocerciasis has actually been highly beneficial in expanding therapeutic coverage, from 1,968 communities in 2001 all the way up to 39,100 communities in 2012<sup>10</sup>. It is a self-sustaining system, with its success or failures being dependent on the community workers. UFAR itself is shooting for organizing an entire 56,719 community distributors to assist in the treatment of 37,551 villages alone, not including any of the other NGOs.

In order to understand the importance of the community-directed distributors, it is important to understand how exactly river blindness is perceived by the people of the DRC. Onchocerciasis is viewed by the locals as a curse cast by a witch. They do not view it as an illness, necessarily, as a Westerner would. While in the developed world, the blindness caused by onchocerciasis is seen as a crippling affect, the primary group affected by the disease do not see it in that way, as they do not connect the blindness to the itching symptoms, leading them to view the issues as separate. They seek out traditional practitioners or healers as opposed to health

centers for their blindness, as they are less willing to seek help from health centers. The blindness itself is actually seen as a consequence of being unkind to a neighbor. The following quote is a native's statement on the origin of river blindness: "... when a witch casts a spell on you, you can catch several diseases, including the "Mbitiri's Disease". The witches are there to make people suffer, that is why they can send the "Mbitiri" to sting you to hurt you. This is the reason why harm due to "Mbitiri" bites can only be properly handled by a healer or traditional practitioner ..."<sup>10</sup>. Often, the locals view river blindness as a sort of karma for mistreating your neighbor, brought upon you by witchcraft. Also worth mentioning is that the locals do not view onchocerciasis as a crippling disease that needs immediate and powerful treatment, but instead they see it as a nuisance.

The way river blindness is perceived by the people affected by it may be very key in the treatment of the disease. Not only would people not be very willing to seek treatment, but they are also unlikely to view onchocerciasis as something worth treating to begin with. If this is the case, how likely are they to accept help from Western strangers trying to throw unknown drugs at them? Probably not very likely, and that is where the importance of community-directed distributors comes from. CDDs are members of the communities that onchocerciasis affects. They tend to be trusted and capable, responsible for recording details of the drug distribution and administration and are often compensated with amenities such as baseball caps or soccer balls, which are of high value to the people and societies within the DRC.

Training CDDs involves several requirements. CDDs go for training, which can be far from where they live; receive and sign for the Mectizan supplies that are out for distribution and then further give them to the community leader; liaise with the community leader, exchanging

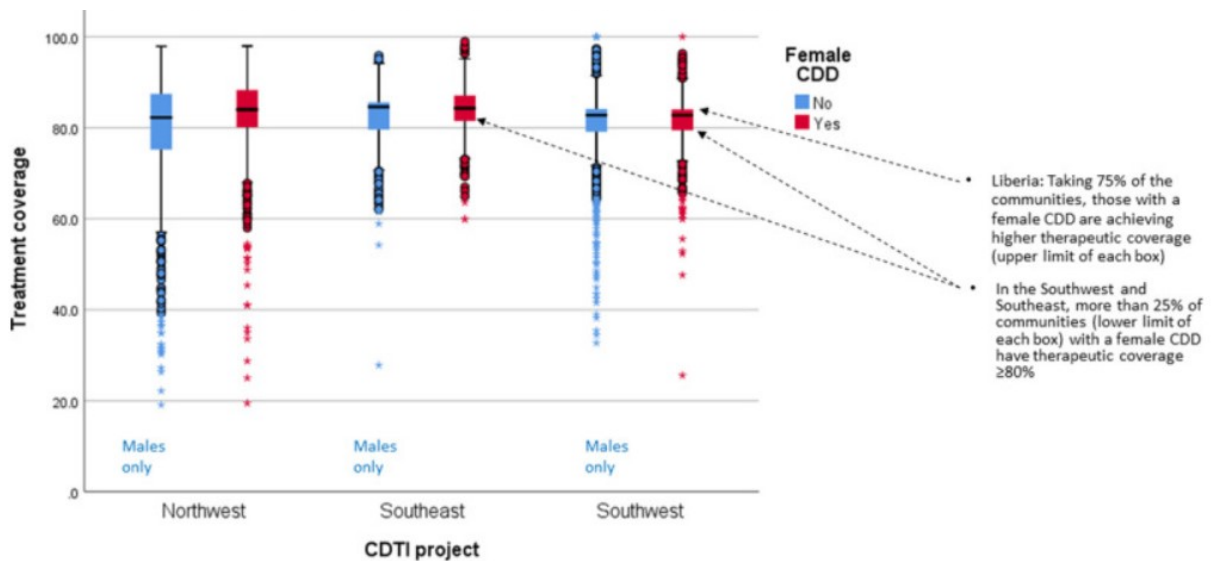
information on timing and other factors; provide health education and sensitization to community members; register and update household member registration; go from house to house to accurately distribute medications; and repeat house visits in order to target absentees or refusals for reconsideration. They also record treatments of the eligible people and later record side effects, give summaries of treatments, take records of treatment, and reassures and/or refer to other health centers those suffering from adverse events after treatment<sup>9</sup>.

Other parts of their training includes being trained in the 400+ dialects spoken in the Congo besides being trained in French, the official language; along with being able to understand and appreciate the meaning of approved as well as proven health education messages to be passed on to members of the community. They must also be able to distinguish between those who are eligible to take ivermectin and those who are not eligible, which they do with a “dose pole” height-measuring device. They then record all the treatments they administer, including how many tablets they give each eligible person and side effects of the medication. CDDs also update census information, data that would otherwise be missing entirely due to a lack of technology in these regions. All of this information is necessary to have, but the issue is making it accessible to researchers. Some organizations have offered to digitalize data collected by the CDDs for this reason. There are also methods of using symbols for the CDDs to quickly and efficiently document findings that can then be translated into applicable information for the digitalization process.

Often, information gathered can be speculative, as certain data that researchers see as important is of little effect to the community distributors, such as distance traveled or time taken to undertake activities. Fascinatingly, there is data on gender differences in mass drug

administration (MDA). Certain studies show that “treatment coverage is better in communities where the proportion of female CDDs is high”<sup>9</sup>. Figure 4 demonstrates this statement, indicating that the top 75% of communities with at least a single female CDD has higher therapeutic coverage than those without female CDDs.

**Figure 5:** Clustered Boxplot of Treatment coverage by CDTI project by Female CDD



This graph shows the effect of the participation of female CDDs on therapeutic and geographic coverage<sup>9</sup>.

This information demonstrates that utilizing the work of female community-directed distributors contributes towards achieving a higher therapeutic coverage level than not having any females working as CDDs. It is unknown exactly why this is—further research on gender analysis needs to be conducted to understand what it is that makes female CDDs approach their work different in heterogenous communities that makes them more efficient at mass drug administration than males are. However, should this be a continuously observed pattern, pushing

for higher levels of female CDDs may be critical in onchocerciasis treatment in order to reach eradication.

Community-directed distribution has not yet been perfected. In many cases, some villages remain entirely unreached and untreated, placing a cap on the level of therapeutic coverage that can be reached. Studies have indicated that an 80% therapeutic coverage and 100% geographical coverage is necessary in order to eradicate onchocerciasis in a hyperendemic country such as the DRC<sup>11</sup>. As of now, the results demonstrate an insufficiency in reaching the 2025 goal of eradication set by WHO. However, this does not mean all hope is lost. It is simply vital that efforts to wipe out onchocerciasis are supported and continue to grow.

Other important factors in the success of the community-directed distribution of ivermectin is getting the individual villages' chief to take the drug for the people to see. Seeing their chief endorse the treatment is key to earning the trust of the people. As the village chief is the most trusted member of the community who was elected into that position, it is vital to convince the chief first in order to convince the people. It is also notable that once people realized that ivermectin stopped the itching symptoms of the disease, the treatment began to spread like wildfire, increasing effectiveness of distribution. As mentioned previously, the itchiness caused by onchocerciasis is noted by the effected people as the most pressing and annoying symptom. Using this knowledge to their advantage is a highly beneficial method for the CDDs. The CDDs also make the effort to connect the black fly and the itchiness to the blindness for the people to understand why exactly it is so important for them to allow the CDDs to treat them with ivermectin.

A challenge UFAR has faced thus far with its community distributors is attrition. Without payment, and with other, bigger NGOs offering pay for work, some CDDs have left UFAR for other companies or careers. UFAR balances this with payment, as mentioned before, such as t-shirts, hats, soccer balls, and other simple resources such as these that are seen as a commodity in the Congo.

The goal in ensuring that onchocerciasis is eradicated is to ensure sustainability. There are some factors that may explain the absence of treatment: “the presence of armed groups in some villages, the fear of serious side effect and geographical inaccessibility”<sup>11</sup>. As mentioned previously, the crippling affects of civil war and the Rwandan genocide still plague the Congo, and many areas still contain militarized groups that can ward off community-directed distributors from approaching with treatments. It is important that the advantages of long-term treatment are explained, as well as making it obvious that it is the whole community’s responsibility to maintain the delivery process. When this was not followed through with, the project suffered. Geographical accessibility is also an issue, as many villages of the Congo are highly remote and difficult to reach. This is one of the issues that UFAR has attempted to provide for, as mentioned previously, by using fundraising to get transportation means for the CDDs.

Some of the challenges involved in distributing ivermectin were mentioned above, starting with the fear of developing serious side effects, some of which that have been observed include the following: neurological encephalopathies that can cause behavioral changes, tiredness, headaches, digestive problems, rashes, swollen limbs and face, muscle pain, fever, and swollen groin lymph nodes. If community members see these symptoms happening to friends or family who received treatment or even received word of it happening to others, they may shy

away from the getting the drug. This brings in the integration of how onchocerciasis is viewed by the people as well, because if they already don't view the disease as something more than a pesky skin problem, they are even less willing to receive treatment.

Convincing the people of the Congo to take ivermectin as the treatment of onchocerciasis was a challenge that community-based allies took on. Plays and performances would be put on to demonstrate the dangers of onchocerciasis and show the great, beneficial effects ivermectin would have should they take the drug in a method that is readily understood. In the form of entertainment, the message was easier to convey. The people began to take it, and within time, 90,000,000+ people as of 2015 were being treated with Mectizan, helping to protect the at-risk population of 115,000,000. Through all of this, 40,000 cases<sup>11</sup> of river blindness are prevented every year.

One of the many happy stories stemming from ivermectin treatment was detailed in an impact assessment interview done by UFAR. A woman's appearance is highly important to her survival in many of these villages, as men marry based off of how beautiful the woman is. Women whose skin has become "unsightly" due to scratching it from the parasites under their skin face divorce from their husbands as they are no longer beautiful to look at. Many didn't just scratch with their nails but also rocks and knives to satisfy the intense itch. However, since taking ivermectin, their skin has rejuvenated and become "beautiful" again. One woman was even quoted saying that she was having a hard time turning down all of the men who wanted to court her now that she is so beautiful. This is an example of a happy ending for onchocerciasis victims whose lives were changed by taking ivermectin.

Another woman was losing her sight due to onchocerciasis and found herself retiring into her home at sunset with her animals instead of getting to spend time with her village and community after dark, as is a traditional past time. After taking ivermectin regularly, her vision decline ceased and she could see better at night again, allowing her to spend time with her family.

Threats to health such as these two previously mentioned factors can be barriers in the way of ending onchocerciasis infection in the DRC forever. Pulling money and resources away from treatment for onchocerciasis could cause a relapse in rising cases and a struggle in the health system to maintain community-directed distribution.

The goal of treating onchocerciasis victims is not just to treat their symptoms—the end goal is to entirely eliminate onchocerciasis from the face of the planet. In the Americas, particularly South America, the target for elimination was set for 2022, while the goal was set for 2030 in African countries<sup>24</sup>.

As previously mentioned, UFAR also focuses its effort on four other neglected tropical diseases. These diseases were chosen due to their crippling effect on health and economy in the country, causing 90% of the Democratic Republic of the Congo's health issues (Dr. Shungu, 2021). The diseases chosen by UFAR are lymphatic filariasis, schistosomiasis, soil-transmitted helminthiases, and trachoma. Lymphatic filariasis (LF) is another tropical, parasitic disease affecting lymph nodes, spread by infected mosquitoes that deposit a parasite into the host that lead to mostly symptomless cases. There are some exceptions, such as long-term damage to the lymphatic system and elephantiasis. Ivermectin can actually be used to treat LF, along with albendazole, according to WHO. Every year for about 6 years, this medication is mass



administered via similar methods used for onchocerciasis. The disease also causes economic devastation by way of taking workers away from their positions until billions of dollars a year are lost due to it. This is another reason to emphasize consistent annual treatment to help reverse debilitating symptoms, stop the spread, and rejuvenate communities that have been so negatively impacted by onchocerciasis infections.

Schistosomiasis is a disease caused by parasitic flatworms that reside inside a type of freshwater gastropod mollusks, infecting the urinary tract or intestines. It can lead to liver damage, kidney failure, infertility, bladder cancer, poor growth, and learning difficulties according to WHO. The disease is spread when a victim comes into contact with fresh water contaminated by parasites. While improving access to clean water and reducing the number of snails that spread the disease would be beneficial to preventing or even eliminating schistosomiasis, it has already been discussed how this would be a difficult task to achieve in a country that does not value the health of its people. The medication praziquantel, another deworming medication, is used for treatment. Reducing the number of snails that can carry the flatworms is also a method of slowing the spread. Schistosomiasis has the second greatest negative economic impact, second only to malaria, also due to taking workers away from their tasks.

Soil-transmitted helminthiasis is caused by helminth roundworms, transmitted through soil contaminated with fecal matter. It is the most common parasitic disease in humans throughout the world, surpassing even malaria. It is estimated that one third of the global population is infected with soil-transmitted helminthiasis. The frustrating part of diseases like soil-transmitted helminthiasis is how preventable the disease is by way of improved sanitation

and public awareness of hygiene. Albendazole is form of medication to treat STH, preferably administered annually to affected populations. Ivermectin can also be used in this disease.

The last neglected tropical disease UFAR focuses on is trachoma, the leading preventable cause of blindness in the world, ahead of onchocerciasis. Caused by *Chlamydia trachomatis*, the infection roughens the eyelids and can lead to permanent blindness when the eyelids turn inward if left untreated. The disease can be spread both directly and indirectly via an infected person's nose. Reasons for spread include poor sanitation, limited access to clean water, and crowded living conditions. Antibiotics are used to treat the disease, with 80,000,000 having an active infection of trachoma<sup>20</sup> as opposed to the approximately 25,000,000 that have an active onchocerciasis infection.

Despite the success of ivermectin in treating onchocerciasis, there are always challenges in this process. For instance, there is a lot of misinformation on the treatment of COVID-19 by using ivermectin. Ivermectin, besides its critical use in river blindness, is used in veterinary settings to de-worm/de-parasite animals, especially cattle and horses. Taking large doses of ivermectin meant for these large animals can be very dangerous and have sent many people in the hospital for medical attention. The type of ivermectin used for animals is also formulaically different than ivermectin for humans. The animal version is more highly concentrated for large animals, and some inactive ingredients have not been evaluated for use in humans. It is unclear how any of these factors will interact in the human body; and, when considering how there is no information to support ivermectin as a safe and effective treatment for COVID-19, there is no reason for people to be taking it if not to de-worm themselves. As COVID-19 is not caused by a parasite or worm, ivermectin has no effect on the virus itself. Another problem with people using

ivermectin for COVID treatment is not only the illegality and health uncertainty, but the fact that as demand gets higher, it may be harder for donation programs to continue to run if they could be losing too much money on sending it both to Africa/countries with river blindness and to illegitimate resellers for COVID-19 uses. In an age of misinformation, it is important to get a grasp on what is right and what is false before people get killed due to misinformed, uneducated, and unendorsed approaches to treatment.

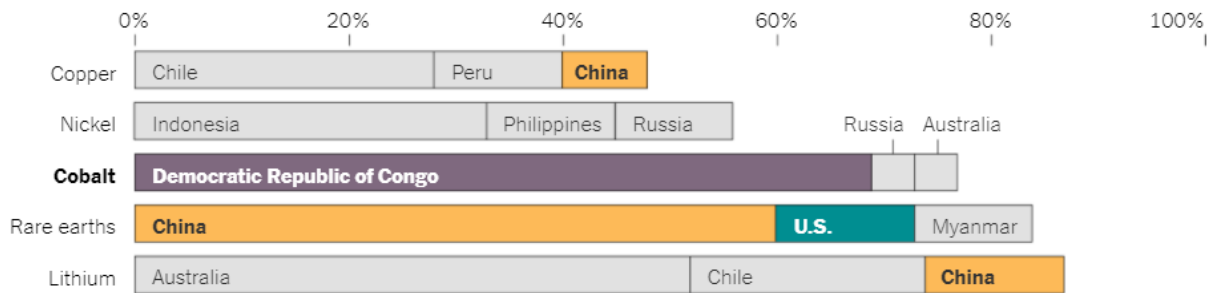
Another challenge lies in ivermectin itself: the drug kills the microfilariae, but not the adults. While the treatments to get rid of microfilariae are highly effective and working well in the process to eradicate onchocerciasis, there is still a need to kill off the adult worms that are already present in the body and causing infection. One study from 2014 indicated the success of chemotherapeutic methods, such as doxycycline, in killing adult worms, along with sterilizing the adult female worms<sup>16</sup>. However, besides this study on doxycycline as an adulticidal therapy for onchocerciasis, there is little research on how to kill adult worms early before they can even begin to start producing microfilariae in order to stave off infection.

Over the past year, there was also an issue of an Ebola outbreak in the Congo. The Ebola virus, an incredibly deadly disease that claims up to 90% of the lives it effects, was quickly labeled as an outbreak on June 25<sup>th</sup> of 2021. The cases came from the Biena Health Zone in the North Kivu Province. It was believed that this outbreak stemmed from a persistent infection from a survivor of the 2018-2020 outbreak led to a relapse of cases, although there is some evidence to suggest a sexual transmission of the virus. Forty-two days later, on May 3<sup>rd</sup> of 2021, the Democratic Republic of the Congo's Ministry of Health and the World Health Organization announced the end of the outbreak after no new cases since the last survivor tested negative.

There were 12 cases and 6 deaths. Due to the incredible infectiousness of the virus, this was a high number of cases that prompted immediate concern for the health of the Congo. This was one of several outbreaks in the country, with another one occurring in the Beni Health Zone of the North Kivu Province as of just October of 2021.

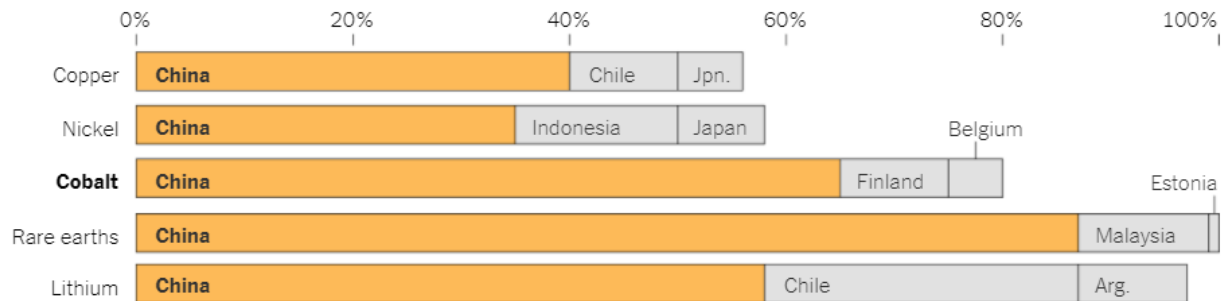
Another polarizing issue in the Congo at this time is the question of why the Chinese are in the Congo. Currently, there is a number from the Chinese embassy of 5,000 Chinese people living the Democratic Republic of the Congo, although many believe that there are far more—anywhere from 5,000-50,000<sup>21</sup>. The main reason for this is the rich mining industry in the DRC, as mentioned previously—the Congo is incredibly rich in natural resources. To emphasize this point, 60 out of 75 of the mineral processing plants in the Katanga Province and 15 out of 19 cobalt-producing mines are owned by Chinese entrepreneurs exploiting the Congolese people for their labor and taking their resources<sup>22,25</sup>. Along with these questionable acts, the Chinese also have been accused of child labor and insufficient health and safety standards<sup>22,25</sup>. In fact, over twelve employees and contractors at the Tenke Fungurume mine in the Congo have complained of a drastic decline in safety with an increase in injuries, of which not many have been reported to the management<sup>25</sup>. The Chinese company has, in response, stated that these complaints were fabricated, never admitting to failures. In retaliation, there have been several instances of anti-Chinese violence by Congolese mobs attacking Chinese businesses. The Congolese motivation for violence has been attributed to resentment by the local businesses that struggle to compete against Chinese stores, along with resentment and concern about exploitation from investment deals between Chinese companies and the DRC government.

**Figure 6: Where Clean Energy Metals Are Produced**



Each line demonstrates the top three producers of 5 different clean energy sources. Over 60% of the world’s cobalt comes from the DRC<sup>23</sup>.

**Figure 7: Where Clean Energy Metals are Processed**



Each line demonstrates the top three processors of clean energy metals. China, despite not being a producer of cobalt, processes over 60% of the world’s cobalt<sup>23</sup>.

The struggle for resources from the Democratic Republic of the Congo has not gotten easier—as electric cars become more commonplace, so does the need for cobalt, which is found in the DRC more than it is anywhere else in the world<sup>23</sup>. The implications of this issue includes tainting rivers where women do laundry and dishes, homes being destroyed, and more. This colonial-era pattern that has been seen again and again throughout history is extremely

concerning as outsiders continue to exploit natural resources and people. For an example of the Congo being exploited within recent history, the United States used uranium from Congolese mines to build the bombs dropped on Nagasaki and Hiroshima. Both China and the U.S. are prone to price shocks and supply shortages in the journey towards clean energy. The U.S. even had “decades of diplomatic and financial investments”<sup>25</sup> in the Congo that it failed to protect as China was set to dominate the clean energy market. An American mining company sold two major cobalt reserves to China in 2016 (as if they owned the land there in the first place). The Congolese government is realizing the corruption China is imposing on them as it cheats the country of promised revenues, after reviewing contracts with assistance from the American government in an effort to stem down corruption. China is being accused of withholding money from the Congolese government. This demonstrates another moment in history when a quest for good—clean energy to prevent global warming—follows this tired pattern of exploitation, greed, and corruption. As long as greed continues to consume the hearts of men, the people of the Congo will continue to suffer.

The Congo’s struggle to maintain health throughout the course of history has been a complicated and winding path. Throughout their history, the Congolese people have no experienced peace as they are continuously taken advantage of by greedy, corrupt, downright evil politicians and dictators who strive to put money into their own pockets instead of into the hands of their own people. Without leadership that truly cares for them, the people of this large and beautiful country suffer from health problems that go undiagnosed, untreated, even unrecognized by any governing power—not even just their own. With such limited access to health resources, becoming healthy enough to take control of their own government seems impossible for the near future.

There is some ray of hope for the future, however, as organizations such as the United Front Against Riverblindness push for community-based treatment programs. Such initiatives put the power to treat into the hands of the very people who need to be treated. Empowering people to take control of their own health and livelihoods has implications for the political sphere: should the people become the masters of their own health, they can be empowered to take back their government and elect into positions of influence people who have their best interests in mind. One would hope that an initiative as small as people helping their neighbors with taking ivermectin could lead to the takeback of a nation that could be so powerful if given the chance to thrive, essentially putting away the history of violence, war, exploitation, and disease.

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