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Mozambique, Infectious Disease

Mozambique: An Attack on Malaria for the World

Across the Atlantic Ocean, on the southeast coast of Africa, two infectious diseases are ravaging a country called Mozambique. Malaria and dengue fever are fatal diseases that are thriving in Mozambique because of the country's climate and lack of quality pest control. Both of these diseases are vector-borne meaning "vectors are the transmitters of disease-causing organisms; that is, they carry pathogens from one host to another" (Institute). These diseases are spreading rapidly in Mozambique, negatively affecting population and agriculture. Because Mozambique is a country that has naturally well-fertilized land, it depends on agricultural products for economy. With the constant threat of these debilitating diseases, Mozambicans desperately needs a solution.

Mozambicans have been continually waging war against both malaria and dengue fever. In 2002, severe flooding combined with Mozambique's moist and humid climate created a perfect storm – the flood waters had not drained in the intervening years, attracting gargantuan swarms of mosquitos from surrounding countries (Tembe). These mosquitos (female Anopheles mosquitos, specifically) carried with them diseases including malaria and dengue fever. The locals have struggled with combating this problem. Non-governmental organizations specifically the Bill and Melinda Gates Foundation have shipped in medication, but this merely treats the problem instead of finding a solution to it (Fuller).

Situated about 1,000 miles south of the equator, Mozambique enjoys a humid subtropical climate with an average temperature of 82 degrees Fahrenheit. It is also a coastal country, bordering the Mozambique Channel in the east. This helps form the ideal climate for breeding mosquitos, but also allows Mozambicans the ability to cultivate the two important cash crops of corn and cassava, a potato-like root vegetable. Their farming methods are antiquated – most of Mozambique's population of 26.6 million people are subsistent farmers (family farming passed down through the generations) – and utilize primarily slash-and-burn techniques ("The World").

Typical Mozambican farm families are large, averaging five children per woman. They are also living in poor conditions, 65% of housing units are made of woven straw and 96% do not have electricity (Mozambique – Housing). Even though the government of Mozambique has provided a nationalized healthcare system since 1975, civil wars and rampant disease led to widespread infrastructure collapse. During the civil war and disease outbreaks Mozambicans fled to surrounding countries, labor migrants from rural areas whose crops failed, and the now unemployed moved to find work as miners. The other jobs that are opened to Mozambicans relate to informal and manufacturing sectors. However, the devastating effects of diseases are causing sanitation practices to suffer, private medical practices have shut their doors, and doctors and clinics have generally been in short supply. This, coupled with Mozambique's 2.46% population increase rate per year (20th in the world) has been leading Mozambicans to worry ("The World").

Bordering countries such as Tanzania and Zimbabwe are not blind to the Mozambicans' plight; they want to help modernize their farming techniques and provide medical assistance, but the threat of malaria and dengue scare them away. And for good reason: malaria-infected individuals suffer from intense headaches, migraines, muscle and joint pain, vomiting, diarrhea, rashes, nosebleeds, and in extreme cases, seizures and death. Dengue fever is more mild: it has similar symptoms (with a characteristic skin rash) but lasts for a shorter period of time – however, a small percentage of cases develop into a hemorrhagic fever with extremely low blood pressure (Paddock).

Medical information and statistics paint only a partial picture; for Mozambicans, their day-to-day lives are affected by these diseases. For Guy Pederson, cattle rancher and grain farmer, living in fear of malaria was a reality. He is one of few Westerners who risked traveling to southeast Africa since the epidemic began. While farming in Mozambique, Pederson encountered locals on a daily basis who either currently had or recently had malaria or dengue fever. In an effort to avoid sickness, Pederson took preventative tablets and miraculously never contracted either disease. He lived in both urban and rural hotels, and comments that while both utilized insecticide-treated mosquito nets, they were few and far between. Mozambicans who contract the disease more than once tend to develop resistances to them, but malaria in particular causes farmers to be bedridden for days at a time when they are desperately needed out in the fields. Pederson observed that Mozambicans, like Americans, harbor strong opinions about malaria tablets and often believe that each brand effects an individual in a unique way. Some locals prefer not to take the medication and even avoid giving it to their children for fear their symptoms and susceptibility will only worsen. First-hand observations like Pederson's are useful to give insight into the country's plight, but it is this plight that causes foreigners to fear for their health and stay away (Pederson).

It is important to understand a disease and its effects in order to develop ways to combat it. Both malaria and dengue fever are spread by mosquitos – in the case of malaria, it is the female Anopheles mosquito. These mosquitoes are unique in that they are able to host a malaria parasite and allow it to complete its life cycle stages beginning with an egg, followed by the larva, pupa, and lastly, adult. The first three stages are aquatic – therefore, land areas that contain warm water are overflowing with infected mosquitoes. A female Anopheles mosquito becomes infected when the parasite enters its body, making it past the mosquito's stomach wall and then feeding on the blood that the mosquito has consumed. A mosquito's ideal blood meal is either provided by cattle or by humans. The disease is transmitted when the female mosquito feeds on its next blood meal provider. Dengue fever is spread similarly to malaria, only through the female Aedes mosquito, and is not as common as malaria. Both diseases, however, run rampant throughout all regions of Mozambique and do not yet have effective vaccines or cures (Balentine).

The segments of the population that are most susceptible to malaria and dengue fever are pregnant women, the extremely young, the elderly, and those infected with HIV. "Malaria is also deadly for pregnant women, who run the risk of severe anaemia, which can be fatal. In addition, malaria contracted during pregnancy can lead to low birth weight – one of the most important factors in determining a child's future survival," ("Mozambique, Protecting"). This is equally devastating for the younger population of Mozambique. "More children die of malaria than any other disease in Mozambique. It accounts for 60 percent of pediatric hospital admissions and 30 percent of hospital deaths. And it is a major reason why Mozambique still has one of the world's highest child mortality rates," ("Mozambique, Protecting"). Similarly, the elderly population also experience severe consequences of both diseases because their immune systems are comprised from age. A part of the population that is less spoken about is the people with HIV/AIDS. "While infection with either malaria or HIV/AIDS can cause illness and death, infection with one can make infection with the other worse and/or more difficult to treat" (Alemu).

Genetically modified mosquitoes, or GMOsquitoes, would solve these problems and drastically reduce the number of malaria and dengue fever cases in Mozambique. Through gene editing, female mosquitoes would develop resistances to the malaria and dengue parasites and be unable to host them and pass the parasites on to humans. This resistance would also be passed on to their offspring. In research at the Centers of Disease Control or CDC, scientists have experimented with the procedure of selecting specific strands of DNA from An. Gambias mosquitoes which are immune to the malaria parasite. By removing the DNA strand from those mosquitoes and then implanting the immune strand into the female Anopheles mosquitoes, it will become immune to malaria. Female Anopheles mosquitoes lay up to 200 eggs every breeding season. As the seasons pass, the genetically modified mosquitoes will produce immune offspring, leading to a decrease in the population of infected mosquitoes. As a result, this should cause a

decrease in the number of malaria cases in the countries that are the most affected. However, challenges will likely be encountered during this potentially life-saving solution. Some challenges will probably be overcome through the continuing advancements in science and technology.

Many of the issues can be avoided by carefully studying and documenting experiments that have been tried in the past. For example, distribution of insecticide-treated nets in 2000. Around 1.7 million nets were handed out to decrease the transmission of malaria. "Nelia, 17, received her net from Ms. Victoria at the health centre. 'I am relieved to have a net,' says the teenager, who became pregnant while still in school. 'I cannot afford to get sick with malaria,' ("Mozambique, Protecting")." Other methods that health care providers have tried are as follows: mass distribution of malaria medicine, specific treatment on infants and pregnant women, and larva control. Another alternative would be to modify genes in male mosquitoes instead of female mosquitoes, creating "bull" mosquitoes which would be rendered infertile, leading to a potentially precipitous drop in the local mosquito populations; this, however, would not eliminate malaria and dengue fever transmissions to humans.

While these measures help to reduce the number of humans affected by the bite of the disease carrying mosquitoes, the ideal method of eradicating malaria and dengue fever would be to prevent the parasite from completing its life cycle in the female Anopheles mosquito. During research the main challenge that scientists could struggle to overcome is when attempting to implant the DNA strand into the Anopheles mosquitoes, the DNA strand could fail to be in the correct area. Consequently, the whole process would become ineffective. However, various measures will be implemented to insure the completion of this unique solution.

Solving this dilemma in Mozambique will involve thinking through a variety of processes. This solution involves genetically modifying mosquitoes to alter them so they become malaria parasite resistant organisms. A typical characteristic of a genetically modified organism is that their offspring will produce the same trait. As mentioned before, Anopheles female mosquitoes have up to 200 eggs per breeding season. Therefore, the population of immune mosquitoes will grow rapidly, if the following steps are taken properly according to the FAO (Food and Agriculture Organization) and the EFSA (European Food Safety Authority). The positive effects of this include saving the lives of the suffering Mozambicans.

"Production of GMOs is a multistage process which can be summarized as follows: 1. identification of the gene interest; 2. isolation of the gene of interest; 3. amplifying the gene to produce many copies; 4. associating the gene with an appropriate promoter and poly A sequence and insertion into plasmids; 5. multiplying the plasmid in bacteria and recovering the cloned construct for injection; 6. transference of the construct into the recipient tissue, usually fertilized eggs; 7. integration of gene into recipient genome; 8. expression of gene in recipient genome; and 9. inheritance of gene through further generations," ("The Process").

While conducting these steps in order to genetically modify mosquitoes, the EFSA has a list of risk factors that one needs to take into consideration. The first risk assessment is the feed, food, and animal welfare of GM (Genetically Modify) animals. "The risk assessment approach compares genetically modified or GM animals and derived food and feed with their respective conventional counterparts, integrating food and feed safety as well as animal health and welfare aspects. The basic assumption of this type of comparative assessment, which is required under current EU [European Union] legislation for all GMO's submitted for market authorization, is that food and feed from conventionally-bred animals have a history of safe use and therefore can serve as a baseline for the risk assessment of food and feed derived from GM animals," ("Genetically"). Even though Anopheles mosquitoes will not be eaten by human, but one must consider the mosquitoes' predators. The other risk factor is the environmental assessment of genetically modified animals.

Based on the wide range of GM research thought to be currently underway related to several different animal species, the European Commission requested that EFSA develop environmental risk assessment

guidance for GM fish, insects, mammals and birds. ("Genetically"). These risk assessments are important to follow when genetically modifying mosquitoes in Mozambique. Each of the steps listed above need to be conducted in order to remove an immune strand from the An. Gambias mosquitoes and then implanting them into the female Anopheles mosquitoes, to prevent the malaria parasite from thriving in the stomach of the Anopheles mosquitoes. Before performing the artificial inserting of the immune DNA strand, the need for funding for materials is essential to this life saving process.

In order for one to obtain funding, appropriate connections need to be made. One of the most prevalent private donators is Bill and Melinda Gates. The Bill and Melinda Gates Foundation is extremely generous with each of their donations to different starter research facilities. These issues of Malaria and Dengue Fever in Mozambique have been brought to their attention. Recently, the Bill and Melinda Gates Foundation have contributed to the purchase of Malaria medication and vaccines. Approximately $168 million dollars in grants were given to fight Malaria in Mozambique. The Bill and Melinda Gates foundation has not yet been informed about that process of genetically modifying mosquitoes, in order to eliminate to number of infected Anopheles mosquitoes. Therefore, the need for communicating with Mr. Gates about this alternative solution to reduce the Malaria outbreaks in Mozambique needs to be presented to him. The way this could be done is by submitting the idea and research to his website. With determination and persistence, receiving a grant from the Bill and Melinda Gates foundation is possible. This grant will allow for further research, for the purchase of the proper materials and people that are required for this operation (Fuller).

Establishing the framework is a basic necessity for all projects, no matter how simple or complex. This project will need a broad spectrum of individuals that are open minded, intelligent, and inventive. Bringing in optimistic and open minded people will eliminate the misconception that Mozambique is only a perfect breeding ground for Anopheles mosquitoes. One must be educated in entomology, biology and genetics. People that have an inventive quality do not see ways that do not work as mistakes but, as a lesson learned. Finally, one of the characteristics that is required is they need to be compassionate toward the people of the Mozambique. As a country it has repelled most of its desired help because of the high risk of malaria and dengue fever.

This solution has not yet been attempted within the borders of Mozambique. The reason behind this is Mozambique is an ideal breeding ground for the female Anopheles mosquito and this leads to an increase in malaria not only in the locals but, the visitors as well. Out of all of the countries in southeastern Africa Mozambique rejects a large amount of educated farmers that need to be there and teach the smallholder farmers about modernized farming techniques that they can use to increase and better their agriculture products. Malaria is the wall standing in the way of Mozambique's chance to have a better agricultural system and healthcare program. This main issue in Mozambique must be resolved in order better the country (Pederson).

The malaria and dengue fever epidemics in Mozambique will only worsen over time. This developing country's economy depends on farming to survive, and if farmers continue to contract these diseases their economy will continue to suffer. Pregnant women and infants will continue to die, the health care infrastructure in Mozambique will continue to collapse, and no other country will be willing to step in to help. Previously proposed solutions for attempting to prevent these diseases have not worked, but GMOsquitoes is a solution that has not been tried yet. The process involves transferring an immune DNA strand into the parasite hosting mosquitoes. If it is successful, generations of mosquitoes will be unable to host the malaria and dengue parasites and humans will no longer fear infection by them. Another positive result from eradicated these infectious diseases will lead to giant steps Mozambican agriculture. This operation will not only benefit Mozambique's population, but it will create a schematic for the rest of the cases of malaria and dengue fever cases across the globe, as well as countless other diseases.

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