Ethan Walters
Rossville High School
Rossville, Indiana, USA
Nigeria, Malaria

Nigeria: Genetically Modified Mosquitoes and Malaria

Nigeria is a western African country located on the coast of the Atlantic Ocean. It is the most populated country on the entire African continent with almost two hundred million residents. Lagos, Nigeria's former capital until 1991, is the country's largest city with over twenty-one million people. Nigeria's new capital, chosen for its central location and easy accessibility is Abuja, one of the richest cities in of Africa. Nigeria is a democratic republic with an elected president and constitution much like the United States. Almost half of the country's population is Muslim and the other half is Christian. Nigeria has a tropical climate and a land mass of 923,768 square kilometers. Nigerian geography varies greatly across the country and consists of tropical rainforests in the south, low lying plains in the southeast, and the Shebshi Mountains in the far east. Temperatures tend to be consistent year-round with an average temperature of 70 to 90 degrees Fahrenheit with cooler nights. There is also a wet and a dry season (World Bank, 2019). Agriculture is the largest sector for employment in Nigeria accounting for 70% of the country's employment, and it is estimated that around 40% of Nigeria's land is arable. Nigeria's major cash crops include oil palm fruit, cocoa, cassava, and ginger. Most Nigerian farmers are sustenance farmers. Sustenance farming is a very common practice for Nigerians where farmers raise food primarily to provide for themselves and their families. It is estimated that 20 to 50% of Nigerians live off of the food they produce themselves. Popular crops produced by sustenance farmers include rice, maize, and cassava (Food and Agriculture Organization, 2020).

There are approximately five to eight people living in every Nigerian household often including many children and extended family members. Housing for Nigerian families can vary. Mud houses are common in many regions. Some urban areas have more traditional houses made of cement and brick roofs, but living conditions are poor. Less than 10% of urban dwellers have an indoor toilet. The quality of life for a family living in Nigeria is less than desirable. Healthcare, education, and internet access along with many other basic amenities are scarce. Lack of clean water and electricity are major issues that the Nigerian government have been working to address, however many households are without both. The air quality in Nigeria is poor due to pollution from factories scattered around the country. The country ranks fourth worldwide in deaths related to poor air quality (Parke, 2016). Nigerians farm and grow their own food. Traditional meals popular in Nigeria include rice, fufu made from cassava, skewered spicy barbeque meat, and a variety of soups. For those Nigerians who are employed, they make very low wages. According to The World Bank (2019), nearly half of the population is living below the threshold of the international poverty line which is only $1.90 a day. Furthermore, unemployment is as high as 20%. Nigerians also face many health risks due to infectious diseases. The country has the second largest number of HIV/AIDS cases in the world according to the World Health Organization (WHO, 2020). Another significant disease that plagues the people of Nigeria is the mosquito borne disease, malaria. Together, all of these things have reduced the average life expectancy of Nigerians to 53 years old, which is eighteen years less than the global average (WHO, 2020).

Malaria is an infectious disease caused by a plasmodium parasite that feeds on humans and invades the red blood cells. The parasite is transmitted by the bite of an infected female Anopheles mosquito. The mosquitoes reside in many tropical and subtropical regions of the

world especially around the equator. Sub-Saharan Africa and South Asia are two continents that have the most cases of malaria transmission. There are four types of malaria that affect humans Plasmodium vivax, Plasmodium malariae, Plasmodium ovale, and Plasmodium falciparum. Plasmodium falciparum is the most dangerous and can be life-threatening. This type is very common in many countries in Africa near the equator including Nigeria (CDC, 2019).

In order for human transmission to occur, malaria first enters a mosquito through contact from an infected person's blood. The malaria parasites remain dormant until the mosquito bites a human passing the disease onto its new host creating an ongoing cycle. Once inside the human's bloodstream, malaria targets the liver. After a brief incubation period in the liver, malaria begins to attack the host's red blood cells. The red blood cells begin to die, which triggers an immune system response, subsequently causing flu-like symptoms to develop. The person infected with malaria may experience fevers, chills, night sweats, headaches, muscle pain, nausea and vomiting. Persons with malaria can suffer from serious complications such as liver failure, bleeding disorders, and severe brain damage due to swelling of blood vessels. The severity of the illness can vary with death occurring in the most severe cases especially with young children (CDC, 2019).

Malaria can cause food insecurity in families across Nigeria due to sickness or premature death of individuals who work and are the breadwinners for their families. This deprives the entire family of critical funds needed for food or the ability to produce food, which can ultimately lead to poor nutrition and health. Ninety seven percent of Nigeria is at high risk of malaria infection. As the population of Nigeria rapidly increases so does the number of malaria cases. According to the CDC, around one hundred million people who contract malaria are reported each year, and three hundred thousand of those people will die. Malaria is most deadly to children under the age of five. Nearly 20% of malaria deaths worldwide affect children younger than five years old making it the third leading cause of death in this age demographic. The elderly population over age sixty-five are also at high risk and are ten times more likely to die when infected. Economic disparities can also be attributed to the increased risk for infections due to the high number of Nigerians who live in rural poverty stricken areas (CDC, 2019). Many organizations, such as the United Nations and the Red Cross, give millions of dollars to fight against malaria in Nigeria each year. Despite their efforts, malaria cases continue to rise. Rural and undeveloped states in the west are the most at risk. The urban and developed south coastline is the least at risk for malaria, yet they still remain at risk (World Bank, 2019).

The most common recommendations to date to stop the spread of malaria have been aimed at preventing mosquitoes from coming into contact with humans and therefore biting them and passing on malaria. In many developing African countries, mosquito nets cover beds and tents to protect people from mosquitoes while they sleep. While these bed nets are helpful, they are inconvenient during daytime hours when a person is moving or working outside. Another way to prevent mosquito bites is through the use of insect repellents with the active ingredient, diethyl-meta-toluamide or DEET, which can be applied to the skin and clothing. Insect repellants can have varying levels of success since there is the risk of human error with application and reapplication. Insect repellents that are applied on the skin must be tested and approved for safety and effectiveness to ensure that they are not harmful. Human health and environmental

safety must be considered priorities while also ensuring that the insect repellants offer long-lasting effective protection against mosquitos.

There are also medications and vaccinations that can be prescribed to prevent malaria. Antimalarial drugs, such as chloroquine, mefloquine, or malarone, are often prescribed to a person who is traveling to a malaria infected country to protect themselves. Although antimalarial drugs are effective, they are not 100% effective in preventing malaria. These drugs are also more effective for short term use and are generally not prescribed long term. The expense of these medications if taken daily in high risk areas would be cost prohibitive for the impoverished people of Nigeria. This makes antimalarial drugs an impractical solution for Nigeria. A newer advancement towards reducing malaria infection is a vaccine called RTS,S also known by the trade name Mosquirix. RTS,S was approved in Europe in 2015 and is the only vaccine in the world used to prevent malaria. This is due to the malaria parasite's complex life cycle which makes the development of a vaccine very challenging. Currently RTS,S only has a 30 to 40% success rate. The target population for vaccination has been children under five years old. While the vaccine is reasonably priced, this may still not be affordable for poverty stricken countries like Nigeria. Thus while a vaccination seems hopeful, more research is needed before widespread global implementation can begin (World Health Organization 2020). The vaccine is not yet a permanent solution for defeating malaria.

A new discovery led by Ruth Mueller may be the breakthrough needed to stop malaria through extinction. Since the discovery of malaria in 1880 by Sir Ronald Ros, researchers have been searching for a way to eradicate the world of this devastating disease. Now almost one hundred and forty years later, a group of scientists have genetically modified a small test group of mosquitoes no longer capable of carrying or transmitting malaria creating a new type of mosquito that has complete immunity to malaria. This immunity occurs by adding a new gene into the mosquitos' DNA that targets malaria making it impossible for mosquitos to become vectors for the disease. The gene is designed to be a dominant gene ensuring that the mosquitoes acquire the trait and produce offspring also immune to malaria. Doing this is no easy task, however, as scientists will have to completely change the genome of an entire animal species. As the genetically altered mosquitoes integrate into native communities of mosquitoes, they will quickly pass the new immune trait to future generations. Eventually all mosquitoes will carry the gene and malaria will be rendered extinct. Scientists believe that the mosquitoes would integrate and breed so quickly that malaria would not have time to mutate (Kurzgesagt, 2016). This form of genetic engineering provides a solution to eradicating malaria-carrying mosquitoes worldwide with the introduction of CRISPR, a new form of genetic engineering that will allow humans to make "fast large scale changes to entire species" (Kurzgesagt, 2016). Therefore, genetically modified mosquitoes have incredible potential in the fight against malaria.

Since their discovery in 1994, genetically modified organisms (GMOs) have been used to improve the quality of human life. Previously however GMOs have been used mostly to create longer lasting and more nutritious food. Although some are skeptical when it comes to these genetically altered mosquitoes being released into the environment, these non-malaria carrying mosquitoes could effectively eradicate malaria (National Public Radio, 2019). Furthermore, an innovation like this could open the doors to eliminating other insect borne diseases, such as the

Zika virus, Lyme disease, West Nile virus, and Yellow fever, while still maintaining and causing no harm to mosquito populations (WHO, 2020).

CRISPR provides a cost effective solution to addressing malaria infections. The average Nigerian would not have the financial burden for this project. Organizations like the United Nations could provide funding for ongoing research and the implementation of CRISPR. The World Bank could also be an alternative group who could lead the implementation of this technology. Little to no effort would be required from the local government or community as small groups of trained researchers could release the mosquitoes into the environment. All that would be needed is the approval of the Nigerian government and possibly the approval of neighboring countries as mosquitoes may migrate over Nigerian borders. Approval from the African Union may also be necessary as Nigeria and all of its neighboring countries such as Chad, Niger, Cameroon, and Benin are current members of the African Union. Once the mosquitoes are released into the wild, they will need to be carefully observed. Scientists will want to study the mosquitoes to make sure there are no mutations and that the new genetically edited mosquito is sustained resulting in the extinction of malaria. Possible funding for these research groups could also be provided by the United Nations or the World Bank. Little to no funding would be required from the Nigerian government due to the humanitarian aspects of implementing CRISPR in Nigeria.

CRISPR is the best possible solution to fight against malaria as the goal is to completely eradicate this fatal infectious disease, not just to prevent it or cure it as the other options such as mosquito nets, insect repellants, medications, and vaccinations attempt to do. Ridding the world of malaria is much more cost effective than preventing or curing it since it will be a long lasting solution. Future generations will avoid falling ill from malaria. Individuals and families will not have to take time off of work or incur medical bills. These things would help ensure food security for families. There would also be less financial drain on national economies long-term since there would be no illness or death from malaria (CDC, 2019).

Fear from the public about genetically modified organisms can be a true barrier to CRISPR. Opponents of CRISPR fear that the genetic modification of mosquitoes could cause unforeseen side effects. Some journalists have made claims that CRISPR can cause autism, however at this time, those fears are unfounded. Many also argue that once the mosquitoes are released into the wild they cannot be returned to their natural state, making any mutations a permanent danger. Therefore if the mosquitoes have any dangerous side effects they cannot be reversed and all effects are permanent. At this time, no data exists showing any correlation between the genetically modified mosquitoes and hazardous side effects. The claims made against CRISPR have been proven false by researchers, and there is no evidence to support great risk to either mosquitoes or people (National Public Radio, 2019).

Using the CRISPR technology to change the DNA of an entire species has far greater rewards outweighing the few potential risks. Lives will be saved. Disease and complications of the disease will be eliminated. The productivity of poor rural countries will increase as workers will not have to take time off to recover from malaria and its complications. The cycle of disease, hospitalizations, and missed work days that can worsen poverty will ultimately end. The technology to stop the spread of malaria is available. However, public knowledge of the project

is limited and coverage from mainstream media is insufficient. More discussion, research, and funding is needed to support CRISPR. This technology could open up countless doors to curing and eliminating diseases spread by insects and other pests.

The possibilities of using CRISPR to end insect-borne diseases, such as malaria, is very exciting. The technology should be heavily regulated and monitored for sustainability and to ensure there are no harmful effects. Using CRISPR to end these life threatening diseases is vital to ongoing global health, wellness, quality of life, work productivity, and food security.

Bibliography:

"Q&A On the Malaria Vaccine Implementation Programme (MVIP)." *World Health Organization*, World Health Organization, 20 Jan. 2020, www.who.int/malaria/media/malaria-vaccine-implementation-qa/en/.

"Overview." *World Bank*, www.worldbank.org/en/country/nigeria/overview.

Udo, Reuben Kenrick, and Anthony Hamilton Millard Kirk-Greene. "Settlement Patterns." *Encyclopædia Britannica*, Encyclopædia Britannica, Inc., 21 Nov. 2019, www.britannica.com/place/Nigeria/Settlement-patterns.

Stein, Rob. "Scientists Release Controversial Genetically Modified Mosquitoes In High-Security Lab." *NPR*, NPR, 20 Feb. 2019, www.npr.org/sections/goatsandsoda/2019/02/20/693735499/scientists-release-controversial-genetically-modified-mosquitoes-in-high-securit.

Nuwer, Rachel. "Mosquitoes Kill More Humans Than Human Murderers Do." *Smithsonian.com*, Smithsonian Institution, 30 Apr. 2014, www.smithsonianmag.com/smart-news/mosquitoes-kill-more-humans-human-murderers-do-180951272/?no-ist.

"CDC - Parasites - Malaria." *Centers for Disease Control and Prevention*, Centers for Disease Control and Prevention, 11 Dec. 2019, www.cdc.gov/parasites/malaria/index.html.

Dettmer, Philipp, director. *Genetic Engineering and Diseases – Gene Drive & Malaria*. *Kurzgesagt*, 2016, www.youtube.com/watch?v=TnzcwTyr6cE.

Gates, Bill. "The Deadliest Animal in the World." *Gatesnotes.com*, 2014, bit.ly/1UdvIqI.

"Nigeria HIV Country Profile: 2016." *World Health Organisation* , 2016, www.who.int/hiv/data/Country_profile_Nigeria.pdf?ua=1.

Parke, Phoebe. "World's Most Polluted City by Air Is in ... Nigeria." CNN, Cable News Network, 1 June 2016, www.cnn.com/2016/05/31/africa/nigeria-cities-pollution/index.html.