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Managing Malaria: Proposals for Prevention and Treatment in Nigeria

“Nigeria has no business with poverty. With our human and material resources, we shall strive to eradicate poverty from our country.” (Obasanjo, 1999). This powerful quote is from a speech given by former Nigerian President, Olusegun Obasanjo. Despite Obasanjo’s optimism, Nigeria is still the most populous and perhaps troubled country in Western Africa. Nigeria shares its borders with Benin, Chad, Niger, and Cameroon as well as the Gulf of Guinea. With 565,925 square miles of land and water, Nigeria boasts the title of the 14th largest country in Africa (Central Intelligence Agency, 2019). Approximately 195,874,740 Africans call Nigeria home, or “gida“ in Hausa, Nigeria’s most widely spoken language. The country is split nearly equally between rural inhabitants (49.7% of the population) versus urban (50.3% of the population) (World Bank, 2018). Although Abuja is the capital of Nigeria, the most populous city is Lagos. Poverty is prevalent in Nigeria with 87 million Nigerians living in extreme poverty, more than any other African country (CNN, 2018). Labor-intensive occupations such as small-scale agricultural businesses dominate the Nigerian workforce. This proves problematic as 97% of the Nigerian population is at risk of contracting what has virtually paralyzed Nigerian productivity: the malaria parasite (Malaria Journal, 2016). Thorough research suggests that efforts to educate young children about transmission and prevention, invest in public service announcements and outreach programs, improve infrastructure, and locally produce the highly efficacious Sweet Annie plant would comprise the most logical multi-faceted approach to fighting malaria in Nigeria.

Until recent years, a lack of governmental unity was exacerbating the public health crisis in Nigeria. The Nigerian government suffered constant political turmoil until 1999, at which time a new constitution was established and the government was unified under the direction of President Olusegun Obasanjo. The unification of Nigeria enabled the country to focus on turning its abundant supply of natural resources into profit. Aside from commodities such as natural gas, petroleum, and ores, fertile land is Nigeria’s greatest asset. The temperate climate allows for the utilization of land year-round. Smallholder farmers dominate the production agriculture industry. The average Nigerian farmer practices subsistence farming often working 50 acres of land (Nations Encyclopedia). According to the Trading Economics online magazine, 74,131,614 acres of farmland is under cultivation. However, it has been estimated that approximately 193,000,000 acres of land would be required to feed the Nigerian population.

Household size, diet, education, and access to medical care and utilities, all vary greatly from region to region. The average household size is larger in northern Nigeria (5.1 persons) when compared to household sizes in the south (4.7 persons). Diet also varies based on the region. The northern Nigerian diet is heavily based upon beans, sorghum, and brown rice; those residing in the southern and eastern regions of Nigeria often incorporate dumplings, mashed yams or mashed cassava into their daily diet (Food in Every Country 2007). The setting in which Nigerians live (urban versus rural) significantly determines access to education, medical care, and utilities/resources. Children raised in rural settings are significantly less likely to attend secondary school. Those who live in urban settings are more advantaged overall in terms of household characteristics. Half of the urban households have access to drinking water within a 15-minute radius while only one-third of rural homes have the same access to water (Nations Encyclopedia). Approximately 85% of urban homes have access to electricity compared to only 34% of rural residents (Nations Encyclopedia). Poor infrastructure in rural areas reduces access to local markets

and delays the movement of goods. When examining the number of malaria cases across Nigeria, it is clear that a majority of patients reside in rural areas across the northern portion of Nigeria (Food and Agriculture Organization of the United Nations, 2018).

Nigeria is the world leader for cases of malaria (World Health Organization). Malaria is caused by *Plasmodium*, a parasitic protozoan found in the *Anopheles* female mosquito. After entering the bloodstream, the malaria parasite often completes its full life cycle inside the bloodstream of its victims. Extensive studies conducted by the Center for Disease Control found that the parasite first grows and multiplies in the liver, then in red blood cells. Consecutive offspring of the parasite grows inside red cells and destroy them, releasing daughter parasites (merozoites) that continue the cycle by invading other red cells. When a form of the blood-stage parasite (gametocytes) is ingested during blood feeding by a female mosquito, they mate in the gut of the mosquito. After roughly two weeks a different form of the parasite (sporozoite) migrates to the mosquito's salivary glands. When the *Anopheles* mosquito takes a blood meal on another human, the mosquito's saliva is injected with the sporozoites into the human bloodstream. The sporozoites migrate to the liver of the human, beginning a new cycle. The infected mosquito acts as a vector and transmits the disease from one human to another. The mosquito does not suffer from the presence of the parasites. Malaria can also be transmitted through blood transfusions, organ transplants, or shared needles and syringes. The parasite may also be transmitted from mother to infant before or during delivery. In malaria-endemic areas such as Nigeria, the transmission is so intense that a large portion of the population is infected, but not made ill by the parasites. Such carriers have developed just enough immunity to protect them from malarial illnesses, but not infection.

Symptoms of malaria are generally non-specific and often start with a fever, chills, sweats, headaches, muscle pains, nausea, and vomiting, which often delays a proper diagnosis. Patients with severe malaria cases often show signs of confusion, neurological focal signs, severe anemia, respiratory difficulties, and even fall into comas. When treating a patient with malaria, doctors must formulate their course of action based on four considerations: infecting species, the clinical status of the patient, expected drug susceptibility of the infecting parasite, and previous use of antimalarials. The course of treatment is determined by the severity of the case. The treatment of malaria heavily relies on a tannin produced by the *Artemisia annua* plant. The *Artemisia annua* plant, nicknamed "Sweet Annie," contains artemisinin which reduces the number of *Plasmodium* in the blood of patients. Artemisinin is often paired with a "partner drug" to form Artemisinin-based Combination Therapies (ACTs). Artemisinin reduces the number of parasites during the first three days of treatment while partner drugs eliminate the remaining parasites not killed by the Artemisinin. Severe malaria patients are treated with intravenous artesunate. Treatment of any kind is unaffordable for many malaria patients. *Artemisia annua* dried leaf tablets are a more affordable option. Patients treated with an ACT are generally cured (provided that the partner drug is highly effective). Plant-based artemisinin combination therapy (pACTs) is generally administered orally through consuming leaves or drinking in a tea infusion. While many malaria patients can recover, the parasite will live in the patient's body for the rest of their lives. Clinical studies have found that many malaria survivors are at an increased risk of developing major psychiatric disorders (depression and schizophrenia) and decreased immunity.

Resource and geographically based difficulties in controlling malaria include Nigeria's favorable climate for the breeding of mosquitoes, a weak infrastructure to deal with the disease, and the high cost of the intervention. Many social and cultural contexts also contribute to struggles in controlling malaria. Many Nigerians lack understanding in regard to the treatment and transmission of malaria. In turn, Nigerians do not effectively use preventative measures. In 2001, the Nigerian government integrated malaria prevention into the public health system. Prevention methods most widely used in Nigeria include insecticide-treated nets used in homes and residual spraying (Centers for Disease Control and Prevention,

2018). The BMC International Health and Human Rights Organization recorded that many Nigerian households dedicate one-quarter of the household income (480-645 USD) to malaria treatment and prevention. During interviews with Western Africans conducted by David M Maslove and his research team, it was discovered that many Nigerians believed that malaria is caused by environmental factors (excessive heat, wind, or cold), dietary factors (eating oily foods, certain fruits, and grains, or too much of the same foods), drinking or bathing in dirty water, and supernatural causes. The belief that malaria cannot be prevented was also a prevalent theme in interviews. Many Nigerians engage in ineffective prevention practices. Maslove's interviewees explained that they believed eating a balanced diet, drinking herbal teas, wearing charms, and not vaccinating children would prevent malaria. Few of the "preventative measures" Nigerians are engaging in are preventative. Staying in well-screened areas and using bed nets at night, using mosquito repellent, wearing clothing items that cover the skin (long sleeves and pants), and utilizing antimalarials are the most effective prevention methods (US National Library of Medicine National Institutes of Health, 2018).

Virtually all of the Nigerian population is at risk for contracting malaria (United States Embassy in Nigeria). It is imperative to understand the forces that drive the transmission of malaria throughout Nigeria. Lifestyle, occupation, and Nigerian culture determine the risk of infection in Nigerians as each gender is equally susceptible to malaria. Nigerian men typically work outdoors, putting them at a higher risk of contracting malaria than women who traditionally stay at home. The Demographic and Health Surveys Program released a report that estimated a striking 84% of households were headed by males. This statistic is particularly troubling when it is known that a majority of males are the sole source of income and food for their entire family. Subsistence farming- the act of producing enough food for your household- accounts for 88% of crop production in Nigeria (Food and Agriculture Organization of the United Nations, 2018). The illness of an adult male puts the entire household at risk by reducing his ability to provide funds and food for his family. When a farmer who is also the head of a household contracts malaria, they are unable to work for either a short or long period depending on the severity of their case. As a result, a family often stares food insecurity in the face for an extended time while also battling the stresses of caring for a sick family member. Many Nigerians face food security issues and nutritional deficiencies even when the male of the household can produce food through subsistence farming. When the immune system of a patient is already compromised due to a lack of proper nutrition it is logical to assume that they will succumb to the parasite and take longer to recover. Numerous studies have found that families caring for a sick family member often report a decline in their mental health as the situation digresses (BMC, 2016). In addition to the risks associated with a typical male role in the household, the family structure in Nigeria also poses a risk to women. Women often have a larger workload at home and seeking timely care is not a priority. Malaria's impact on fertility in women, as well as infant mortality, must not be forgotten. The World Health Organization reports that every two minutes a child dies of malaria (World Health Organization, 2007). The financial impact of malaria on the GDP (Growth Domestic Product) is staggering. Malaria costs Nigeria about 2 million dollars annually (US National Library of Medicine National Institutes of Health, 2007).

New antiprotozoal drug developments and increased humanitarian efforts within the last 20 years have undeniably lessened malaria's grip on Nigeria. While continued scientific studies and foreign aid are both necessary, more emphasis should be placed on educating Nigerians about what they can do to overcome malaria. As previously stated, many Nigerians believe that malaria is caused by factors other than the parasite carried by the *Anopheles* mosquito and are not utilizing effective preventative measures. Preventative education would enlighten not only those who are unaware of how malaria is transmitted but also Nigerians who are engaging in ineffective preventative measures. Malaria disproportionately affects rural Nigerians, many of whom do not attend secondary school. However, the Demographic and Health

Surveys Program reports that there is no significant difference in rural and urban areas in the number of primary school-aged children that attend school. For this reason, information regarding the transmission of the parasite should be most heavily aimed at children in primary school. Ideally, education regarding the transmission of infectious diseases would be incorporated into the health education curriculum for both primary and secondary schools simultaneously. However, creating and implementing new education standards and programs will take time. As with any public health initiative, the priority should be educating highest amount of people (students in this case) at once. Due to the number of youths regularly attending school, primary schools would be best positioned in terms of immediate program implementation and government support. As support grows, incorporating malaria education into upper-level classes would make sense. It should be noted that a majority of Nigerians do not pursue education after sixth grade. However, the DHS (Demographic and Health Surveys) reported that in 2011, roughly two-thirds of households in Nigeria regularly use a radio. Investing in public health announcements and updates concerning transmission, preventative measures, and basic hygiene, much like the United States in doing amidst the COVID-19 pandemic, would be a reliable and effective way to reach Nigerian citizens.

In addition to malaria transmission education, proper prevention methods and basic personal hygiene should also be incorporated into the classroom. The most effective preventative measures against malaria are also some of the simplest. Basic information such as staying in well-screened areas, using bed nets at night, using mosquito repellent, and wearing clothing items that cover the skin (long sleeves and pants) could easily be relayed to youth (Stanford Health, 2020). Providing schools with all of the tools they need to prevent malaria is just as important as educating about preventative measures. Children who attend school spend just as much time in a school building as they do at home. To protect the health of the public, schools must also work to implement and utilize as many preventative measures as possible (nets where feasible, encouraging children to wear long clothing, accessible mosquito repellent, antimalarial distributions to students and their families on a semi-regular basis, etc.). This will be particularly challenging as schools, specifically buildings in rural communities, receive little to no financial help from the Nigerian government. Partnering with global education organizations such as the Association for Childhood Education International (ACEI), UNESCO, and UNICEF could be reliable sources of funds. The long-term benefits of preventative education far outweigh startup costs. One initial investment in education would be enough to change the trajectory of a country. Eventually, these educated children will grow and start families of their own. Armed with the knowledge of effective prevention measures and basic hygienic habits, these Nigerians will be able to ensure the health of not only themselves but also their children. As the cycle continues, engaging in simple prevention practices would become mainstream. As prevention methods take root in the culture of Nigeria, treatment would no longer be such a critical issue as fewer citizens contract the virus.

When Isaac Adewole, the health minister of Nigeria, was asked to share his thoughts on the biggest barriers standing in the way of preventing and treating malaria, he provided insight that is frequently overlooked. The government in Nigeria is severely underfunded. While many initiatives to distribute prevention methods to citizens and improve infrastructure have been launched in recent years, the programs have fallen short or completely stopped due to a lack of funding. One attempt to overcome this issue involved mandating that the private sector give 1% of their profits to a private sector-led fund dedicated to improving infrastructure and access to bed nets. While this was sound, in theory, many private-sector employees were working for the clothes on their backs in companies that were barely able to pay them. Excess funding was lacking. The Nigerian government should attempt to obtain funding for infrastructure by forging partnerships with private investors. The Emerging Africa Infrastructure Fund has been working in Sub-Saharan Africa to utilize funds from both governmental and public and private

entities to help build and improve infrastructure (EAIF, 2020). Funds should be directed towards businesses that show strong potential to improve infrastructure in Nigeria, specifically in rural areas. Long-term construction projects could likely provide several jobs to Nigerians in both urban and rural settings.

One of the most impactful actions Nigerians could take against malaria lies in a literal “home-grown” solution. Nigeria relies heavily upon other countries, specifically Western pharmaceutical institutions, for their much-needed antimalarial drugs. Research conducted by Pamela Weathers at the Worcester Polytechnic Institute demonstrates that pACTs are more effective than ACTs and that Sweet Annie is easily cultivated on the African continent (WPI, 2016). Other African countries, such as Malawi, have already taken to producing their antimalarials (WPI, 2016). The following proposition will take the fundamental principles of programs operating in other African countries and specifically tailoring them to the country of Nigeria. Step one in this solution will be obtaining the seeds. The most dependable method of transporting the seeds to Nigeria would be by land. Refrigeration of the seeds while transporting them internationally would prove to be too expensive. African infrastructure as a whole is underdeveloped and it should be noted that this method of distribution will also prove difficult. Seeds should be purchased from countries in Africa that are already producing Sweet Annie commercially such as Malawi and The Republic of Congo. The distribution of the seeds, once they have been purchased, will most likely be carried out by the government with additional help from humanitarian organizations.

The lifestyles of rural and urban Nigerians are different and it is to be expected that the model of production and distribution between these two areas will also differ. In rural areas, a majority of the seeds distributed would be to rural farmers who practice subsistence farming. Nigerians who farm already have a basic knowledge of how to grow plants and they would not require much instruction in concerning growing the plant. However, these farmers would need to be educated on how to dry the plant matter and manufacture their pACTs. Ideally, the Sweet Annie plant would become a part of their farming operation. Farmers can sow Sweet Annie directly into the ground when they plant their other crops. Much like any other crop produced, farmers can keep what they need for their family and sell the rest for profit. This additional source of income for farmers would eliminate stress surrounding malaria while also providing financial stability to the household. The cultivation of Sweet Annie in urban areas will require a slightly different approach closely resembling a community garden. Citizens would have access to the garden and would be encouraged to care for the plants as they mature. Urban areas are generally more accessible which would make the program more easily accessible to humanitarian organizations. Partnering with women’s empowerment groups would likely increase the amount of financial support and participation. After the plants have been harvested, the leaves would be taken to a local dispensary where they would be dried and manufactured into pACTs for the entire community. Numerous studies have found that the effectiveness of the tannins, flavonoids, and other substances in the plant decline immediately after harvesting (US National Library of Medicine National Institutes of Health, 2014.). In both scenarios, the pACTs are not being transported that far which means that the treatment would be more effective and easily accessible. The implementation of these programs is not a solution. Rather, it is a way to help patients manage the symptoms of malaria when prevention methods have failed.

In summary, Nigerian productivity has not reached its full potential due to the devastating hold that malaria continues to have over the country. However, a varied approach that addresses education, infrastructure, and access to antimalarials would certainly lessen the impacts of malaria in both urban and rural settings. Incorporating the basics of proper hygiene, malaria transmission, and effective preventative measures into the curriculum taught to young children would be the most cost-effective way to change the public beliefs of disease transmission and prevention. In addition to educating school children, the public

should also be educated, mostly through the use of radio advertisements and other public service announcements. Due to a lack of funds, infrastructure in Nigeria remains poor. Partnering governmental agencies with private investors to improve infrastructure would address many other public health issues in addition to malaria while also providing job opportunities and access to essential commodities. Nigerians residing in both rural and urban settings would be able to access more effective antimalarial pACTs if they produced the plant locally. Different models of production would also allow for an additional income stream for rural inhabitants and a source of community and women's empowerment in urban areas. The focused and multi-faceted approach to curbing malaria in Nigeria would certainly bring the country one step closer to making former President Obasanjo's vision of eradicating poverty from Nigeria a reality.

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