Stubborn Enemy: The Persistence of Malaria in Sub-Saharan Africa

Over 90 percent of worldwide malaria deaths occur in Africa, mostly among children under five (Taylor, 2022). Nearly half a million Sub-Saharan African children die each year from malaria (WHO, 2022c). Transmission of malaria occurs through the bite of a mosquito that bears *Plasmodium* parasites, which enter the human body causing the disease's symptoms: fever, chills, vomiting and general malaise. Death occurs as the parasite destroys red blood cells and binds to crucial organs usually causing comas or respiratory failure. In 2020, global spending to fight malaria had risen to $2.5 billion dollars annually, but the mortality rate in children under five has not wavered since 2015 (Leslie Roberts, 2022). Efforts to control mosquitoes, the only *Plasmodium* vector, have been more effective in some regions than others. Over time, mosquitoes have begun to adapt to antimalarial techniques and continue to infect many (Africa Uncensored, 2016). The COVID-19 pandemic stalled progress towards the World Health Organization's (WHO) malaria prevention goals: 63,000 deaths can be attributed specifically to pandemic disruptions (WHO, 2022c). By limiting supply distribution and interpersonal contact, the pandemic thwarted malaria control efforts. By the end of 2021, progress had resumed, but mortality rates had not yet returned to pre-pandemic numbers. Despite setbacks, there is still a strong ambition to eradicate malaria and death rates have halved since the beginning of the millennium (WHO, 2022c). Yet since the year 2000, international NGOs, IGOs, national health agencies, and local caregivers have strived to reduce malaria incidence in Sub-Saharan Africa but are not on track with WHO's malaria elimination timeline. To prevail against malaria, health organizations must adapt and innovate, pursuing a combination of methods and subjecting them to regular evaluation.

Literature Review

Bhatt et al. credit the Roll Back Malaria initiative with kickstarting the fight against malaria in Sub-Saharan Africa in the year 2000 by setting milestone goals for 2015 (2015). They claim that WHO reinvigorated the mission with their 2015 strategy that set new goals for continual antimalarial effort. Trigg & Kondrachine believe that an earlier mission was the one to get the world on board with fighting malaria: the World Health Assembly's 1955 Global Malaria Eradication Campaign (1998). They claim that, "As a result of the Campaign, malaria was eradicated by 1967 from all developed countries."

Bhatt et al. assert that more effective strategies against malaria will require better surveillance to find, "geographically detailed and timely data on malaria incidence" (2015). Due to limited data, they generate mathematical models based on empirical data about malaria prevalence, population density, medical interventions and insecticide treated nets (ITNs). This data informs what antimalarial methods should be implemented more heavily and where resources should be allocated geographically. Rabinovich et al. also stress the importance of, "reorient[ing] [malaria programmes'] tools" (2017). They agree that stronger surveillance is necessary to effectively respond to changes in malaria prevalence. The more comprehensive and active the data collection, the more accurate the predictions and the better the allocation of resources can be organized.

Bhatt et al. recognize indoor residual spraying of insecticides and ITNs as the most effective methods in reducing infective parasite prevalence, taking 68 percent and 13 percent of the responsibility respectively (2015). Van den Berg et al. agrees that insecticide residual spraying (IRS) is particularly valuable, noting DDT specifically as the most successful

insecticide to reduce malaria transmission. The Stockholm Convention, which over half of countries have ratified, bans DDT except for its use in malaria vector control (United Nations Environment Programme, n.d.). However, van den Berg et al. insists that insecticide-free methods of vector control need more focus: larval management and house improvement (2017). They assert that DDT use should be banned completely but they admit that new solutions are required to make up for the loss of that technology.

Polio elimination has been successful with a vaccine because humans are the only reservoir for the virus. However, even this disease is not yet eradicated as it persists in a few countries. The barrier to eradication is no longer “biological, but operational, e.g., security issues … and a funding deficit” (Russell, 2011). Eradicating diseases that have animal reservoirs is particularly hard because controlling the population of a small insect species is unrealistic. Rabinovich et al. agree that operational barriers exist in the eradication of malaria, but argues that other important variable exist, both, “ecologic (e.g., climate and outbreaks) [and] biologic (e.g., vector or parasite resistance)” (2017). Together, these factors have allowed malaria to persist.

Leading the War on Malaria

The World Health Organization (WHO) is the biggest orchestrator of global malaria reduction. WHO is a United Nations (UN) organization acting internationally to further “the attainment by all peoples of the highest possible level of health" (United Nations, n.d.). WHO has created global strategies against malaria since 1955 (Strategic Advisory Group on Malaria Eradication, 2020). From 1990 to 2010, malaria death rates were relatively constant despite the United Nations announcing Millennium Development Goals in the year 2000. Goal 6 was to

"have halted by 2015 and begun to reverse the incidence of malaria and other major diseases" (United Nations, n.d.). WHO's "Global technical strategy for malaria 2016-2030*"* was released in 2015 to follow the expiration of the UN Millennium Development Goals and provide quantitative milestones (2021). This strategy to fight malaria was most recently updated in 2021, instating a long term goal of 90 percent malaria reduction across the plan's lifetime. WHO continuously gathers data from Sub-Saharan Africans through web portals and apps. This system, what WHO calls "surveillance", allows for on-the-ground reporting of population data and malaria prevalence, for example (WHO, 2022c). WHO makes forecasts, annual assessments and actions plans based on this data, updating their recommendations based on current progress in malaria elimination. Groups including UNICEF, Doctors Without Borders and some African national health ministries hold WHO's goals as the standard of success. (UNICEF, 2022); "Despite Existing Medical Solutions, Malaria Remains a Killer," 2010).

Adherence to WHO's recommendations by these national and international groups has brought promise, but not total success. In the plan's early stages from 2015 to 2020, malaria deaths decreased by 22 percent but malaria incidence by only 3 percent. The first approved malaria vaccine, 'RTS,S' sold under the name Mosquirix, was recommended by WHO in 2021. Following this recommendation, a promotional video by WHO shared a Ghanaian mother's testimony to the importance of the vaccine (WHO, 2022a). She shares that her infant son contracting malaria affected not only him, but also her healthy children because of her having to prioritize his health by travelig to health clinics. This story not only appeals to emotion but garners trust by featuring a woman with whom the target group may identify. WHO makes

appeals to both individuals and larger health and government organizations to reduce malaria prevalence.

WHO pioneered international malaria eradication strategies that remain the most effective today, but their two main tools are not enough to eradicate malaria alone. Though the United States began their National Malaria Eradication Program in 1947 (CDC, 2018), their efforts ended in 1951 when they considered malaria eliminated from the country. This success was primarily through an insecticide spray made with DDT. This insecticide was sprayed onto the interior of homes, called indoor residual spraying (IRS), but some areas with high malaria presence were also sprayed outdoors by airplanes. In 1955, WHO announced their global eradication mission through widespread use of IRS, at the time considered the gold standard based on success in the United States (Migiro, 2016). Though IRS is effective, WHO no longer recommends DDT but four other classes of insecticides instead (WHO, n.d.). DDT remains the most effective, but is reserved for areas of high need because it is an environmental contaminant and a potential carcinogen. Despite being the second most common antimalarial method used by National Malaria Programmes (NMPs) in Sub-Saharan Africa, only 5 percent of Sub-Saharan Africans are protected with this method (WHO, 2022c). Distribution of bed nets and antimalarial drugs was the other big component of WHO's 1955 mission, but neither of these were implemented widely in Africa. It was only in 2005 that Togo became the first country with a national bed net distribution campaign (CDC, 2005). In the 2000s, WHO credited ITNs as the most successful method in reducing malaria cases (WHO, 2022c). Today, ITNs are the most widely implemented and least costly antimalarial campaign with 87 percent of all nets being deployed in sub-Saharan Africa (WHO, 2022c). ITNs are valuable because they protect sleeping people, as the mosquitos generally feed at night. Today, most African countries distribute free

ITNs. Across Sub-Saharan Africa, 53 percent of children sleep under ITNs (UNICEF, 2022). Specific ITNs, long-lasting insecticidal nets (LLINs) are the best choice with an approved lifespan of about three years before the insecticide is no longer effective or the net tears. In practice, these nets have an average lifespan of closer to two years (WHO, 2022c). ITNs primarily use a class of chemicals called pyrethroids. Unfortunately, mosquitos are gaining a resistance to these chemicals so new classes of insecticides are added to these nets to increase their effectiveness. ITNs without insecticides are not nearly as effective as those with. The increase of insecticide resistance calls into question how long ITNs will remain a primary tool to prevent mosquito bites. Both IRS and ITNs only work for preventing mosquito bites occurring inside of the home so a diversity of strategies is needed to cover gaps in protection.

Methods to Maintain Progress: Vaccines

The approval of the first malaria vaccine was a significant milestone. After clinical trials, the vaccine was rolled out on the pilot scale in Malawi, Kenya and Ghana in 2019 (de Vrieze, 2019). So far, the reception has been positive, Malawian healthcare worker Alfred Kaponya saying, “The community has welcomed the vaccine.”. At the end of 2022, Malawi announced that the malaria vaccine would be incorporated as a core vaccine for babies (Chinele, 2022). In 2023, Kenya’s National Ministry of Health announced that vaccine accessibility will be increased across previously unserved areas. The vaccine’s overall success will be determined in upcoming years as vaccines continue to roll out across the region. In December 2021, the Gavi Alliance pledged $160 million specifically for the distribution of the malaria vaccine (WHO, 2022c). UNICEF has pledged to distribute 18 million Mosquirix vaccines from 2023 to 2025. As of July 2022, 1.3 million children had been vaccinated (WHO, 2022b).

A vaccine better than Mosquirix is on the horizon: the Oxford R21 vaccine. While the dedication to the distribution of the Mosquirix vaccine is notable, the vaccine's efficacy is only 36 percent in children aged 5-17 months (Datoo et al., 2021). Mosquirix also currently has unexplored safety concerns (de Vrieze, 2019). Meningitis occurred 10 times more often in children who received the vaccine compared to a control group that received the rabies vaccine. This relationship has not yet been elucidated. Malawi National Ministry of Health Community Health Ambassador, Maziko Matemba emphasizes that just because a vaccine became available, "people should not relax. They should continue to sleep under a mosquito net and take antimalarial drugs … [Malaria] requires a pool of preventative interventions" (Chinele, 2022). A full series of Mosquirix vaccines costs three times more than a bed net with a course of antimalarial drugs (Topazian et al., 2022). Large pledges will increase the availability of the vaccine but currently, demand far exceeds the supply (WHO, 2022b). The new Oxford vaccine achieves WHO's malaria vaccine efficacy goal with an efficacy of over 80 percent (Ledford, 2022; WHO, 2013). Oxford vaccinologist Adrian V. S. Hill explains why else the new R21 vaccine trumps Mosquirix: the R21 vaccine is half the cost and has 30 times greater production capabilities (Ledford, 2022). Hill is the director of the Jenner Institute, a research organization developing vaccines for prominent infectious diseases in low-income countries. These organizations are crucial to developing medical interventions to achieve humanitarian milestones.

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Major Players in the War

Doctors Without Borders (MSF) effectively adapts their humanitarian efforts to target the greatest area of need based on emerging factors. MSF treats malaria in over two million people each year (MSF, n.d.). MSF's standard operation includes deployment of mobile clinics where healthcare is otherwise inaccessible, treating manageable cases and transporting extreme cases to hospitals. Mobile clinics are necessary to serve communities isolated by political conflict or impacted by weather catastrophes like floods. MSF also offers training and supplies to local healthcare providers, especially to groups continually displaced by nearby violent conflict, helping them to reorganize for their own safety and to better serve their community. Instead of traveling to a hospital in dangerous territory, local healthcare workers and MSF staff can move with the community, becoming their own mobile hospital. Because of displacement, some local healthcare workers have had limited opportunities to receive formal training. Dr. Philippa Pett, MSF physician, claims that South Sudanese healthcare staff "love the teaching [MSF employees] give them … They really value this" (2017). A few months after WHO's recommendation in 2012, MSF quickly began their own Seasonal Malaria Chemoprevention (SMC) program. This program involves preemptively distributing antimalarial pills by anticipating malaria spikes based upon seasonal weather changes, specifically the rainy season. By 2016, National Health Ministries across the region took over the SMC program in their country from MSF. MSF still employs their own SMC programs in areas of need, such as a 2019 pilot scale program in Aweil, South Sudan (MSF, 2021a). MSF makes a point to study how climate change may guide their humanitarian efforts (MSF, 2021b). For example, climate change has severely impacted crop yield in Magaria, Niger. MSF gives aid to combat malnutrition, which in combination with

malaria, is particularly deadly. Other malaria prevention strategies MSF employs are WHO-recommended IRS and ITN distribution. These efforts further MSR's mission of achieving diversity, equity, inclusion without doing harm, in alignment with WHO's goals (MSF, n.d.).

Ethiopia's Ministry of Health (MoH) is one Sub-Saharan national government organization that has shown major success by implementing solutions within their own country. Their action plan is called the National Malaria Elimination Program (NMEP), "responsible for designing, planning, implementation, monitoring, and evaluation of malaria-related interventions and activities" (Solomon, n.d.). The NMEP sets its own national goals to track its individual progress against other Sub-Saharan African countries. Their latest is a five year program from 2021-2025. They say that one of their goals is to achieve 100 percent coverage with at least one mosquito control method by "2021 and beyond." Despite not meeting this goal, they did surpass their 2021 goal for distribution of bed nets, supplying over 6.5 million nets to Ethiopians (WHO, 2022c). Achieving these goals requires good record-keeping. Health Extension Worker (HEW) Mulu Tirfe says, "We were trained to work on the paper system [but] our file management was not proper" (Digital Health Activity, 2022). In 2016, Ethiopia launched electronic Community Health Information System (eCHIS) to provide a more accurate network of health records, in turn increasing surveillance to assess their progress and target their methods. HEWs have agreed on the two most valuable aspects of eCHIS: higher accuracy of population counts and assurance that people who have been referred to medical clinics have actually sought care. To increase accessibility of care, the MoH organizes voluntary campaigns to supply free diagnostic and curative medical services across all regions of the country. These efforts have contributed to Ethiopia's achievement of WHO's malaria mortality reduction goal of 40 percent in the east and

southern Africa region from 2015 to 2021 (WHO, 2022c). This region includes 11 high-transmission countries but only Ethiopia, Rwanda and Zimbabwe met that malaria reduction milestone.

Barriers to Success

COVID-19 is an emergent barrier to healthcare that has stalled progress in fighting malaria. From 2000 to 2019, malaria deaths in WHO's African Region have declined every year except for a relatively small uptick in 2017 (<3 percent) (WHO, 2022c). In 2020, the start of the COVID-19 pandemic, malaria deaths increased by 10 percent with a total number of deaths similar to 2012 figures. The number of malaria cases followed the same trend, suggesting that COVID-19 stalled malaria prevention efforts. 13.4 million additional malaria cases can be attributed to COVID-19 disruptions (WHO, 2022c). These disruptions include supply shortages; The planned distribution of bed nets was severely impacted, some countries distributing absolutely no nets. Dr. Fasomoyin Oluwaseyi, who treats malaria patients in Sierra Leone, explains another negative impact of the COVID-19 pandemic on malaria patients: "A lot of people are scared of coming to the hospital … [thinking] that if they come to the hospital, they will be infected with the virus" (BBC News Africa, 2021). In reality, COVID-19 had a much smaller impact than malaria; malaria killed 100 times as many Sierra Leoneans as COVID-19 in 2020. Since the start of the pandemic, deaths rose not only because of weakened malaria prevention resources, but also from hesitance to receive care.

Effectiveness of these antimalarial strategies depends heavily on trust. Though vaccine reception has been particularly good in urban areas, others are still skeptical (de Vrieze, 2019).

WHO's 2020 goal was to have 90 percent of all children vaccinated (WHO, 2013). In a survey in Kassena Nankana Municipality in Kenya, 94 percent of children had received the first vaccine. However, in the rural part of the municipality, only 50 percent had received the first vaccine (Yeboah et al., 2022). This deficit may in part be due to lack of accessibility or poor reporting in rural areas. Only increased surveillance can clarify this, which according to WHO, is necessary to continue reducing malaria prevalence (WHO, 2022c). Malaria elimination will only be possible if vaccination rates are high. Thus, increasing vaccine uptake is important but depends heavily on the experience given by the healthcare provider in terms of knowledge and demeanor. A poor attitude in medical staff may lead to vaccine refusal (Yeboah et al., 2022). A lack of vaccine literacy is associated with vaccine hesitancy as the risks are overblown and the benefits of the vaccine are not understood (Engelbrecht et al., 2022). Sub-Saharan Africans have been reported to refuse vaccines because of their religion or a fear of needles (Dzinamarira et al., 2021). Trust in the healthcare providers is key, as colonial medicine can incite a fear of exploitation as test subjects by high-income countries (Mutombo et al., 2022). Generally, patients place more trust in healthcare providers with similar backgrounds to their own (Mbanya et al., 2019). Healthcare outcomes will improve if local healthcare providers can effectively convey the safety and importance of the vaccine. Government trust is another factor in rejection of vaccines and other antimalaria efforts (Engelbrecht et al., 2022). Not only is indoor insecticide spraying invasive and smelly, some local people fear there is a sinister motivation behind the method (Leslie Roberts, 2022). Without trust, some may be hesitant to commit to crucial steps to eliminate malaria.

Without widespread local healthcare workers in Sub-Saharan Africa, not all local people can or will utilize preventative and curative care. Though pilot vaccine programs are spreading and uptake appears relatively high, African mothers must be aware of the importance of completing the full course of vaccines (Yeboah et al., 2022). Though 97 percent of children returned for their second and third dose, only 56 percent of children received the fourth and final dose. Education by healthcare providers is necessary to effectively implement this new vaccine. If malaria is contracted, early intervention is vital to preventing death. Without a nearby health clinic, a caretaker of a sick child or a pregnant woman may find that traveling is too difficult. This issue worsens as many healthcare workers are emigrating to further their career (Poppe et al., 2014). Some cannot even enter a training program in Africa because there are not enough spaces at universities to accommodate all those who wish to enter the field. Many training programs are not comprehensive with limited specialties to pursue. Others who emigrate fear for their safety because of political instability and ethnic divide across the continent. One physician explained the situation that triggered him to flee from Africa to Europe: "I was on duty. And the person who sat in front of me was a soldier of another ethnic group. … he said: 'well, if you don't save my child, I [will] kill you.' It's like that that I fled the hospital" (Poppe et al., 2014). The scarcity of medical training opportunities and the dangers of political instability prevent healthcare workers from achieving their education and career aspirations, contributing to a lack of widespread healthcare across Sub-Saharan Africa. It is necessary to build an accessible network of knowledgeable healthcare providers to increase the use of antimalarial medical interventions.

Successful methods to fight malaria already exist but technology has outpaced logistical capabilities. Gaps in financial support, infrastructure and other material resources cause WHO's malaria eradication goals to be unmet. Using particular effective methods in the wrong way will not achieve the success that is expected. New effective methods or better application of existing methods is required. First, the failures of the system must be diagnosed, which requires data. Data capture is deficient in Sub-Saharan Africa, contributing to stalls. Once the chief failures are identified, possible solutions can be prescribed. However, identifying a solution is easier than implementing one. In the case of malaria elimination campaigns, implementation of those solutions is the sticking point. Given logistical limitations, the best progress has been made by constantly adapting, targeting new solutions and strategies to areas that appear the most deficient. Continually evaluating progress allows for course correction along the way; sticking to the same plan for a distant goal may end in being dismally off course by the time the deadline arrives. Global commitment to the war on malaria by organizations and individuals will improve the outcome of implementation of antimalarial techniques, preventing deaths in hundreds of thousands of children each year.

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