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Malaria Related Issues in Western Uganda During a 9-year Period of Implementing Prevention Strategies

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Malaria Related Issues in Western Uganda During a 9-year Period of Implementing Prevention Strategies

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Abstract

Introduction: Malaria, a protozoal infection of human red blood cells transmitted by the female Anopheles mosquito, remains a considerable threat especially to pregnant women and children, and remains the tenth leading cause of death in Uganda.

Methods: This mixed methods study utilized key informant interviews conducted in three Ugandan districts. This study described the penetration of malaria preventative strategies and challenges with their uptake. In addition, a retrospective analysis of de-identified data from the medical reports of patients from the Nyakibale emergency department (ED) located in western Uganda.

Results: Results revealed the use of various interventions for malaria prevention, but also reported many barriers to the use of current recommended prevention strategies. Results of analysis of the de-identified data revealed a significant reduction in cases of malaria between 1/2010-12/2018 [$p<0.001$]. Our results also show that the burden of malaria cases in Uganda displayed a seasonal component with the highest number of cases diagnosed between November and January [$p<0.001$]. Finally, although several threats to Artemisinin-based Combination Therapy (ACT) resistance were identified through key informant interviews, a significant reduction in the treatment of slide-negative malaria [$p<0.001$] and cases that were not tested prior to treatment [$p<0.001$] at Nyakibale Hospital was noted.

Conclusion: Results revealed that community level interventions can decrease the ED burden of malaria although numerous challenges and barriers remain to their uptake in the community. We describe trends in malaria seen between 1/2010-12/2018. I addition, a variety of new, innovative strategies being implemented by public health officials are described.

Introduction

Malaria, a protozoal infection transmitted through the bite of the female *Anopheles* mosquito, is a serious global disease caused by infection of human red blood cells by the *plasmodium* species (CDC, 2018). There are five different plasmodium species including *plasmodium falciparum, plasmodium vivax, plasmodium knowlesi and* two forms of *plasmodium ovale* (WHO, 2015). *P. falciparum*, the most prevalent in sub-Saharan Africa, is almost always the cause of severe malaria (Nkumama, 2017). Symptoms of malaria include headache, fatigue, muscle aches, fevers, and chills. Prompt diagnosis and treatment within 24 hours of onset is vital to preventing mortality and other complications. Delayed or ineffective treatment secondary to medication resistance can cause severe malaria, leading to seizures, coma, renal failure, anemia, pulmonary edema, bleeding, shock and death (MSF, 2017).

Malaria is endemic in Africa, Central and South America, the Caribbean, and parts of Europe and the South Pacific (CDC, 2018). Currently, sub-Saharan Africa has the greatest global morbidity and mortality rates (Bioland, 2000). Approximately 90% of malaria cases occur in sub-Saharan Africa, with victims under 5 years old accounting for 78% of deaths caused by malaria. Children and pregnant females have the highest risk of acquiring the disease (WHO, 2015). Children are at higher risk due to their lower immunity to the parasite as they have not had as much exposure. The higher vulnerability seen in pregnant women has been attributed to changes in hormone levels and depressed immune system (Population Reference Bureau, 2001). In addition, when malaria occurs during pregnancy, it is more difficult to detect as the parasite can sequester to the placenta resulting in false negative tests when samples are taken from the patient’s vein (WHO, 2015). This can lead to delays in diagnosis.

Background

Many interventions have been put into place to prevent and eliminate malaria. According to the 2014 World Malaria Report, malaria prevalence worldwide declined by 48% and mortality decreased by 47% between the years 2000–2013 (WHO, 2015). Nevertheless, malaria remains a major issue in sub-Saharan Africa (Jhpiego, 2014). Although estimating the true prevalence of malaria in Africa is complicated, according to the WHO, there were 219 million reported cases of malaria in 2017 (WHO, 2019). This may under-represent the true case number as many people with fever do not present to healthcare facilities and some may self-treat assuming they have malaria. Surveillance data may also be imprecise according to the WHO. Finally, the registration of these cases may not be complete due to lack of diagnostic resources and lack of trained providers who treat based on symptoms rather than a confirmed diagnostic test (Nkumama, 2017).

World Health Organization (WHO) recommendations for controlling malaria

The two principal public health goals for malaria control are to reduce transmission to others by rapid diagnosis and treatment and to prevent drug resistance (Uganda Ministry of Health [MOH], 2011). Decreasing the number of people with *P. falciparum* in their blood decreases the reservoir for the infection, thus reducing transmission to others. The WHO's Guidelines for the treatment of malaria recommends several core standards for the prevention of malaria. Early diagnosis and treatment are critical when patients present with fever in a malaria-endemic area. Guidelines call for treatment with artemisinin-based combination therapies (ACTs) if the test is positive. If testing is not readily available, febrile patients with clinical signs of malaria should receive immediate treatment to prevent complications, and tests should be performed at the earliest availability. If the test returns negative, the ACT should be stopped and further work up for source of the fever should be initiated (WHO, 2018).

Another preventative strategy uses Intermittent Prevention Treatment (IPT), which involves giving anti-malaria prophylaxis to high-risk groups including pregnant females, children, and those with human immunodeficiency virus (HIV) or sickle cell disease (SCD). WHO recommends the prophylactic treatment of pregnant females with sulfadoxine-pyrethamine (SP) in malaria-endemic areas at least three times during their pregnancy, as the parasite can become sequestered to the placenta causing false slide-negative results (WHO, 2015). Pregnant women can harbor an asymptomatic form of the infection, which can increase the reservoir of *P. falciparum* in the community, leading to unfavorable birth outcomes such as low birth weight, anemia, stillbirths and miscarriage (Uganda MOH, 2011). In addition, in 2012, the WHO introduced recommendations to use seasonal chemoprophylaxis during rainy seasons to children residing in high prevalence areas. They recommend giving sulfadoxine-pyrethamine + amodiaquine to children ages 3-59 months at monthly intervals during the rainy season. This would be in replacement of IPT in children in these areas (WHO, 2019). Other control strategies include indoor spraying for mosquitos and use of insecticide-treated nets (Tamari, 2017). The most effective approaches have involved multiple prevention strategies rather than just one method (Nkumama, 2017).

Artemisinin-based combination therapies and resistance

Controlling malaria and preventing deadly complications of the disease is dependent on rapid initiation of anti-malarial drugs. Artemisinin-based combination therapies (ACTs) are the current recommended treatment for malaria caused by *P. falciparum*. ACTs employ a combination of an artemisinin derivative with a second, longer-acting anti-malarial medication. These medications work quickly and are highly effective at treating the disease on an individual level, as well as reducing transmission on a population level, by reducing the gametocytes in the bloodstream. Malaria gametocytes do not cause clinical symptoms; rather, they are responsible for the spread of infection as they are transmitted from human host to the mosquito. The gametes differentiate in the midgut of the mosquito and are then spread back into a human host (Nkumama, 2017). Although malaria resistance to ACTs has been observed in Southeast Asia, such resistance has not been seen in Africa to date (Nkumama, 2017). According to the WHO, the use of at least two anti-malarial medicines (as is the case when using ACTs) will decrease the chance of an endemic area developing anti-malarial resistance (WHO, 2018).

Entomological inoculation rate

The annual *P. falciparum* entomological inoculation rate (*Pf* EIR) is an indicator of a community's exposure to mosquitos infected with *P. falciparum.* The *Pf*EIR, a measure of the infectious bites per person per unit of time, is calculated by multiplying the average number of Anopheles mosquito bites per person by the sporozoite rate, which is the percentage of the mosquito population infected with *P. falciparum.* The higher the EIR, the higher the prevalence of malaria. This measure is typically analyzed annually to identify the highest risk areas and assess the impact of vector control methods (Shaukat, 2010).

Seasonal variations in malaria

The presence of malaria varies based on season. During the dry season, the malaria vector, the *Anopheles* mosquito, goes into a hibernation state where they stop reproducing, thereby reducing metabolism and feeding. The onset of the rainy season provokes rapid reproduction, which leads to a resurgence of the mosquito population and increased incidence of malaria (Geshem, 2018). Describing this resurgence by region is important as it could dictate the best time for insecticide and larvacide interventions and possibly utilize seasonal chemoprophylaxis in children, as described by the WHO.

Diagnosis of malaria: microscopy and rapid diagnostic tests

Malaria is diagnosed using microscopic or non-microscopic tests (Rapid Diagnostic Tests, RDTs). The WHO recommends a “test before treat” policy.

Light microscopy

Light microscopy involves direct observation of thin and thick blood films to identify the presence or absence of the parasite. In addition, it allows for species identification and quantification of parasitemia. Although light microscopy is currently considered the gold standard for diagnosis of malaria, it is time consuming, requires training and, in low resource areas, can be limited by the lack of the availability of a functioning microscope and electricity (Reyburn et al, 2007). Benefits to this test are the low cost of consumables and high sensitivity and specificity. However, a negative test even by light microscopy does not always rule out malaria in endemic areas. Malaria caused by *P. falciparum* can be sequestered in capillaries and may not always be visible in a specimen from a peripheral blood draw (Allan, 2006). If there is strong suspicion of malaria, the test can be repeated.

Rapid Diagnostic tests (RDT)

The RDT for malaria involves detection of parasite antigens; in contrast to microscopy, RDT produces only qualitative results. However, this method is quick and can be used by people with a basic level of training (Talisuna, 2007). RDTs have a sensitivity of 94–100% and specificity of 89–100%, depending on the manufacturer (Reyburn et al, 2007). There are several limitations of RDTs as well. First, they are more expensive compared to performing light microscopy. Second, technical issues have been observed with the tests (Talisuna, 2007). Several parasites contain deletion mutations of the HRP-2 genes, which encode the antigen detected by the test which results in false negative tests. In addition, the test can become inconclusive when the parasite antigen overwhelms the capture site (Reyburn et al, 2007).

Accurate and timely diagnosis followed by rapid treatment is key to correctly prescribing medications and preventing complications of the disease. In a study assessing the accuracy of prescribing patterns in febrile patients in Tanzania, Reyburn et al. found that 51–54% of cases that tested negative were given anti-malaria medications anyway (Reyburn et al, 2007). Overprescribing anti-malarial medications to those with negative test results not only increases the threat of ACT resistance, but suggests that providers may be missing other diagnoses causing fever in these patients. It might be expected that the availability of more RDTs might reduce the practice of over-prescribing anti-malarial medications. However, Reyburn et al. (2007) found no difference in prescribing patterns whether providers used RDTs or microscopy.

Malaria in Uganda

Malaria remains a major public health issue in Uganda as it is endemic to 95% of the country and is the tenth leading cause of death in the country (World Life Expectancy, 2019). Uganda has the third highest number of *P. falciparum* cases in sub-Saharan Africa. Throughout Uganda, malaria causes 34% of outpatient visits and 37% of hospital admissions (President's Malaria Initiative, 2017). In fact, the Apac district in northern Uganda has the highest entomological inoculation rate in the world (Fatunmbi, 2018). The districts in the southwest region have experienced reduced prevalence of malaria while northern region districts continue to have higher incidence (National Malaria Control Program, 2018).

Between 2009–2014, indoor residual spraying in 11 districts caused a significant reduction in the prevalence of malaria, from 42% to the current prevalence of 19%. According to the 2017–2018 Malaria Annual Report, prevalence has remained steady (~19%), with 191/1000 confirmed malaria cases. However, as of 2016, malaria prevalence in children in Uganda is reported at 30%. The mortality rate is at 9 deaths/100,000 people, which is a 52% reduction since the 2016/2017 annual report and accounts for 5% of deaths in Uganda (Uganda MOH, 2019).

Health system in Uganda:

The country is divided into 127 districts, each headed by a "local council". The districts are further subdivided into sub-counties, which are further divided into parishes.

Each parish is comprised of several villages, each housing ~50–70 households where 250–1000 people reside (Kavuma, 2009).

Uganda has a decentralized healthcare system, and the MOH oversees both public and private sectors. The private sector includes private health practitioners (PHPs), private not-for-profit (PNFPs) and traditional medicine practitioners. The public realm includes National Referral Hospitals, which serve populations upwards of 30 million people, and Referral Hospitals, which serve ~2 million people from many districts. In addition, there are district level health services and Health Centers at the lower levels. Health Center III facilities serve at the sub-county level, Health Center IIs serve at the parish level, and Health Center Is serve at a village level. In addition, Village Health Teams provide screening and education within the village (Mukasa, 2012).

National Malaria Control Program in Uganda

The National Malaria Control Program in Uganda guides malaria prevention in the country based on the Uganda Malaria Reduction Strategic Plan, which was updated in 2011 and 2018. The strategic plan calls for providing integrated vector management to 85% of the country and ensuring proper utilization of the methods with the objective of reducing malaria morbidity by 80%, malaria prevalence by 85% and morbidity to 1/100,000 people by 2020 (Uganda MOH, 2019). The policy outlines Uganda's malaria prevention methods based on six key strategic objectives: integrated vector management, diagnosis/case management, health promotion, program management/collaboration, surveillance/research, and emergency epidemic preparedness (Uganda MOH, 2019). The specific policies recommended by the MOH through the National Malaria Control Program (Uganda MOH, 2014) are outlined below.

1. Rapid diagnosis

    The National Malaria Control Program recognizes the implications of misdiagnosis of malaria and recommends diagnosis with either a light microscopy or RDT if microscopy is unavailable before treatment for malaria. Malaria treatment initiated without confirmation poses a potential risk for ACT resistance in the area (Uganda MOH, 2011).

2. Rapid treatment with ACT

    In 2000, the MOH in Uganda revised treatment recommendations to recommend a combined treatment with chloroquine and sulfadoxine/pyrimethamine, as treatment failure with a single anti-malarial medication was being recognized. However, between 2002 and 2004, increasing treatment failure to this combination of medications was noted; therefore, recommendations in 2004 were updated to use ACT for first line treatment of uncomplicated malaria and intravenous artesunate for severe or complicated malaria (Uganda MOH, 2011)

3. Vector control

    For mosquito control, the policy recommends using integrated vector management, which employs multiple strategies to control the mosquito population carrying the malaria-causing parasite. The policy calls for universal coverage of the population with a long-lasting insecticidal nets (LLIN) advocating for one net per two persons. Second, the policy recommends using indoor residual spraying insecticides and larvacide as well as performing intermittent tests for mosquito resistance to these products to inform the choice of insecticide (Uganda MOH, 2011).

4. Intermittent preventative treatment (IPT)

   The MOH in Uganda recommends IPT for malaria during pregnancy with sulfadoxine/pyrimethamine (SP). Recommendations prior to 2017 were to give at least three doses, one month apart starting in the second trimester. In December of 2017, recommendations were increased advocating to give pregnant women SP monthly starting after 13 weeks.

5. Surveillance and research

   The National Malaria Control Program describes the government intentions to strengthen malaria surveillance by creating a system for mapping hard-to-reach and high-risk populations and to improve communication and distribution of information about these preventative methods to the public (Uganda MOH, 2018). In addition, they have developed a tracking program to ensure implementation of malaria prevention strategies with the aim of developing policies based on evidence-based research (Uganda MOH, 2011). Finally, entomologic indicators, as described above, are utilized to assess mosquito infectivity (Uganda MOH, 2011).

Challenges and Barriers to Prevention of Malaria

Despite these existing guidelines, malaria remains a major public health issue for Uganda, stressing the importance of identifying barriers and challenges for using these strategies. According to the 2016 Uganda Demographic and Health Survey, which interviewed 18,506 women (15–49 years of age) and 5,336 men (15–54 years of age) in 19,588 households sampled, 78% owned at least one insecticide treated net, which was a significant increase from 16% in 2006 (DHS Uganda, 2016). However, only 55% of interviewees stated that they utilized the LLINs for sleeping. Among the most vulnerable, 70% of pregnant females and 67% of children reportedly slept under LLINs. The survey investigated the use of IPT in pregnancy, reporting that 75% of pregnant females interviewed took at least one dose of preventative anti-malarial medicines, while only 17% took the recommended three doses. Interestingly, the prevalence of malaria was lower and the use of LLINs and IPT was much higher between 2014–2015 (DHS Uganda, 2016).

Maslove et al. (2009) conducted a systematic review of 39 research articles that assessed beliefs about causes of malaria and prevention in sub-Saharan Africa. They found most of the studies were performed in rural areas and almost all concentrated on barriers in malaria prevention in childhood. Major barriers identified included lack of education and reliance on cultural beliefs, such as using herbal tea or wearing charms, which were ineffective at preventing malaria. There was also a lack of knowledge in regard to transmission of malaria, beliefs that it could not be prevented and belief in the use of traditional remedies instead of using anti-malarial medications. Some had mistrust of the anti-malarial medications. Other system barriers included financial issues for medications or mosquito nets and lack of accessibility to a healthcare facility (Maslove et al, 2009).

Kokwaro (2009) assessed challenges to the diagnosis and treatment of malaria and found that the major barriers included parasite resistance to medications such as chloroquine, sulphadoxine-pyrimethamine, amodiaquine, mefloquine and quinine. Also described was difficulty of administering these medications to infants and children. He also found that time to diagnosis and treatment was a barrier to prevention and suggested that further education was needed for healthcare workers and the community (Kokwaro, 2009).

Thiam et al. (2013) assessed system barriers to use of intermittent preventative treatment in pregnancy in Sub-Saharan Africa and found the primary issues to be lack of funding, lack of provider knowledge of ITP, supply chain issues, low accountability and difficulty of patients obtaining transport to healthcare facilities for prenatal care.

Research Aims

While progress has been made in addressing malaria over the last decade in Uganda, more needs to be done to meet the goals of the presidential commission. This thesis utilized a mixed methods research design generating both qualitative and quantitative data to assess trends in malaria, prevention measures currently in use and to identify what barriers still exist in prevention of malaria.

Specifically, this thesis aimed to: 1) identify current prevention strategies actively being used in Uganda and gain insight on the degree of acceptance of these strategies in the community; 2) identify challenges with the uptake of these preventative strategies in the community; 3) identify solutions to close the gaps between Ugandan policy recommendations and current practice; 4) identify potential threats to ACT resistance; and 5) describe trends in malaria seen in an emergency department (ED) in western Uganda over an 8 year time period.

Methods

This study analyzed ED records obtained from the Nyakibale Health Center ED located in rural western Uganda combined with key informant interviews in western Uganda. Since southwest Uganda has seen an overall improvement in the prevalence of malaria over the past decade, it becomes an interesting area to understand both the implementation of prevention measures and as well as the barriers that contribute to prevalence.

The Hospital

Karoli Lwanga "Nyakibale" Hospital, located in the Rukungiri district in southwest Uganda, is a rural, private, nonprofit community hospital. The hospital has approximately 300 beds and provides emergency, medical, surgical, orthopedic, pediatric, and obstetric/gynecological services. This hospital has a catchment area of over 180,000 people, of whom roughly half are under age 20 years (Global Emergency Care, 2018).

Qualitative Methods

Key informant interviews were conducted with community health workers, nurses, malaria prevention outreach workers, practitioners including midwives, medical officers and emergency care practitioners, medical officer district team leaders, and WHO officials. These interviews were conducted to gain an understanding of the current malaria prevention strategies being used and to identify barriers that may hinder execution of these strategies. We searched for potential gaps between policy recommendations and current practice. We assessed community risk factors that may lead to ACT resistance in the future. A total of 17 interviews were performed at seven different facilities located in the districts of Masaka, Mpigi and in Kampala. The goal was to speak to a variety of key informants to gain different perspectives.

We interviewed a variety of key informants (Table 1 in Appendix 2) in western Uganda in February 2019 utilizing semi-structured interview questions (included in Appendix 1). We utilized an open coding system for qualitative analyses to describe the penetration of malaria preventative strategies in the community, identify challenges with the uptake of these preventative strategies, and identify solutions to close gaps between recommendations in the Malaria Control Strategy Policy and current practice within the communities of western Uganda.

Quantitative Analysis

Data were extracted from the records of all patient visits in the Nyakibale Hospital Emergency Department (ED) from 11/2009–12/2018 and analyzed using Stata 15.1 (Stata Corp, College Station, TX). Given only 2 months of data were available in 2009, this data was excluded. We assessed whether the implementation of public health measures was reflected in the ED burden of malaria. The major districts served by this hospital included Rukungiri, Ntungamo, Kanungu, Rakai, Mitooma, Mbarara, Masaka, and Mpigi among others. Nyakibale Hospital primarily used microscopy, rather than RDT's, to diagnosis malaria, thus slide-negative and slide-positive malaria were the outcome variables used to indicate the presence of malaria.

To assess trends in incidence of malaria over time, the data were stratified by three phases: baseline phase (1/2010–12/2013), the first intervention phase (1/2014–12/2017), and the second intervention phase (1/2018–12/2018). These phases were chosen based on results from our key informant interviewees who discussed the initiation of interventions at the start of these phases. In 2013, updated national guidelines called for the use of IPT in pregnant women and recommended that pregnant women receive at least two doses of sulfadoxine- pyramthamine (SP) during their pregnancy. The first intervention phase (1/2014–12/2017) occurred at the beginning of the universal distribution of LLINs, and the second intervention phase (1/2018–12/2018) coincided with guideline changes to increase the frequency of IPT in pregnant women (given monthly after week 13). There was some uncertainty among key informants of whether IRS was used in this area as well around 2013-2014 but these reports could not be confirmed. Pearson's chi squared analysis was used to assess for trends in incidence between the three phases.

In addition, we assessed trends in mortality secondary to malaria over time between 11/2009–12/ 2018. Pearson's chi squared analysis was used to identify differences in case fatality rate (CFR) between years. Relative risk reduction was analyzed (calculated by the absolute risk difference * number of patients/year * case fatality rate) between the baseline phase and first intervention phase and between the first and second intervention phases.

To identify a potential role for seasonal chemoprophylaxis in children, we assessed the results of malaria microscopy tests with respect to month to investigate seasonal variations in the incidence of malaria. Data extracted from patient records between 12/2010–12/2018 were grouped together by month. Once again, data from 11/2009-12/2009 when collection was started was excluded to avoid skewing the data towards the months of November and December. Pearson's chi squared analysis was used to identify differences between months.

Finally, with the recent concerns related to ACT resistance and the WHO guidelines of "test prior to treating", we assessed trends in prescribing patterns over time to determine whether providers from Nyakibale Hospital were following the "test prior to treatment" recommendations. We utilized chi squared analysis to assess the number of cases treated with a prescription for an anti-malarial medication despite having a negative microscopy test over time. We also used chi-squared analysis to assess the number of cases treated for malaria in patients who had not been tested for malaria to assess for trends over time.

Ethical Considerations

Prior to initiation, this research proposal was reviewed by the Institutional Review Board at the University of Connecticut and deemed to be exempt from review given no personal questions were asked of key informants and the quantitative data analyzed was previously de-identified.

<u>Results:</u>

Qualitative Results:

Malaria prevention strategies employed in western Uganda:

The following results are separated into community level responses and governmental level responses. The key informants contributing to the community level responses include members of village health teams, malaria outreach workers, nurses, midwives, medical officers, physicians and practitioners that practice in the community. Key informants contributing to the governmental level responses include district leaders and public health officials who worked for the WHO.

Community level:

The first prevention method noted by every key informant interviewed from the community was use of LLINs, which have been distributed by the government every two years since 2014. The majority of interviewees estimated that approximately 70% of community members use the LLINs.

IPT with sulfadoxine/pyrimethamine (SP) during pregnancy was the second most common prevention technique employed. Since December 2017, the Ugandan MOH has increased recommended frequency of IPT to monthly doses starting at 13 weeks. Compliance was not well known as key informant estimates ranged between 50–100% of pregnant females. IPT is also given monthly to patients with sickle cell disease, but compliance was not known by the key informants interviewed.

Other common prevention strategies utilized include community education, clearing around homes and rapid diagnosis/treatment. Teams of nurses and community health workers called “ready home teams” or “village health teams” are deployed in the villages to identify people who have fever. RDTs are used to test individuals with fever and, if positive, Artemether + Lumefantrine (the most common ACT used in this area) is given twice daily for three days. They also educate the community residents to present early to the health center with any signs of malaria for rapid diagnosis with microscopy or RDTs. In addition, they refer pregnant females to the clinics to receive the above-mentioned IPT as well as education directed at maintaining cleanliness in the area surrounding the homes. They recommend slashing bushes around the homes, keeping trash to a minimum, and clearing stagnant water by filling in holes and pouring motor oil over remaining stagnant water to kill mosquitos. They educate the community to close their doors at dusk and install wire mesh (screens) over the windows to keep mosquitos out of the home. Furthermore, community members build fires to create a layer of smoke around their homes and plant “Omuteete”, a citronella-like plant, to keep mosquitos away.

Strategies that have not been employed include IPT for school age children or seasonal chemoprophylaxis. In addition, there is little to no use of indoor residual insecticide spray in western Uganda. Two key informants reported that areas surrounding Rukungiri were sprayed between 2013-2014 but stopped. Key informants estimate 0–30% of households utilize IRS in their homes, but only if they can afford it. In addition, personal repellent use is very low, with estimated use between 0–20% of the population.

Governmental level

According to public health officials, the government has a variety of malaria prevention initiatives. The government level policies and guidelines are based on the

Uganda Malaria Reduction Strategic Plan 2014–2020, with the 2020 goal to reduce prevalence of malaria from 19% to 7%.

For integrated vector management, the “Indoor Residual Spraying Project” was initiated in 2009 in 11 Ugandan districts where prevalence is highest. Unfortunately, it was discontinued in 2014 due to lack of funding. However, when the mid-review of the Uganda Malaria Reduction Strategic Plan was performed in 2017, a resurgence of malaria was noted throughout the country, especially in the north. Therefore, the “Continued Indoor Residual Spraying Project” was re-initiated with spraying in another 15 districts starting in northern Uganda.

The use of larvacide is currently being piloted in three districts. Larvacide is a type of insecticide that targets larvae before they develop into adult mosquitos (EPA, 2016).

In 2016, surveillance was introduced as a core intervention as well as utilizing both epidemiologic data and the entomological surveillance (or EIR) described above. Entomologic training was conducted for 35 vector control officers in 23 districts. Although LLINs were distributed in 2014–2015, the first Universal Coverage Campaign was introduced in 2017, which called for 100% of households to own a LLIN. A total of 26.5 million LLINs have been distributed, and it was estimated that over 95% of households should own at least one net, but it is estimated that 70% of the population use them.

A majority of districts utilize Integrated Community Case Management with a goal of at least 90% of cases receiving prompt diagnosis and treatment. Efforts include education of practitioners and village health teams, quality control of diagnostic tests and ensuring availability of anti-malarial medications. They encourage the “test before treatment” policy as is recommended by the WHO.

A policy also exists to promote IPT during pregnancy. Prior to December of 2017, it was recommended that pregnant women receive at least three doses throughout their pregnancy but policy recommendations changed at this time recommending IPT be given monthly starting at week 13. In 2018, close to 70% of females received two or more doses of IPT during pregnancy, which was up from 57% in 2016 (MOH, 2019).

The Mass Action Against Malaria plan, recently approved by the President, is the newest initiative being employed, which uses high burden–high impact methods with a goal to reach every household in Uganda. It calls for malaria prevention accountability at multiple levels starting at the head of each household, village health teams, schools, parishes at health centers, sub-counties and finally up to the district level. Messages on key malaria prevention strategies are being publicized through village health teams, religious leaders, social media, television and radio. Information on malaria prevention is even being disseminated through music, theater and dance.

Key informants also noted strategies that have not been employed in Uganda. First, IPT has not been implemented for school-age children (5-15 years old), but this may be a possible strategy in the future. In addition, seasonal chemoprophylaxis is not used in Uganda because of the lack of clearly demarcated seasons as seen in other countries.

Barriers and challenges to malaria prevention strategies:

The key informants noted many challenges to the adoption of malaria prevention strategies in the community. Although the nets are typically distributed by the government free of charge, health workers reported supply chain issues as well as lack of funding for distribution once they are received. The nets were known to tear easily and could not be easily replaced at times. Although most families own a LLIN, due to sleeping arrangements, several members of the family are often left outside the net. Teenage males are the group noted to most often be left outside the nets, as they are supposed to be “tough”. In addition, community members stated they will not use the nets as they feel they are too hot, have an unpleasant odor, and make it difficult to breathe. Some community members will not use them because of concerns about being allergic to the permethrin treatment. Some community members distrust the intentions of the government in giving them free nets and believe they are targeting their capacity to reproduce. Also, most people sleep on the floor and when the nets are hung, they are often too short to reach the floor leaving gaps for mosquito entrance. On occasion, the nets are used for other purposes, such as keeping gardens or chickens enclosed or for fishing. Finally, the color of the nets has been a barrier to their use. For example, in 2017, the government distributed nets that were blue, which was the color associated with the Forum for Democratic Change political party, and those against the party would not utilize the nets.

Key informants noted several barriers for IPT use in pregnant females and patients with sickle cell disease. First, many patients have difficulty obtaining transportation to the clinics for monthly prophylaxis. Second, many are allergic to sulfa drugs and SP, the medication used, is a sulfa derivative. In addition, with the recent change in policy to expand the number of prophylactic doses given in pregnancy, clinics have run out of SP, especially at the year’s end. Finally, several nurses noted that if not directly observed, many patients will not take the medication as they distrust the reasons they are being given the medication.

Although the WHO recommends the use of indoor residual insecticide spray in conjunction with LLINs as part of integrated vector management, cost of the spray is a substantial barrier, leaving much of the country without this prevention strategy. According to key informants in the government, indoor residual spray helped reduce the overall prevalence of malaria in the country after it was performed between 2009–2014. However, funding ran out, followed by a resurgence of malaria.

There are several barriers with regard to the use of rapid diagnosis and treatment. Although there is typically a good supply chain for RDTs, microscopy is more difficult as it requires trained laboratory technicians, which are in short supply. Additionally, most clinics lack power, and the microscope can only be used with natural sunlight on a bright day that is not cloudy or rainy.

Many community members might delay seeking care or attempt self-treatment with over-the-counter or expired anti-malarial medications. It was reported that some community members believe that their body will fight off the malaria and they do not need medications to get better.

According to public health officials, providers still do not always follow “test and treat” policy, particularly among private providers. Retention of providers trained about malaria guidelines was reported to be an issue, thus requiring training to be almost continuous.

Key informants stated that it is difficult to obtain reliable and valid data resulting in inaccurate incidence reporting. Surveillance data, including community environmental indicators, which could be important in developing solutions, were lacking.

Educating the community comes with its own challenges. Although there is an abundance of written materials on malaria, it is not translated into all of the local languages, which is problematic as over 40 different languages are spoken in Uganda. Village health teams provide the primary mode of distributing education in the community, however, these important groups are underfunded. Not only has there been a decline in the number of village health teams, but money for training and materials has been reduced, as well.

Community residents found it difficult to follow environmental prevention recommendations such as using smoke to keep the mosquitos away, closing doors and windows at dusk and reducing stagnant water. The smoke causes poor air quality making it difficult to breathe. Uganda also has a hot climate, with average temperatures in the 90s during the dry season, which is a barrier to closing windows and doors. Furthermore, the prevention strategy employing pouring motor oil on stagnant water is an environmental pollutant and can cause harm to wildlife and humans alike.

Threats to ACT Resistance

The community key informant interviews revealed several threats to the potential risk of ACT resistance. They estimated that 10–20% of malaria patients fail to complete their entire treatment regimen. When patients start to feel better (usually at treatment Day 2), they typically stop taking the drug and may save the pills for future use if they again develop a fever. This early cessation leads to a second problem in that community members might self-treat or provide medication to their family members if they develop a fever without obtaining a diagnostic test, sometimes using expired medication from a previously half-treated course. Thirdly, ACT medications are sold over-the-counter at local drug stores. One key informant said that community residents often either over- or under-dose themselves when they self-prescribe. Finally, some practitioners noted that even with a negative RDT or microscopy test, if a patient has clinical signs of malaria and no other obvious source of infection, they will treat with both anti-malarial medications and antibiotics until the test can be repeated.

The Therapeutic Efficacy Study (TES) is a technique designed by the WHO to evaluate the use of antimalarial drugs and determine local resistance. Patients with diagnosis of malaria are given medication under supervised conditions and results of microscopy are assessed at days 28 and 42 to assess for relapse (WHO, 2018). According to governmental level key informants, TES was conducted in Uganda between 2013–2014 using the WHO protocol and found no signs of ACT resistance. Another study is currently in process.

Quantitative Results:

a. Trends in incidence of malaria

The total number of ED patients seen at Nyakibale Hospital in the baseline phase (01/2010–12/2013) was 20,303 patients. Of these, 19.5% [95%CI 18.9–20.0] had a positive microscopy slide for malaria. The total number of ED patients seen in the first intervention period (1/2014–12/2017) was 21,943. Of these, 8.57% [95%CI 8.20–8.94] had a positive slide during this time period. The total number of patients seen in the ED in the second intervention phase (1/2018–12/2018) was 5,186. Of these, 1.95% [95%CI

1.57–2.32] had a positive slide for malaria during this time period. Overall, these data showed a significant reduction in case rates over time [$p < 0.001$].

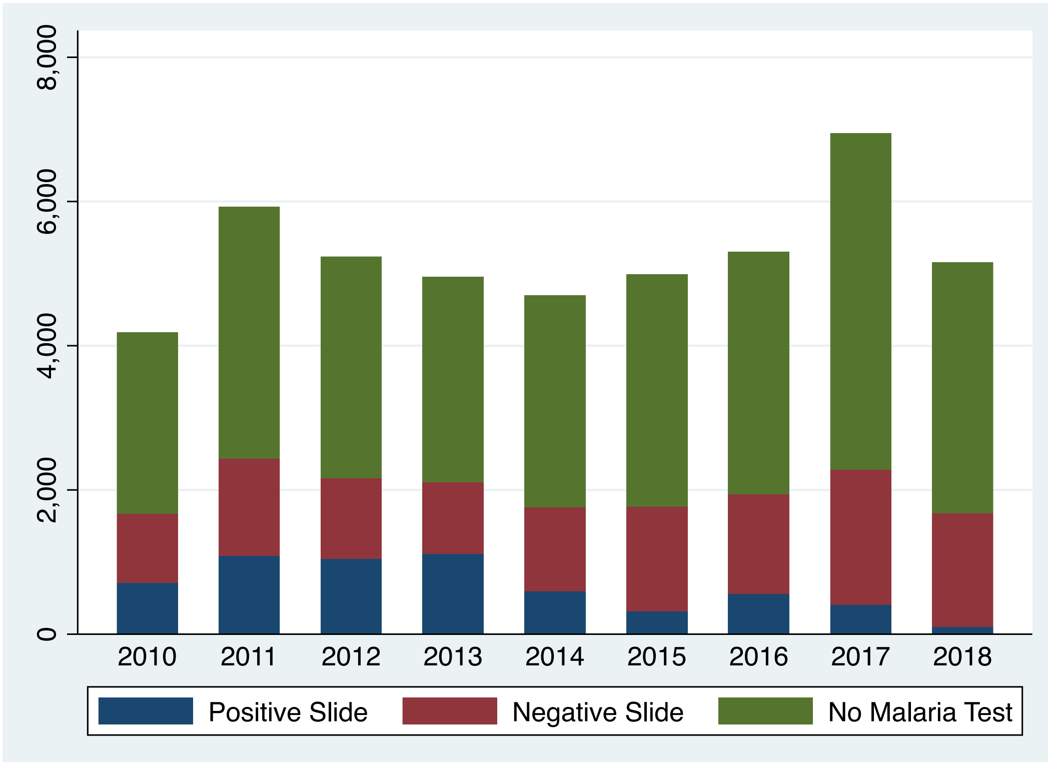

Figure 1: Total numbers of annual malaria cases in the emergency department by year (1/2010–12/2018)

b. Trends in mortality

The CFR for a positive malaria slide by year on average was found to be 2.89% [95%CI 2.47–3.31]. Although significant differences occurred amongst years ($p=0.024$), there was no consistent trend in the CFR changes (See Figure 2 below); thus, the mean CFR was used for mortality calculations.

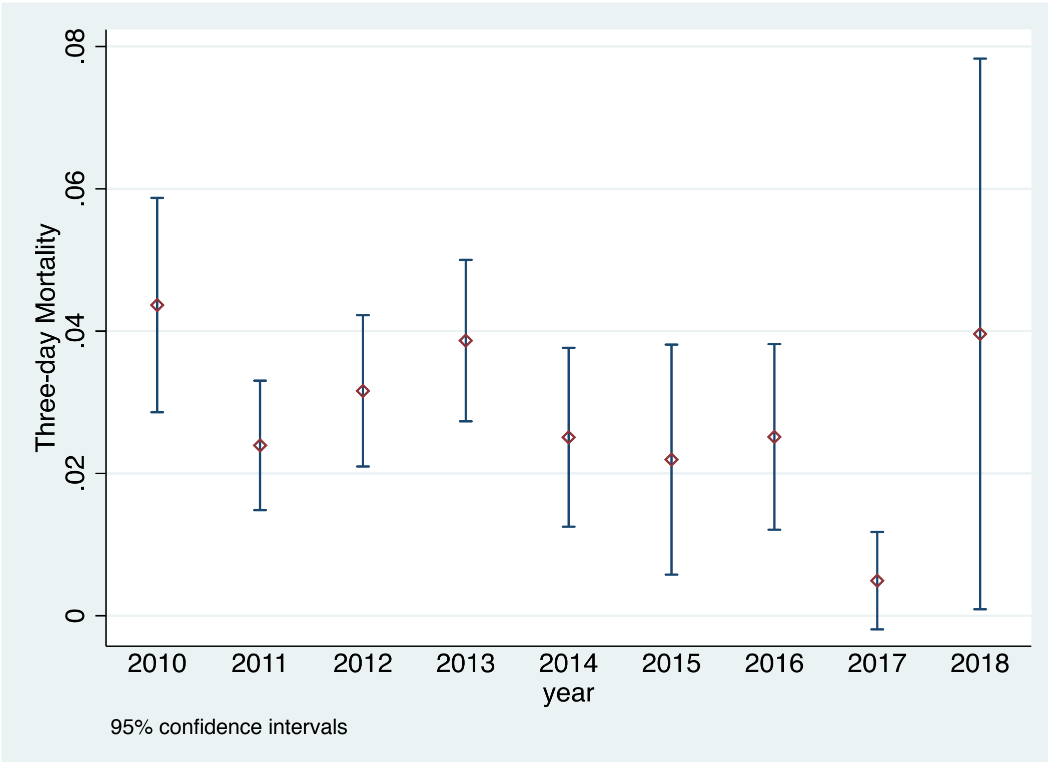

Figure 2: Three-day mortality for malaria cases by year (1/2010–12/2018)

The relative risk ratio for being diagnosed with malaria between the baseline phase and the first intervention phase was 0.44 (p<0.001). This relative risk reduction equates to roughly 606 cases of malaria and 17 malaria deaths averted per year during the first intervention phase.

The relative risk ratio for being diagnosed with malaria between the first and second intervention periods was 0.23 (an absolute risk difference of -6.61%, p<0.001). This relative risk reduction equates to roughly 343 cases of malaria and 10 malaria deaths averted per year during the second intervention phase.

c. Trends with respect to season

The total number of malaria cases in 1/2010–12/2018 were combined and stratified by month to assess trends in malaria by season. Average malaria incidence was 494 confirmed cases per month, and varied significantly by month. When all years were combined, the highest monthly incidence was found to be in January and the lowest was in September (Chisq = 84.08; $p<0.001$).

By looking at total cases combined across all years (Figure 3), there is evidence that the burden of malaria cases displays a seasonal component. The highest numbers of cases were diagnosed between October–January, with a smaller peak from June–August. The lowest numbers of cases were noted in February–March, with another relative dip in total cases in September.

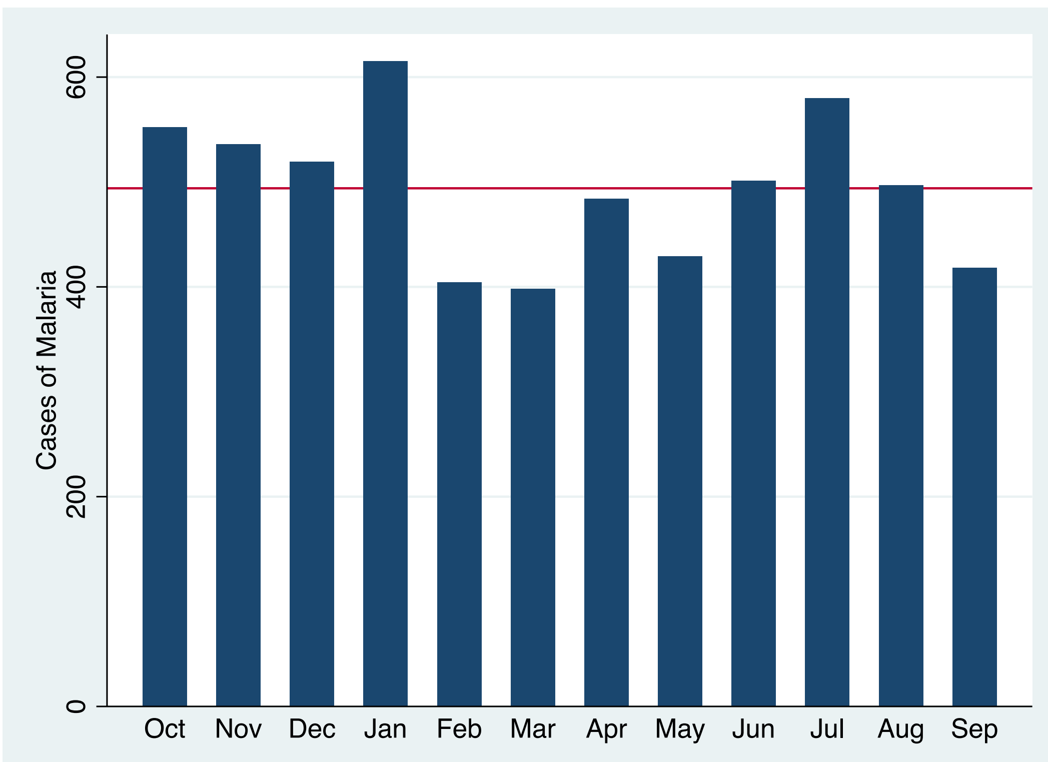

Figure 3: Cases of malaria by month (combining data from 1/2010-12/2018)

d. Trends in prescribing patterns

The data showed a significant reduction in provider-issued prescriptions to patients with slide-negative malaria over time; initial rates of 11.2% in 2010 decreased to current rates of 6.7% in 2018 [Chisq =63.5789; p<0.001] (Figure 4).

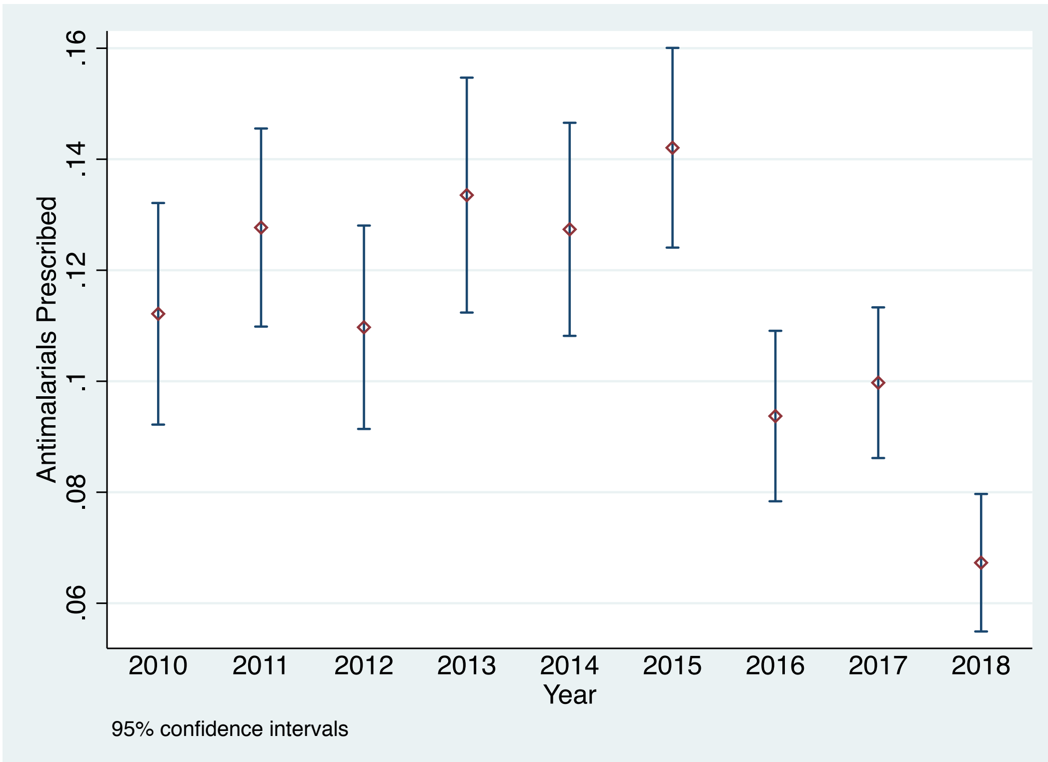

Figure 4: Treatment of patients with anti-malarial medications with negative malaria slide

The data also showed a significant reduction of provider-issued prescriptions to treat patients without first obtaining a malaria test (Figure 5); the rates decreased from 3.6% in 2010 to 1.4% in 2018 [Chisq =83.0151; P <0.001].

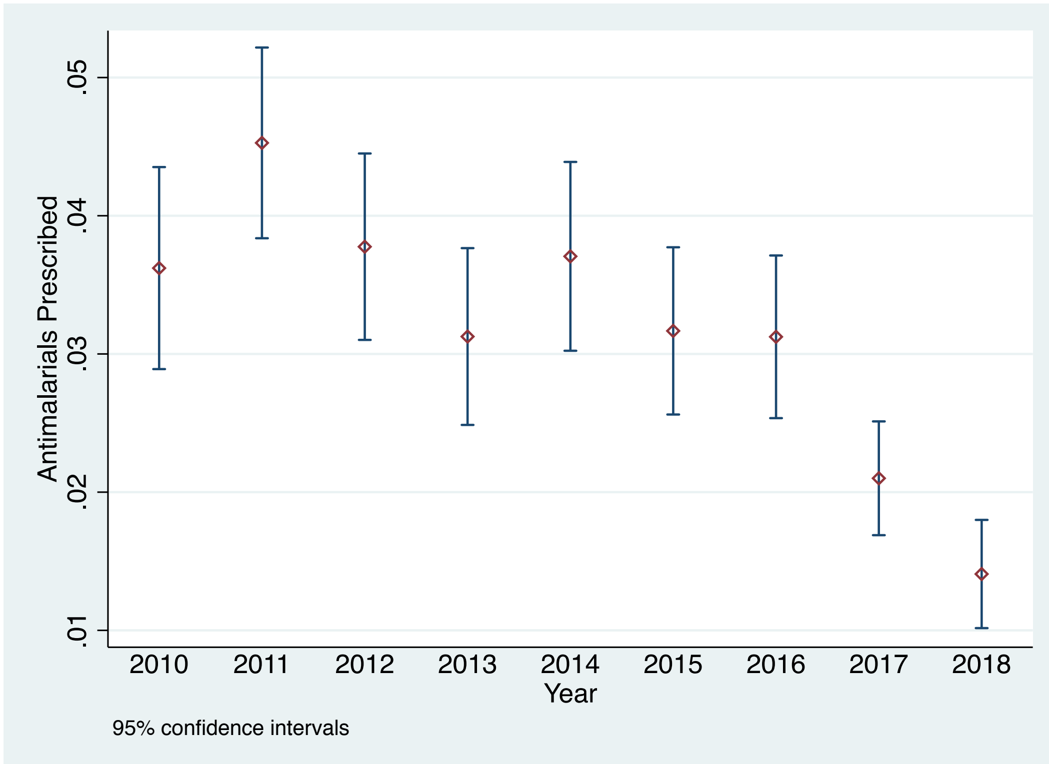

Figure 5: Treatment of patients with anti-malaria medications without testing

Bridging the Gaps between Policy and Practice

Finally, it is important to identify and describe the innovative solutions district leaders have taken in areas with a declining malaria prevalence. These observations can be valuable to other communities around the world dealing with similar challenges.

One important solution that has been implemented has been establishing mechanisms for communication between health care providers and public health officials. Providers in the district of Mpigi, for example, are enrolled in a Short Messaging Service (SMS) system. When there are data quality issues, spikes in malaria incidence, inappropriate treatment or other issues, a message is sent through the system to the provider. In addition, if the district notes an issue in the supply chain of medications, RDT's or other supplies, they can message each health center to obtain data about current stocks and redistribute them strategically. In addition, quarterly meetings with village health teams and providers from health centers have been implemented for education and distribution of prevention material.

Areas with poor malaria indicators are visited regularly to discuss community use of prevention strategies. Public health officials have targeted and educated local council leaders who are elected and well respected in the villages to spread the message of malaria prevention. Key informants said that misuse or repurposing of LLINs is no longer being tolerated. In fact, in one area interviewed, misuse of nets has become illegal. In addition, key informants reported new promotion strategies using musicals to spread messages on malaria prevention, quarterly bulletins with performance data and community competitions for “malaria smart households”.

Discussion

Uganda has made major headway in the implementation of malaria prevention strategies in the community, with a remarkable reduction in malaria from 42% in 2009 to 19% in 2019 (Uganda MOH, 2019). Understanding current challenges and barriers facing both the government and local communities in their implementation of malaria prevention strategies is critical to devising suitable solutions to combat malaria.

According to key informants, major malaria prevention strategies used in Uganda include promotion of rapid diagnosis and treatment, use of village health teams and healthcare workers for malaria prevention education, IPT for pregnant women and patients with HIV and Sickle Cell Disease, distribution of LLIN’s, use of IRS and promotion of environmental cleanliness.

A summary of the major barriers was lack of funding to support village health teams and IRS, inaccurate and missing surveillance data, failure of distribution of educational material in the local language, and misuse of prevention strategies in the community. In addition, lack of adherence by community members to prevention and treatment guidelines continues to remain a major barrier, including presenting early to a clinic at the onset of fever, failure to use prevention methods in their homes and not completing the full course of ACT.

Retrospective analyses of de-identified data obtained from the Nyakibale Hospital ED between 2010 and 2018 showed a marked reduction in positive cases between 2013 and 2014. This correlates to the year the national guidelines were changed to treat pregnant women with at least doses of SP (IPT) during pregnancy. In addition, in 2014, the universal coverage campaign began to distribute long lasting insecticide treated nets throughout the country. While we found no significant trends in case fatality rate over time, the significant reduction in cases seen in the ED (relative risk ratio = 0.44, $p<0.001$) between the baseline (1/2010–12/2013) and first intervention phase (1/2014–12/2017) meant that an estimated 606 cases of malaria and 17 malaria deaths were averted per year. Additionally, the second intervention phase (01/2018 – 12/2018) was seen to further reduce the relative risk of malaria (relative risk ratio = 0.23, $p<0.001$) when compared to the reduced risk in the first intervention phase, and an additional 343 cases of malaria and 10 malaria deaths were averted in the year 2018.

Our data showed a significant difference with respect to season. The burden of malaria cases displayed a significant seasonal component, with the highest number of cases diagnosed between November and January. This result is likely related to the dichotomy between the rainy and dry seasons. Uganda has two rainy seasons, one from April to May and one from September to November. September marks the onset of the rainy season in which rapid reproduction and resurgence of the mosquito population occurs leading to a rise in the incidence of malaria seen in the fall and winter. Uganda does not currently employ the use of seasonal chemoprophylaxis in children, as is done in other countries. Our results suggest this strategy may be a valuable prevention strategy.

Finally, key informant interviews revealed several threats to the potential risk of ACT resistance, including provider treatment of slide-negative malaria or treatment without being tested, patient failure to compete treatment regimen, and self-treatment with ACT medications bought over the counter. Despite these reports, the results of our quantitative analyses revealed a significant reduction of provider treatment of slide-negative malaria and presumptive treatment of malaria without testing at Nyakibale Hospital.

Future Recommendations:

Based on these findings, we make the following future recommendations in combatting malaria in Uganda. First, we recommend more frequent distribution of LLINs, of neutral color, to prevent the use of old nets and to assure that all family members have access to their own net. We recommend distribution of educational material regarding proper use and reason for use of LLIN’s in the local language in conjunction with the nets. Second, we recommend continued education for providers through quarterly meetings. These meetings could also be used to distribute educational materials, LLIN’s, RDT’s, and medications from the district leadership to the local healthcare facilities taking out the need for additional funding for transport of these goods. Third, we recommend investing in indoor residual spraying with both insecticide and larvacide to be done in all areas of Uganda. Fourth, entomologic evaluation to assess for infectivity and for mosquito resistance to the insecticide should be performed regularly. Fifth, we recommend monitoring of providers to assure the practice of the "test before treat" recommendations to prevent misuse of anti-malarial medications that might increase the risk of resistance in sub-Saharan Africa, as currently seen in Asia (Nkumama, 2017). Continued regular communication to address challenges to malaria prevention should be maintained among village health teams, health centers, subcounties and district medical leaders, with supporting regular visits from governmental actors and implementing partners. We also recommend the consideration of seasonal chemoprophylaxis in children in highly endemic areas during the months of November through January. Finally, we recommend malaria education delivery to the community be done in more modern ways. For example, given the fact that many community members own smartphones, distribution of prevention messages through radio, television, billboards, and social medial utilizing Facebook, Instagram, and what's-app may have more utility. In addition, other creative ways to disseminate information about malaria prevention could be used through theater, dance and popular music.

Limitations:

There were several limitations to this study. First, the key informant interviews could only be conducted in western Uganda. It would have been helpful to compare these findings to the perceived barriers in communities in northern Uganda where the prevalence of malaria is higher. Second, key informants, although they were knowledgeable about malaria prevention throughout the entire country, were only interviewed in Kampala, Mpigi and Masaka. The quantitative data was obtained from an ED in Rukungiri district, located several hours from where key informants were interviewed. In addition, this study would have more depth if a larger number of district health officers could be sampled as they play a major role in development of new ideas for prevention material distribution and education. Finally, comparing districts according to statistics regarding malaria prevalence would be valuable but these data were not able to be obtained for this study. Despite these major limitations, documenting the challenges and solutions to the implementation of malaria prevention strategies in these few districts may help other communities overcome similar barriers.

Future Research:

We also recommend that further research be performed. The risks and benefits of eliminating the availability of over-the-counter anti-malarial medications should be investigated. While eliminating this availability may reduce the risk of ACT resistance, it might lead to unintended consequences of causing a resurgence of malaria cases in populations with limited access to medical care.

In addition, further studies are needed on use of IPT and seasonal chemoprophylaxis in school-aged children. Staedke et al. (2018) reported that the use of IPT in children in Jinja, Uganda may have had a role in reducing the prevalence of malaria. However, data was only significant for children between the ages of 5–15 years old with the malaria prevalence from 32.8% in the control group compared to 24.9% in the intervention group. No significant difference was found in those younger than five or older than fifteen years old. In addition, the authors found no difference in parasitemia in the intervention and control communities, measuring 5.1 and 5.3%, respectively (Staedke, 2018). The potential benefits of IPT should be compared with the risk of increasing anti-malarial resistance to thoroughly consider the costs and benefits of this strategy.

Appendix 1
Interview Questions

Public Health Officials

- Describe the public health measures put into place to reduce the prevalence of malaria?
- When were the policies developed and initiated?
- Do you feel the communities have adopted these measures? When do you think this occurred?
- How does surveillance work to see if these policies are making a difference in prevalence of malaria?
- What percentage of the population is estimated to have LLIN's?
- What percentage of pregnant and lactating females are receiving prophylactic malaria treatment?
- What areas are utilizing seasonal chemoprophylaxis against malaria?
- Do you have any additional comments on the topic?
- How do you feel about outcomes of delivery?

District Medical Officers

- What local public health measures have been taken to reduce the prevalence of malaria?
    - When were these public health measures implemented in your district?
    - How has this been done? (How do you bridge the gap between the policies recommended by the government and the local community)?
    - What barriers or challenges have you found with bridging this gap?
- Have the communities you serve have adopted the following preventative strategies?
    - Use of long-lasting insecticide treated nets
    - Integrated Vector Management: including both use of insecticide treated nets and indoor residual insecticide spray
    - Seasonal chemoprophylaxis for malaria
    - Intermittent preventative treatment (IPT) for pregnant females? Children?
- Do you feel there is widespread adoption in your area? How has the community reacted to these measures?
- How do you measure the outcomes of these preventative measures?
- What are some of the challenges with the uptake of these preventative strategies in the community?
- With emerging ACT resistance in other areas of the world, do you feel like providers are following the "test before treat" guidelines to reduce the amount of over-prescribing of anti-malarial medications?
    - Do you monitor prescribers for this?
    - What threats to ACT resistance have you noted?
- Any additional comments on the topic?

Practitioners

- What local public health measures have been taken to reduce the prevalence of malaria?
- When were these public health measures implemented locally?
- How has this been done?
- Do you feel there is widespread adoption in your area? How has the community reacted to these measures?
- Have you identified any challenges or barriers in the community to use of these prevention methods?
- What percentage of the community uses long lasting insecticide treated nets?
- How often is indoor residual spraying insecticide used?
- How do you measure the outcomes of these preventative measures?
- Are there regions that you feel have not fully adopted these measures?
- With emerging ACT resistance in other areas of the world, is there a "test before treat" policy to reduce the amount of over-prescribing of anti-malarial medications?
- Do you have any additional comments on the topic?

Community Health Workers:

- What local public health measures have been taken to reduce the prevalence of malaria?
- When were these public health measures implemented locally?
- How has this been done?
- Do you feel there is widespread adoption in your area? How has the community reacted to these measures?
- What challenges or barriers have you found to their adoption of these methods?
- What percentage of the community uses long lasting insecticide treated nets?
- How often is indoor residual spraying insecticide used?
- Do community members sell or use their insecticide treated nets in other ways?
- Do you have any additional comments on the topic?

Appendix 2

Demographics of Key Informants	
Positions	Nurse/ Community health workers on village health teams- 7 Malaria prevention outreach workers- 1 Practitioners: midwives, medical officers and emergency care practitioners- 6 District Medical officer-1 WHO officers-2
Gender	7 Male 10 Female
Facilities	Masaka Referral Hospital Bukeeri Health Center III Buwungu health center II Kitabaazi Health Center II Malaria Action Programme for district office Plot 18, Matuba, Katwe, Butego, Masaka WHO office- Kampala Mpigi District Medical Office

Table 1: Key Informant Demographics (February, 2019)

Malaria Prevention Strategy	Community Adoption	Barriers and Challenges to this Prevention Strategy
Long Lasting Insecticide Treated nets (LLINs)	Majority of key informants estimated 70% coverage (although estimates range between 35-80%) They are free/ distributed from the government every 2 years (2014,2016,2018)	•Supply chain issues •Tear easily, get old and not replaced frequently •Not used correctly (ie. most people sleep on the floor and when hung, the nets do not reach the floors. Some people do not sleep under them and believe that just hanging them will keep the mosquitos away) •Allergy to permethrin treatment •Itchy/ scratchy •Color of nets (2 years ago distributed blue nets which is associated with (Forum for Democratic Change, or FDC political party) •People feel they suffocate under the nets. •People get too hot under the nets. •Each family only typically has 1- so depending on sleeping arrangements many in the family do not get to use (usually give to younger children and typically leaving out teenage boys because they should be "tough") •Cannot stand smell of the nets •Nets are misused (ie. keeping chickens fenced in, fencing in gardens, fishing, selling)
Indoor Residual Insecticide Spraying (IRS)	In general, this is not done in this area except in boarding schools because they do not allow insecticide treated nets. Key informants estimated between 0- 30% of homes use IRS	Expensive, only being used in northern and eastern Uganda where there are epidemic levels of malaria
Intermittent preventive treatment: pregnant women	Use sulfadoxine- pyramthamine (SP)- Starts at 13-20 weeks and given monthly in most areas. This guideline changed last year.	Many pregnant women have difficulty obtaining transportation to the clinics for their prophylaxis.

	Before that they were giving 3 doses during pregnancy. Key informants estimated between 50-100% compliance	Many are allergic to Sulfa If not directly observed, they will not take the medication.
Intermittent preventive treatment: seasonal or in special populations (children under 5, patients with HIV, or Sickle cell disease)	Sickle cell patients are given chemoprophylaxis (SP or chloroquine) monthly. Children are not given chemoprophylaxis but in most communities, they are given an insecticide treated net at their DPT vaccination. There is no seasonal chemoprophylaxis done here.	Many are allergic to Sulfa
Individual use of insecticide/ repellant	Approximately 10-20% use	Expensive
Rapid diagnosis	Rapid diagnostic tests and microscopy used. In general, centers have good supply of RDT's	Lack of power- can only use microscopy by natural light and if it is cloudy or dark cannot use microscopy. Lack of technicians to use microscopy Delays in seeking treatment: Key informants note patients take 2-3 days to present after onset of fever. (ie. transportation issues, they feel they can get through it without medication even if they have malaria so they do not get tested)
Treatment with ACT: (mostly Artemether + Lumefantrine used)	All communities using ACT's for treatment (twice daily for 3 days). Most follow "test before treat" policy but estimates between 0-40% patients with clinical symptoms of malaria are given antimalarial medications with antibiotics with a negative RDT or microscopy test with clinical signs of malaria. This medication tastes good.	Although it is a short course most people will take only 2 days of their medications because they stop when they begin to feel better. People will use leftover anti-malarial medications when they or a family member spike a fever People are able to buy these medications at drug stores on their own so many take them as soon as they get a fever before being tested for malaria. Some do not believe they need treatment for malaria and it will "go away on its own"
Education and screening within the community-using" Village Health Teams" or "Ready Home Teams" which consist of nurses and community health workers.	"Group discussions" are done in the villages to educate Will go to homes and screen febrile children with rapid diagnostic tests and if positive, will treat.	Many do not follow advice Due to lack of funding, there are less teams available
Slashing bushes to reduce population of mosquitos near homes and planting (Omuteete or Teete) which is a citronella plant.		Many do not follow advice
Reducing stagnant water to reduce breeding ground •Reduce bottles/ other trash that can hold stagnant water		Many do not follow advice Environmentally unfriendly

•Pour motor oil on stagnant water to suffocate mosquitos		
•Closing doors and windows before dusk (5 pm) and use of wire mesh on windows to keep mosquitos out		Hot climate
•Use of smoke/ fires around homes to decrease mosquitos		Poor air quality

Table 2: Prevention strategies, community adoption and barriers based on community key informant interviews from the community (February 2019).

Malaria Prevention Strategy	Community Adoption	Barriers and Challenges to this Prevention Strategy
Distribution of long-lasting insecticide-treated nets (LLINs)	98% of households own at least 1 net	Main challenge is getting people to use them due to: • misconceptions of the intentions of the government to give free LLINS, believing the government is targeting reproduction capacity by surrounding them with insecticide. • misuse of LLINs • Limited funding for LLIN distribution
Indoor residual spraying	Performed in northern Uganda where there are epidemic levels of malaria • 11 districts during 2009–2014 • 15 districts since 2017	Expensive
Integrated Community Case Management: goals of early diagnosis and treatment (test and treat policy) with proper medications to reduce the time parasite is in the reservoir.	96 out of 127 districts utilize ICCM. 60% reduction in treating presumed malaria cases that were not treated 18% increase in treatment of slide-negative cases.	Private providers have had challenges adopting the test before treatment policy- they will give suboptimal treatment, use the wrong medications, treat without testing and treat negative tests. Community members do not present to health centers early enough to obtain test. Some inappropriately treat themselves with over the counter anti-malarial or old medications without being tested.
Education	Education of community members through Village Health Teams. Education on "test and treat" policy for private/public practitioners.	Many of the materials are only in English and not the local languages. Funding for Village Health teams have run low resulting in fewer teams in the communities and less ability to have quarterly meetings to distribute new material and educate the VHT's. Difficult to keep up with the 'test and treat' training as there is a high turnover of providers.
Surveillance: epidemiologic and entomologic	Surveillance is done at each level- from the village (through village health teams), parishes and subcounties (through health center data) and districts on a weekly basis. If there are areas with poor indicators or a spike in malaria, the health center is contacted and is visited. Entomologic training was conducted for 35 "vector control officers" in 23 districts.	Data Quality issues (skewed or incorrect data reported). Village Health Teams only report diagnosis and treatment. No reported data on environmental prevention methods.

IPT for high risk population	This is done for pregnant females, not for children. Close to 70% of females received two or more doses of IPT in pregnancy 2017-2018.	Inefficient supply of SP after recent recommendations change to increase prophylaxis in pregnant females to be given monthly after 13 weeks.
Seasonal chemoprophylaxis	Not done.	No clearly demarcated seasonal component to spikes in malaria prevalence.
Mass Action Against Malaria	Initiated in 2018- adoption currently.	Too early in implementation.

Table 3: Prevention strategies, community adoption and barriers based on government key informant interviews (February, 2019)

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