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Resistance to Artemisinin-based Combination Therapies in Uganda: An Impending Threat

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Abstract

Plasmodium falciparum malaria is one of the most significant causes of morbidity and mortality in tropical Africa. Chloroquine phosphate emerged as the revolutionary drug of choice for the prevention and treatment of malaria, pushing the previously administered quinine to the sidelines. However, since the 1970s, sensitivity to chloroquine has been on the decline. In response to this, health professionals began to turn to a different drug: artemisinin-based combination therapies (ACT). ACT is now accepted by the World Health Organisation (WHO) as the most effective strategy to treat Plasmodium falciparum malaria, despite some initial misgivings (their long-term usefulness has yet to be determined). In this light, based on a few tentative studies conducted since 2003, the WHO has established an emerging, yet noticeable, trend in growing resistance to ACT drugs. Although, at this moment, there is no hard evidence of any ACT resistance within the Ugandan population, this paper will explore, through published and unpublished sources, and a baseline survey conducted in July 2008 by AMREF (African Medical and Research Foundation, an international medical organisation based in Kenya), how this resistance will soon emerge in Uganda, what the precipitating factors are, and through a careful evaluation of these causes, offer courses of action so as avoid the devastating consequences of ACT resistance.

Author's Note

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Keywords: malaria, resistance, artemisinin-based combination therapy, anti-malarial drugs, tropical medicine, disaster planning.

1. Introduction

Plasmodium falciparum malaria is one of the most significant causes of morbidity and mortality in tropical Africa. The discovery of chloroquine phosphate was revolutionary for the prevention and treatment of malaria, pushing the previously administered quinine to the sidelines. It has been the drug of choice for several decades, thanks to its inhibition of parasite development in the blood. However, since the 1970s, sensitivity to the chloroquine has been on the decline, and resistance to anti-malaria drugs is now proving a major and challenging problem in most affected parts of the world. This emergence of chloroquine resistance has been

associated with recent surges in malaria mortality in several regions of the world; in fact, now, almost every malaria-susceptible country is reporting partial to full chloroquine resistance, with huge implications for its susceptible populace (World Hwalth Organization (WHO), 2006).

In response to this, health professionals began to turn to a different drug: artemisinin-based combination therapies (ACT). The World Health Organisation (WHO) now recommends ACT as the most effective strategy to treat *Plasmodium falciparum* malaria, despite some initial misgivings (their long-term usefulness has yet to be determined). In this light, based on a few tentative studies conducted since 2003, the WHO has established an emerging, yet noticeable, trend in growing resistance to ACT drugs. This worrying claim could have many implications for the vulnerable population in tropical Africa, and Uganda specifically, where the incidence remains high, the infrastructure lacking, and the manpower small. Although, at this moment, there is no hard evidence of any ACT resistance within the Ugandan population, this paper will explore, through published and unpublished sources, and a baseline survey conducted in July 2008 by AMREF (African Medical and Research Foundation, an international medical organisation based in Kenya), how this resistance will soon emerge in Uganda, what the precipitating factors are, and through a careful evaluation of these causes, offer courses of action so as avoid the devastating consequences of ACT resistance. First, I will offer background on ACT and its extensive use; then, I shall outline the Ugandan malarial profile, considering the burden of disease, the particularities of resource management and cultural climate that would foster the emergence of antibiotic resistance. Finally, I will discuss how state efforts to educate the population are fruitless in the face of a crippled infrastructure, and argue for health sector refurbishment and re-equipment as priorities in addressing the impending health crisis of ACT resistance.

2. Background

Plasmodium falciparum malaria is one of the most significant causes of morbidity and mortality in tropical Africa. The WHO estimates that the parasite is responsible for 1.4-2.6 million deaths per annum, as well as 270-480 million clinical attacks. Chloroquine-resistant strains of *P. falciparum* were first observed in 1978 in East Africa and, within 10 years, similar strains had been reported in all tropical African countries, resistant to chloroquine, sulfadoxine-pyrimethamine and amodiaquine (conventional antimalarial drugs), amongst others. In response to this resistance and the health threats it entails, artemisinin-based combination therapies (ACT, derived from the plant *Artemisia annua* – sweet wormwood) were deployed on a large scale, after being strongly recommended by the WHO, and are gradually replacing obsolete drugs in malaria-resistant areas. To the medical and public health world, these compounds appear to be the wonder-drugs: they are well tolerated by patients, and could cure *falciparum* malaria in 3-7 days by reducing gametocyte carriage, thus diminishing malaria transmission. The WHO estimated that 120 million ACT treatments would be needed globally annually. It is so far, undoubtedly, the most effective and modern drug approved by FDA and on market (WHO, 2006).

The possibility of ACT resistant strains of *P. falciparum* would have devastating consequences for millions of lives in dozens of countries. Establishing

whether this is a potential outcome is of crucial importance to the medical and public health world. There has been some research into the matter, the most noteworthy of which was conducted by the WHO in 2007. They hoped to ascertain whether there is prevalence of ACT resistance, or strong indicators to the prospect of it, by conducting a clinical trial in the Thai-Cambodian border region. Its results showed that there is a noticeable trend, albeit in its very beginnings, and that this possibility will become reality (WHO: *Report Of A Meeting On Containment Of Artemisinin Tolerance*, 2008).

This paper will spotlight the risk of emerging artemisinin resistance in Uganda, a tropical sub-Saharan country that experiences intense perennial malaria transmission over 95% of the landmass, and where it accounts for 39-44% of outpatient presence, and 20% of inpatient mortality (AMREF-Uganda: Malaria, AIDS and TB (MAT) Integrated Model Baseline Study, 2008). The Ugandan Ministry of Health estimates that malaria causes between 70,000 and 100,000 fatalities per annum, the majority of which are children. The indirect and direct costs of malaria are high, as poor households spend an estimated 25% of their monthly income on malaria-related care (Ministry of Health, Uganda, 2003). Although Uganda has developed a policy for integrated malaria, HIV/AIDS and TB management, it is poorly implemented, exacerbated by several budgetary limitations, inadequate infrastructure and equipment and a healthcare workforce crisis. The Ugandan districts of Luwero and Kiboga, which this paper will focus on, have been part of the country's disease management initiatives, but with slow progress: the massive nation-wide campaigns for Insecticide Treated Nets (ITNs) and Intermittent Preventative Treatment in pregnancy (IPTp) have yielded low results; 54% of pregnant women currently receive the recommended 2 doses of Sp/Fansidar for IPTp, whilst the national target is 80%; finally, only 62% of symptomatic children under 5 years old access the antimalaria treatment they need within 24 hours of fever, and instead rely first on home-based care of fever (MAT Baseline Study, 2008).

Despite the WHO carrying out their study on the Thai-Cambodian border, I deem the examination of ACT resistance in Uganda to be a relevant course of action. It should be noted that both regions have experienced significant population movements, a risk factor for the spread of malaria resistance: approximately 200 000 people cross from Cambodia into Thailand on average per annum, and in Uganda, civil conflict forced 2 million people into Internally Displaced Persons, or IDP, camps – 1 million have returned home since. In terms of demographics, Uganda has less successful statistics on most levels than both Cambodia and Thailand (life expectancy, under-5 mortality, GNI/capita, ITN use, etc.) – if Uganda is at a relatively less developed stage than the other 2 countries, with a much faster growing population (Uganda's fertility rate is 6.6, whereas Thailand and Cambodia are at 1.8 and 3.3, respectively (UNICEF, 2006)), the need to study ACT resistance is Uganda is just as valid and pressing, because of its rapidly expanding population.

In Uganda, the landmass is divided into 80 districts; each district is progressively divided into sub-districts, counties, sub-counties, parishes and villages. There are typically 1-4 villages per parish. Health centres are graded as Health Centres II, III IV, with each being more equipped than the last; each serves a parish, a sub-county and a sub-district, in that order (*Special Programme For Research And Training In Tropical Diseases, 2006).*

3. Status Quo in Luwero and Kiboga

A baseline survey conducted by AMREF-Uganda in June/July 2008 sought to establish awareness, treatment practices and behaviour patterns associated with malaria of local Ugandans living in the districts of Luwero and Kiboga. The research team compiled a table of results, the most pertinent of which are listed here:

HOUSEHOLD KNOWLEDGE, ATTITUDE AND PRACTICE

KAP	Kiboga	Luwero	MEAN
Nº of ITNs in household	0.92	1.1	1.01
% ITNs in good condition	56	66	61
Ratio of number of persons to one ITN	6.6:1	5.5:1	6.05:1
% recognise ITNs as best protection	95	98.6	97
% of population without ITNs	54	56	55
% knowledge of mosquitoes as vector of malaria	96	83	90
% knowledge of breeding grounds for mosquitoes	82	91	87
% knowledge of destruction of mosquitoes	69	71	70
% awareness of IRS (Indoor Residual Spraying)	78	92	85
% favouring IRS	88	45	67
% against IRS	3	34	19
% recognised fever as symptom of child malaria	90	97	94
% initially try home-based treatments	76	50	63
% take child to HC within 6 hrs	69	65	67
% know of IPTp	73	67	70
% with VHT in community	74	45	60
% seek treatment from VHT	74	-	

All values quoted from now on will be the mean values, unless indicated as Luwero- or Kiboga-specific results

HEALTH CENTRE SURVEYS (MAT Baseline Study, 2008)
KIBOGA:

	Level II Unit	Level III Unit	Level IV Unit	Kiboga Hospital
% diagnoses done symptomatically	100	82	n/a	66
% units able to offer ACT	69	67	100	Yes
% units able to offer ITNs	0	17	0	No
% units able to test by blood slide	0	25	n/a	34
Number of pregnant women on IPTp	3	30	319	454

LUWERO*:

	Level II Unit	Level III Unit	Level IV Unit
% diagnoses done symptomatically	94	58	69
% units able to offer ACT	81	100	100
% units able to offer ITNs	0	0	67
% units able to test by blood slide	12.5	93	100
Number of pregnant women on IPTp	6	16	85

* There is no hospital in Luwero – Health Centre IV is the most equipped facility of the district

KIBOGA and LUWERO (averaged) – STAFF AND EQUIPMENT:

	Level II Unit	Level III Unit	Level IV Unit	Kiboga Hospital
% actual staff of authorised	37	48	58	51
Ratio patients : medical workers	206:1	96:1	65:1	41:1
Presence of lab	Not required	68%	100%	Yes
% actual lab staff of authorised	n/a	39	73	60
Presence of binocular microscope	n/a	57%	100%	Yes
Power	7%	17% - Kiboga 73% - Luwero	100%	Yes

The most sustainable way to treat and cure malaria is to educate the populations at risk about protection from the parasite: that is, how to avoid infection altogether. This can be done through the use of Insecticide Treated Nets (ITNs), Indoor Residual Spraying (IRS) of huts, and finding other ways of avoiding or destroying mosquitoes, the vector of *P. falciparum*. Therefore, the most pressing questions are those relating to the vector: breeding, habits, avoidance.

However, the immediate reaction to these results is the irregularity between awareness of vector and awareness of its habits: 90% of the participants were aware that mosquitoes were the vector for malaria, but much fewer knew their breeding grounds, and, therefore, how to prevent their propagation or how to destroy them.

ITN usage, a world-recognized method of prevention against malaria, did not receive strong results. Although respondents were very much aware of its advantages (97% assert it gives the best protection[1]), the availability and quality of the nets is very limited. Each household has on average 1 net, with an average ratio of one net to 6 persons. Because of their higher vulnerability, it is the children who are usually put under the net at night; this still leaves a large group of individuals who remain exposed. Approximately one third of nets are in poor condition, and therefore less efficacious. Finally, around half of the population do not own a net in the first place,

[1] All values quoted hereafter are directly from the table of results from the MAT Baseline Study, unless specified.

which is contrary to government policies of complete net coverage and usage. This remains despite the Ministry of Health's target to increase the proportion of household with one or more nets from 13% to 75% by the year 2005. According to the health centre survey, very few clinics are even able to provide the ITNs as required by the Ministry of Health. These are to be subsidised unless in an emergency situation (e.g. refugee or IDP camps), made affordable to all who need them (Zurovac, 2008).

Survey responses to the preferred and practiced course of action in reaction to visible infection remain varied. Although 94% recognise that fever is a symptom of the parasite, 63% still opt for home-based remedies before seeking immediate clinical attention. This delay is not in the best interest of the patient, and could be due to several factors, among them: wariness of Western antibiotics and trust in traditional practices, distance or inaccessibility to health centres, or inability of health centre to cater to the needs of the populace (MAT Baseline Study, 2008). By law, level II health centres are not required to have a working laboratory, but level III centres are. Laboratories are needed to conduct blood slide tests. The survey shows that although some clinics claim to be able to test by blood slide (i.e. have a laboratory), they still do the majority of their diagnoses symptomatically. This is due to poor infrastructure, lack of equipment, lack of personnel, and lack of electricity. Every laboratory should have a binocular microscope for blood slide testing, and many still don't (57% of level III centres), and continue to use the obsolete monocular microscope. Furthermore, the lack of full personnel puts a huge strain on all functions of the health clinic. With 37% to 58% of the required staff manning the clinics, services are completed far less efficiently than they could be. The most common reason for this lack of staff is that they are not compensated for their services: salaries are rarely paid on time, if at all, and staff quarters are poorly maintained, if present at all. With the average number of patients to health worker ratio ranging from 41 to 206 per worker, the staff does not have the time to conduct all the necessary tests, regardless of the availability of resources.

Village Health Teams (VHTs) are a national public health initiative that have been gradually implemented all over the African continent over the last few decades. They consist of several individuals, often volunteers, who are trained to diagnose illnesses by their symptoms, and recommend the best course of action to the patient. This can mean administering basic treatments and medications, such as ACT. This is especially useful for villages where the health centres are hard to access. Unfortunately, VHTs have some shortcomings: there is often a lack of trained, voluntary personnel, meaning that many targets have not been met. There have also been reports of mismanagement: drug misappropriation, or some other forms of mismanagement. Furthermore, as their resources are limited, and because symptoms can differ from patient to patient, illnesses are sometimes diagnosed and drugs prescribed inappropriately. However, according to the results, 60% of the respondents report a VHT in their village, and in Kiboga, 74% would seek medical help from them, demonstrating their promising status within the community.

All of these results point to a populace that relies more on treatment than prevention of malaria, despite national efforts to curb this unsustainable trend. With ineffectual testing methods and obsolete equipment, staffed by a fraction of the required personnel, Ugandans boast little in the way of early detection systems,

which would indicate a deep, and dangerous, reliance on pharmaceutical recourses, now in the form of ACT.

A study conducted in 2008 investigated the effectiveness of ACT in three sub-Saharan countries, including Uganda. The researchers reported that the adherence to treatment was 81%, lower than the two other trials in Nigeria and Ghana (Ajayi, 2008). The study did not offer suggestions as to why this was the case. Firstly, in this study, unavailability of medications is not one of the factors, as these were provided by the researchers. The other options for this incomplete adherence could be negligence, or the personal judgement of the patients. In other words, participants might have feared that once the clinical trial was over, they would no longer be able to access medication regularly because of inadequate local medical infrastructure. There is some likelihood that patients personally allotted some of the medication to treat their current infection until they felt better, and then kept the rest for the next times they should fall ill (Colonel Robert Leitch, 2008). This means they took an incomplete course of antibiotic treatment, a crucial factor in developing drug resistance.

4. How Can We Solve These Problems?

The Centre for Disease Control (CDC) outlines three principal ways to avoid antibiotic resistance:

1. only prescribe antibiotic therapy when likely to be beneficial to the patient
2. use an agent targeting the likely pathogens
3. use the antibiotic for the appropriate dose and duration (Center For Disease Control (CDC), 2008)

Given these guidelines, we can formulate courses of action pertinent to each precipitating factor, each appropriate and feasible given Ugandan circumstances.

First and foremost, given the poor knowledge about vector habits, education about malaria needs to be consolidated to help avoid contracting the disease altogether. The burden of disease could be significantly reduced if more locals knew to empty out old water containers, drain or pour out sources of stagnant water or cover small puddles with vegetable oil, so that the mosquito larvae cannot emerge – this would lead to a decrease in mosquito populations around the homes.

Although most (85%) were aware of IRS, a large proportion (19%) were against the incentive. This programme has been proven to be highly effective against malaria, and although its coverage its presence is patchy across Africa, full coverage would lower the frequency of malaria cases (Malaria Consortium, 2008).

The biggest shortcoming revolving around educational initiatives about ITNs is that, all too often, the health clinics, responsible for providing them, cannot. According to the survey conducted by AMREF-Uganda, a scarce handful of health centres are stocked with ITNs; in Kiboga, even the main district hospital is out of stock. Consequently, the only recourse for the population is to purchase nets, which are not always within their means, or go without and risk malaria infection. This can only end negatively: if one is told over and over that seatbelts are the only way to be protected in a car, and then no car is equipped with that feature, the at-risk

population will be frustrated and angry. Analogously, the effects of educating locals about the marvels of an ITN are lost when failing to equip them with one.

I propose that this be incorporated more fully into Ugandan National Health Policy, and that they be made completely free of charge. They should be distributed in schools, churches, clinics, police stations and post offices, and be made a mandatory parting gift for every new mother when she leaves the clinic, should she deliver there. Every Traditional Birth Attendant (TBA) should have a stockpile to hand out to mothers with newborns as well. Each time they should be accompanied with an explanation as to proper use: the sleeping person should be entirely covered, frayed nets or those with holes are not useful, etc. Since the introduction of ITN in the country in the early 1990s, the promotion of their use has been mainly by NGOs in the form of limited projects covering small populations. This should be expanded to the whole country, enough for every person.

A significant factor in precipitating ACT resistance is the fact that it can be administered inappropriately, as 83% of patients in Kiboga, and 74% in Luwero are diagnosed symptomatically, i.e. without undergoing a blood slide test, and treated through the judgement of the health workers. Clinics need to have the proper infrastructure. If level III clinics were updated to have full working labs, with modern equipment and full staff, the situation would be ideal. But, on a more realistic scale, the introduction of Rapid Diagnostic Tests (RDTs) would alleviate the burden of work substantially. In the face of the ongoing malaria crisis, limiting ACTs to individuals who are confirmed to be carrying infectious malaria parasites becomes extremely important, especially in the context of rising medication costs and drug resistance. RDTs are lateral flow 'immuno-chromatographic' antigen-detection tests, which rely on the capture of dye-labeled antibodies to produce a visible band on a strip of nitro-cellulose – in other words, a malaria "prick-test". These tests are more cost-effective ($0.95 each) than prescribing an antimalaria treatment (between $0.90 and $2.40 for an artemether-lumefantrine treatment). There are still some issues surrounding shelf-life, price and the training required to administer it. The WHO estimates that for the most cost-effective and successful RDT campaign each test should be priced at $0.65 (WHO Malaria Rapid Diagnostic Tests, 2008). This is still in the works, but could alleviate the burden of disease greatly and drastically reduce the rate at which antibiotic resistance grows, as only infectious malaria sufferers would be treated with ACT. Ingesting ACT when one should not be, regardless of the possible physical side-effects, is a huge causative agent of drug resistance; it goes against all three of the guidelines stated by the CDC. Malaria symptoms can be confused with those of another ailment, just as a health worker, without running the proper tests, could misdiagnose malaria as flu or food poisoning, and not administer antibiotics when needed.

Lack of adherence to ACT is a significant problem, where patient do not complete the full treatment as prescribed. One reason for this, which happens in every culture, is that once a patient begins to feel better, they will stop taking the medication, due to forgetfulness or personal judgement. This is a serious problem in all medical settings in creating drug resistance, and needs to be clearly outlined to every single patient who is given antibiotics. Another reason is that the patient does not necessarily always understand the requirements and stipulations to complete the treatment. In a study by Zurovac et al. (2008), they stated that they

"found that nearly all patients left the facility with an explanation on dosing schedule; however, administration of the first AL (artemether-lumefantrine) dose, and provision of advice to take AL after the meal and what to do in case of vomiting was rarely performed across all age groups. Despite Uganda's investment in interventions to improve the quality of care such as IMCI (Integrated Management of Childhood Illness), deficiencies in drug dispensing and counseling practices persist. The reasons for these suboptimal practices are not clear and demand further qualitative research including health workers misperceptions on administration of first AL dose in the absence of food, the effects of lack of potable water on administering drugs at peripheral facilities and the effects of AL blister packages on the provision of replacement dose in case of vomiting. Better understanding of these factors should guide further interventional studies to improve dispensing and counseling practices as an integral part of appropriate prescribing" (Zurovac, 2008).

Another possible reason for disobedience to the treatment regime, more specific to developing countries, is the fear that next time they fall ill, there will not be any medication available. This is not an unreasonable assumption, given that in Kiboga, 31% of level II health clinics were unable to provide ACT. Some patients decide to keep a small stash for when they or a loved one becomes ill and self-medicate (Colonel Robert Leitch, 2008). This is dangerous and unhealthy, because it means that they do not finish their own course of treatment. And although 81% adherence is high, it should consistently be as close to 100% as possible. To achieve this, ACT must be deployed regularly to all clinics, and perhaps other community health workers, such as Traditional Birth Attendants, who could also be equipped with RDTs and IPTp when expectant mothers come for 'check-ups'. This could potentially also lower rates of malaria during pregnancy, which is immensely dangerous for both mother and baby. Perhaps implementing a system similar to Directly Observed Therapy Short-Course for tuberculosis, where someone checks on the patient every day to ensure they are taking their medication consistently, would be beneficial. But malaria cases are more frequent than TB, so this could prove to be inefficient; it should still be considered though.

Another acute problem is the insufficient production of ACT, and thus the relatively high price of the treatment. The cultivation of *Artemisia annua,* from which artemisinin is derived, was up until recently confined to China and Vietnam. The WHO has undertaken campaigns to stimulate cultivation in Kenya and the United Republic of Tanzania, and I suggest this policy be expanded to Uganda, as well as other parts of Africa. This would add to the Ugandan economy, help African farmers contribute more significantly to the world market, and be one more step in turning away from foreign aid to a more self-sustaining health policy (

WHO: *Meeting on the production of artemisinin and artemisinin-based combination therapies*, 6-7th June 2005, Arusha, United Republic of Tanzania, Global Malaria Programme, WHO/HTM/MAL/2006.1113.

Finally, post-treatment testing to check the efficacy of ACT treatment, and full recovery is important to avoid recurrence and drug resistance; this could be done through another RDT, to confirm that all parasites are dead, and therefore none have survived with a resistant mutation to the antibiotic.

5. Obstacles Ahead

Many of the initiatives suggested to combat mounting antibiotic resistance do not account for the shortcomings of the public health policy structure in Uganda. There is widespread corruption and inefficiency in government. In fact, its Ministry of Health is notorious throughout the country for having its parking lot jammed with large, new Land Cruisers, belonging to the employees. Making the system more transparent and equitable, rather than letting funds trickle down unmonitored, could help solve the problem. Alternatively the installation of internationally approved financial watchdogs to ensure that the funds are routed appropriately would also be effective. This issue needs to be seriously tackled by the Ugandan authorities.

Another growing problem in Uganda is the health workforce crisis. During a conversation I had a with a 25 year old surgeon in Luwero, who had been running the level IV clinic and performing surgery by himself for 5 years, he expressed his desire to relocate to the UK, or Germany, for the promise of a better salary. A medical student who was present also told me she hoped to move abroad after she completed her studies. Health staff are rarely paid on time, if at all, and their salaries are pitiful, even in the Ugandan context. Some of the rural health workers have been reported to hoard medication themselves. Indeed, the level II centre in Bulaga, Kiboga, had to be closed due to drug misappropriation. In another clinic, the doctor was charging $2-5 for HIV testing, and pocketing the profits (MAT Baseline Study, 2008). Often this is not out of malice, but desperation. This needs to be remedied immediately so that the Ugandan people do not lose their brightest and most able medical minds to foreign countries in their time of need.

The surest way to avoid drug resistance is, quite simply, to lower the burden of disease. However, the first recourse to noticeable antibiotic resistance, like in the cases of quinine and chloroquine, should not be to market a newer drug – this will not automatically lower the incidence and prevalence of malaria. There is no such thing as a successful 'silver bullet' approach. The sheer volume of malaria sufferers will trump whatever efforts are put into drug adherence, RDT campaigns or drug availability - and this is currently the case.

6. Conclusion

The biggest challenges facing the medical and public health community, in avoiding ACT resistance, is the lack of substantial success in lowering malaria incidence and prevalence. The burden of malaria is deleterious within Ugandan society, abetted by the scarcity of health care personnel and mishandling of health resources. The paltry governmental successes do not account for long-term implications of pharmaceutical mismanagement: Uganda's government and the WHO cannot just keep adapting medication if there is no attempt to change behavioural patterns and vector spread. Resistance to an antibiotic is a natural biological phenomenon that happens inevitably when exposed to the drug – it is only a matter of time. Yet, more importantly, it is useless to spend so much time, effort and money on education and raising awareness if we cannot provide the medical supplies, such as ITNs and the medication itself, to tackle the very problems we are deliberately highlighting to the populace. In other words, what is the point of

educating a Ugandan family about correct ITN usage if we then cannot provide them with one? Refurbishment of laboratories and health clinics, re-equipment with modern tools and medications regularly, and personnel training with constant appropriate compensation must come first. Education about vector transmission, ITNs or IPTP treatment should come once the infrastructure is ready to cope with this new knowledge. However, many obstacles lay within this commitment to refurbish the health system, notably in the distribution of funds within the Ministry of Health – whilst the necessity for transparency and efficiency are unquestionable, the challenges are undeniable in a system familiar with resource mismanagement.

Appendix

Figure 1: Map of Kiboga District, Uganda.

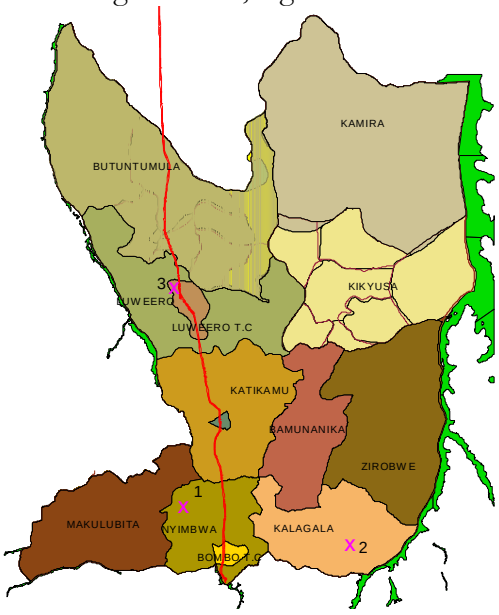

Figure 2: Map of Luwero District, Uganda.

Figure 3: A rural health centre level II (consulting room + store; current staffing level: 1 health worker).

Figure 4: A health centre level III (laboratory, ANC/OB + integrated HIV care)

Figure 5: Patient beds in level III facility

Figure 6: Monocular microscope (best suited to a 6th form Biology class – not powerful enough to carry out necessary analyses)
Figure 7: Binocular microscope donated by AMREF

Figure 8: Empty solar-powered blood bank.
Figure 9: Solar power for blood bank.

Figure10: Chloroquine injection being used [and reused] in a remote health cente

Figure 11: Expired Drugs waiting [months] for collection .
Figure 12: Cold chain fridge out of action due a lack of gas.

Figure 13: The [only] midwife leaves a Health Center III for a day of immunization outreach, after spending all night with a difficult delivery.

Bibliography

N.B. Personal conversations, observations and experiences were drawn upon during the compilation of this study. All are true, and took place during of July and August 2008 in Uganda.

Interview with Colonel Robert Leitch, M.B. E. in Kampala, Uganda, August 2008

Ajayi et al. (2008). Effectiveness of artemisinin-based combination therapy used in the context of home management of malaria: A report from three study sites in sub-Saharan Africa. *Malaria Journal* 2008, 7:190 doi:10.1186/1475-2875-7-190

AMREF-Uganda: Malaria, AIDS and TB (MAT) Integrated Model, Luwero and Kiboga Districts – Baseline Study, June/July 2008. *Not yet published.*

Center for Disease Control and Prevention. Antibiotic Resistance: Questions and Answers. http://www.cdc.gov/drugresistance/community/anitbiotic-resistance-faqs.htm#4, accessed November 2008.

Malaria Consortium: Indoor Residual Spraying, http://www.malariaconsortium.org/page.php?id=107, accessed November 2008.

Policy and Strategy for Insecticide Treated Nets, Malaria Control Programme, Ministry of Health, Uganda, March 2003: http://www.health.go.ug/mcp/ITN_policy_strategy%20final.pdf, accessed November 2008.

UNICEF 2006 Demographics Statistics: http://www.unicef.org/infobycountry/

World Health Organization (2006): Facts on ACTs (Artemisinin-based Combination Therapies. January 2006 Update.

World Health Organization (2008): *Report of a meeting on containment of artemisinin tolerance*, 19th January, Geneva, Switzerland, ISBN 978 92 4 159681 7 (NLM classification: WC 770)
http://www.rbm.who.int/cmc_upload/0/000/015/364/RBMInfosheet_9.htm, accessed November 2008.

World Health Organization. (2006). *Diagnostics for Tuberculosis: Global Demand and Market Potential*. Special Programme for Research and Training in Tropical

Diseases. Foundation for Innovative Diagnostics. http://www.health.go.ug/health_units.htm, accessed Novermber 2008.

World Health Organization (2008). Malaria Rapid Diagnostic Tests: What is an RDT? http://www.wpro.who.int/sites/rdt/whatis/list.htm, accessed November 2008.

World Health Organization (2006): *Meeting on the production of artemisinin and artemisinin-based combination therapies*, 6-7th June 2005, Arusha, United Republic of Tanzania, Global Malaria Programme, WHO/HTM/MAL/2006.1113

Zurovac et al. (2008). Malaria case-management under artemether-lumefantrine treatment policy in Uganda, *Malaria Journal*, 7:181. Published online 19/09/2008. doi: 10.1186/1475-2875-7-181.