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Title: Keyword Malaria—Global Health, History, Ethics, and Technology

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Abstract

This article focuses on the keyword malaria, linking history, ethics, and global health on the African continent. We make three connected arguments. First, that historical knowledge must be integrated into global health epistemic realms and actively used in planning contemporary malaria interventions. Second, we draw attention to the neglected ethical issues surrounding rebound malaria epidemics. We take a closer look at challenging questions related to truth telling, African autonomy, and obligations of researchers. Third, there is an embedded argument about historical continuity, and that especially in the realm of technology and rhetoric, it is a century of similarities and connections.

Introduction

Malaria has had a long and significant impact on the African continent. From nearly any perspective and metric, the effects have been persistent and deep. This article raises critical historical, ethical, and scientific questions related to the disease by focusing on the “keyword” of malaria over the past century. Malaria, as a topic, is a huge area of research and cuts across many disparate fields. There are parasitologists studying plasmodium development in labs; entomologists observing mosquito biting behavior in the field; economists measuring the implications on human capital; microbiologists and geneticists creating genetically modified mosquitos; epidemiologists tracing localized patterns of disease; climate scientists tracking the implications of a warming planet; anthropologists observing the range of therapies used;

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MG conceived of the structure of the article, the topics to be addressed, and drafted the paper. ZA conducted an extensive review of global health literature, drafted early sections, and presented the paper at ASA. Both authors reviewed the final manuscript. The authors have no competing interests to declare. Both authors have work and research experience with malaria: ZA worked for 4 years with RTI International on an IRS project. MG worked with the global health organization Population Services International, involved in the social marketing of public health products such as bed nets and bed net retreatment kits.

historians reconstructing what happened in past control activities; and many others working in fields such as political science, sociology, environmental studies, and more broadly.

Since the study of malaria covers many different disciplines, we have narrowed our focus to *malaria interventions*—by which we mean activities carried out with the intent to control, eliminate, or eradicate malaria both historically and in the present. These terms have always been a bit fuzzy, but eradication refers to permanent zero incidence of a disease across the globe; elimination refers to the interruption of local transmission of a disease in a defined geographic area (like a country or region); and control is any activity intended to reduce the incidence, prevalence, morbidity, or mortality of a disease. Over the past 120 years, malaria control, elimination, and eradication activities have largely been funded, directed, planned, and carried out by international organizations ranging from European colonial governments to the Bill & Melinda Gates Foundation. An emphasis on interventions allows us to consider the importance of these past interactions and how they shape current activities, allow us to see the similarities in approach and tools over the past century, and to reflect on the outsized role played by international scientific actors and organizations.

This article has three main arguments. First, that historical knowledge must be meaningfully integrated into biomedical and global health epistemic realms, and must be used to inform the planning and design of malaria interventions. The second argument draws our attention to one of the neglected ethical questions surrounding malaria control: the risk of rebound malaria epidemics occurring when successful programs end. It presents evidence of how Africans differently understand the risks of participation. The issue of rebound malaria illustrates the practical and moral problems that abound when historical knowledge is ignored. Finally, there is an embedded argument about historical continuity, a recognition that as much as global health experts and scientists involved in malaria activities emphasize large discontinuities between past practices and current methods, from at least a few different vantage points—especially in the realm of technology and rhetoric—it is a century of similarities and connections.

The article begins with an explanation of how the biomedical disease we know as malaria was created around the turn of the century. The next section provides a brief history of malaria activities on the continent over the past 120 years, making clear the overall history of failures in terms of elimination and eradication, and the past two decades of significant reductions in morbidity and mortality. We then take a closer look at the challenging ethical questions that are linked with the risks of rebound malaria, particularly questions of truth telling, appropriate involvement of local communities in decision making, and longer-term responsibilities and obligations. The conclusion steps back to consider the necessity of integrating multiple epistemic forms, arguing that social scientists should more forcefully insert themselves into policy conversations that pertain to their areas of expertise. It's not a new sentiment, nor one that all academics agree upon. But it's a question with urgency and worth returning to.

Throughout the article we evaluate how the Lancet Commission on Malaria Elimination Report, a recent and influential global health report calling for another attempt at malaria eradication, has integrated historical knowledge, considered the ethics and risks of rebound malaria, and discussed the promise of new technology. The 57-page report was released in September 2019 and argues that eradication is ambitious, well-intentioned, and ethically defensible. The report was put together by the University of California San Francisco's Malaria Elimination Initiative and was funded by the Bill and Melinda Gates Foundation. Starting in 2007 with their call for malaria eradication, the Foundation has pushed the envelope of what the

global community thinks is possible, and no one should doubt their influence in setting the global health agenda.

Malaria—as a biomedical disease, and as a bodily condition causing suffering and ill health—is not new, nor is it confined to Africa. One of the first issues we must confront is: Is malaria in Africa exceptional? The answer is yes, malaria in Africa deserves to be considered independently. From an entomological perspective, the continent has the highest density of the most effective (and thus most dangerous) mosquito vectors, *Anopheles gambiae*. This grouping of species has been shown to have a strong preference for biting humans and often lives long enough to ingest the malaria parasite from an infected human and to pass it on to another person, causing a new infection. From a geographic perspective, the entire middle part of the continent has bi-annual rains and those rainfall patterns and high levels of humidity combine to create many ideal mosquito habitats, large numbers of mosquitos, which contribute to year-round malaria endemicity in many areas. Epidemiologically, the most common type of malaria infection in Africa is *p. falciparum*, which is the most severe form. Finally, the likelihood that malaria results in death frequently corresponds to the overall health of the person infected and there are many Africans suffering from co-infections and poor nutritional status. Other societal conditions that contribute to high mortality include overall poverty levels; lack of access to prompt testing and treatment; and many people not having proximity or easy access to medical facilities.

Malaria is a vector borne disease, which means it is transmitted from one infected person to a non-infected person by way of the bite of a female anopheles mosquito. It is a protozoan infection of the red blood cells. Anopheles mosquitoes must first bite an infected human, ingest the malaria parasite, and then live 7-12 days for the parasite to fully develop. For the transmission cycle to be completed, the mosquito must then bite another human, transferring the malaria parasite to cause a new infection. Once a person is infected, the parasite undergoes distinct developmental phases inside the human liver and the blood stream. The physical effects as the parasites proliferate in the body are cyclical fevers, malaise, and often stomach upset or vomiting in addition to anemia. Technically, all malaria cases are treatable and death is preventable if treatment is sought quickly enough, and the right treatment is given (a drug that the parasite is not resistant to). However, if a case of malaria isn't treated promptly, occurs in a young child or person without acquired immunity or who is otherwise weakened, the disease can lead to death.

Malaria and the Creation of a Biomedical Disease

The biomedical disorder we call malaria was created in Europe just before the turn of the twentieth century through a series of discoveries in Algeria, India, and Italy. The word “malaria” is Italian in origin, coming from *mal aria* (bad air) that hints at the pre-germ theory explanations of the disease as one caused by miasmas and bad air emanating from particular environments such as swamps. Scientists used microscopes, experiments, and close observation of animals and people to untangle the disease lifecycle and identify the parasite and vector. By saying that malaria was “created,” we mean that the new field of bio-medicine named malaria as a single bodily ailment, distinguishable from other fevers, etiologically explained by a parasite, with a set of common symptoms presenting in all people. That concept of malaria has only existed for about 120 years.

It may now be obvious that there's a paradox that comes with naming diseases: unless it's a new disease just appearing among humans and it is quickly identified and named (such as Covid-19), most diseases existed as alternately-named maladies causing ill health long before being identified, named, and bounded as a single biomedical disorder (see Langwick 2011 for an insightful discussion of maladies). The malady of malaria existed for millennia on the African continent, and across the world these cases of fever, malaise, and death were described with different names and were ascribed different causes and cures. In some cases, these maladies aligned closely with what would later be named biomedical malaria, by being linked with particular environments (like swamps), or in relation to the presence of mosquitos, or with observations about how different people (such as children) were at greater risk. These maladies existed prior to the formal naming of malaria and many continue to exist into the present (Gessler et al. 1995; Giles-Vernick et al. 2011; Kamat 2008; Muhela et al. 2002). The fact that local categories of illness existed prior to biomedical explanations is not unique to Africa—that was a global phenomenon. Excellent works on the history of malaria in Italy (Snowden 2006), East Asia (Yip 2009), Mexico (Cueto 2007), and the United States (Humphreys 2001; Nash 2007) all show how local disease categories pre-dated the discovery of malaria, and trace how these local categories were affected by the introduction of biomedical explanations.

Though this article can't fully explore this topic, disease categories are firmly embedded in local cosmological and knowledge systems. Explanations of why a particular disease occurs, how it disables, who is affected and why, and effective preventatives or cures all fall within the realm of vernacular knowledge. This body of knowledge encompasses the observational and experiential learning coming from decades or centuries of living with a particular condition. There have been multiple studies of this type of knowledge in relation to biomedical disease, such as Clappterton Mavhunga's *The Mobile Workshop* (2018) focusing on sleeping sickness in Zimbabwe, and Helen Tilley's *Africa as a Living Laboratory* (2011) showing how African knowledge was appropriated into colonial European biomedical and ecological bodies of knowledge. Vernacular knowledge acknowledges different understandings of a particular condition such as that described by Tamra Giles-Vernick, Abdoulaye Traoré, and Sodiomon B. Sirima's recreation of the historical epidemiology of "cold fever" in Burkina Faso (2011). These differences in naming and framing are emblematic of more substantial cosmological and epistemological distinctions (such as the African philosophy and modes of thought Kai Kresse [2018] describes for the Kenyan coast or the "vernacular accounting" described by Adia Benton in West Africa [2012].) As Julie Livingston has noted in her masterful study of how *thibamo* and tuberculosis co-existed and shaped each other, the translation of biomedical disease into locally salient diagnostic categories is challenging because "each is anchored in radically different ontological regimes...based on different etiologies with different moral consequences" (2007, 807).

Doctors and global health workers sometimes express frustration that these local categories of disease exist alongside biomedical malaria. Broadly speaking, these categories persist because they serve: they describe illnesses that doctors diagnose as malaria, but that don't respond to malaria treatment; they allow people to explain illness with a different starting point than the bite of an infected mosquitos; they provide explanations for the tragic deaths of children that don't lay blame on individuals but recognize larger constraints; they recognize the importance of the unknowable in explaining misfortune such as sickness and death (Whyte 1998). There is a deep functionality to many of these categories, whether it's due to biomedical gaps that Vinay Kamat documents in Tanzania (2013), or what Iruka Okeke calls "diagnostic

insufficiency” and finds in Nigeria (2011). There is no reason to expect that local disease categories will disappear, or that these categories endure only because people aren’t knowledgeable about biomedical malaria. This is an important point that is yet to be absorbed within the global health policy community.

Now that it’s clear that diseases are created in a process of scientific-social construction (it starts in a lab with scientific discovery, but then has to be diffused and adopted by larger society), we also have to point out that what constitutes a disease changes over time. Biomedical malaria has not been a single and stable disease category. Knowledge about malaria has changed dramatically over the past century. As just a few examples: it was initially not known there are five different malaria parasites affecting humans (*falciparum*, *vivax*, *ovale*, *malariae*, *knowlesi*) and that each created slightly different symptoms in humans; it was not known that there is a dormant liver stage of *vivax* and *ovale* malaria where malaria can reappear months or years after first infection; it was not obvious how people living in endemic spaces acquire partial immunity to malaria or how people across the continent have a degree of genetic protection through Duffy negativity and how that related to sickle cell anemia. In terms of prevention and treatment, it was not known how much quinine had to be given to protect or cure; and as resistance grew to drugs such as chloroquine, new treatments had to be invented, or rediscovered in the case of artemisinin. Biomedical knowledge is not a static body of facts that are true and unchanging. Just as local conceptions of malaria have changed over time, biomedical malaria should be thought about as an unstable, yet durable, category.

Malaria and History: Elimination Attempts & Failures

We established earlier that malaria in Africa is unique. It’s also worth asking whether the continent’s inability to eliminate the disease is unique. The answer is both yes and no. On the one hand, African countries have been less successful than other countries globally in eliminating the disease. (Of the 38 countries that have ever eliminated the disease, only 3 are in Africa. There is general consensus that wealthier countries with less endemic malaria are more likely to eliminate, and small islands have a particular advantage [Smith et al. 2013; Packard 2007].) On the other hand, it may be more reasonable to compare Africa not to every other part of the globe with malaria, but to consider only places that are similarly malaria endemic or have “stable” or “substantial” malaria. Depending on which report is consulted, 40, 44, or 47 African countries are considered malaria endemic, and none of those have eliminated the disease.² The WHO recognizes that there is no country with highly endemic, stable, malaria transmission that has ever eliminated the disease, and that that countries that have eliminated are “located in areas of low and unstable transmission” (WHO 2008). When we compare African countries with other places with endemic, stable, malaria, the commonality is failure to eliminate. Which means Africa, as an endemic area, is not unique in the persistence of malaria despite concerted efforts.

One area where Africa is similar to the rest of the world is in the strategies used for malaria control, which have remained largely the same over the past 70 years. These activities

²40 comes by manually counting the countries with “substantial” malaria cases in the 2020 malaria report. 44 comes from the 2013 World Malaria Report; 47 comes from the 2017 and 2018 World Malaria report, a sentence that says “of the 47 malaria endemic countries...” There is no obvious source that lists all countries globally that are considered malaria endemic, or that are considered to have “substantial” malaria. As Cohen et al. (2010) have written, just as the term “malaria elimination” has not been clearly defined historically, what counts as “endemic” or “substantial” is also quite vague.

followed the basic principles of destroying mosquito habitat through environmental control, preventing contact between mosquitos and humans with barriers, and reducing transmission with prompt testing and treatment of the infected. There has been a great deal of consistency in these low-tech approaches, including environmental control and what is now called “integrated vector management”—combining more than one approach to reduce the number of mosquitos. A main strategy of environmental modification is destruction of mosquito breeding sites by drainage of swampy areas. This reduces the overall number of mosquitos by destroying the places where females can lay eggs, thus reducing the number of vectors available to move the malaria parasite from one person to another. In Zanzibar, water sanitation practices meant to eliminate swampy areas date back to the Omani era, “anti-mosquito brigades” functioned by 1907, and extensive oiling done by African workers continued for decades (Issa 2011). Another low-tech approach has been to focus on minimizing human-mosquito contact through barriers such as bed nets or sturdily constructed houses with screens and tight-fitting windows, doors, and roofs. Using chemicals and insecticides has also been a mainstay, beginning with the oiling of small breeding sites, outdoor spraying with Paris Green from the 1920s onward, and eventually the development and use of new insecticides such as DDT, dieldrin, and pyrethroids for both indoor and outdoor use during World War II and after.

The largest and most well-known malaria intervention was the WHO’s global attempt to eradicate the disease. The Global Malaria Eradication Programme (GMEP) ran from 1955 to 1969 and it was expected that the new pesticide DDT, sprayed indoors and outdoors to reduce mosquitos, would pave the way to eradication. There were certainly successes in some parts of the globe. During GMEP years, malaria was declared officially eliminated in 15 countries, including Italy, Spain, and Taiwan. There were also what scholars have termed “failure as success” where program goals were not accomplished, but success was still declared (Brown 1999). Some countries, such as India, Sri Lanka, and Korea, saw steep reductions in malaria rates, only to be followed by epidemics of rebound malaria that sent morbidity and mortality surging higher than pre-intervention levels.

It’s worth examining how the Lancet Report engages with the GMEP history given that the first sentence of the report invokes the “noble but flawed attempt to eradicate malaria in the mid-20th century” and points out that we are “again seriously considering eradication” (1). The Report’s position on what to do is clear, that malaria “can and should be eradicated before the middle of the 21st century” (2). With the goal being to prove that eradication today is a good idea, there is 3 paragraph section recounting “Lessons from the Global Malaria Eradication Programme.” The authors recognize that fifty years on, “the findings and conclusions of this final GMEP report are startlingly familiar.” But despite seeing similar operational, technical, and financial challenges, the authors argue that the world in 2019 “is nothing like the world in 1969” due to increases in wealth, health, and education. They acknowledge mistakes, but claim those failures will remain in the past. There is a superficiality in how history is used: “History in global health and many other arenas has taught that success follows bold commitments, and not vice versa” (8).

It is telling that the Lancet Report overlooks all historical works on the topic. Among the 364 references, there is not a single historical book despite works existing. Historians James Webb and Randall Packard have detailed the specifics of programs in Liberia and southern Africa, in addition to writing books about the entire continent (Packard 1996, 2007; Webb 2009, 2011, 2014). These works are unequivocal in their assessments about the past failures and the unlikelihood of elimination in Africa in the future. Packard writes, “Put simply, malaria policy

has largely ignored the human ecology of malaria. The failure to link ecology and policy has prevented the elimination of malaria” (Packard 2007, 247). Webb has pointed out this historical shortcoming in past works by the same team that put together the Lancet Report, writing that the vision of “shrinking the malaria map... seemed to run counter to the long experience with malaria control in tropical Africa” but that skeptical voices were silenced due to the large amounts of money supporting the endeavor (Webb 2014, 146). It’s unclear if this history isn’t incorporated because it’s inconvenient, or if these works remain unread. What is clear is that this type of historical information is woefully un-incorporated into contemporary discussions about malaria in Africa. There are myriad other works by historians and anthropologists that also contain information calling into question some of the Lancet Report’s basic conclusions.

A frequent explanation for the failure in Africa is that no real attempt was made. During the actual campaign, the WHO’s Africa Regional Director stated there was a “temporary exclusion of the African region from WHO’s world-wide malaria eradication plans” (Litsios 2015). It’s an oft-repeated claim in contemporary malaria articles with statements such as: “The clear decision of the GMEP to leave most of Africa out of ‘global eradication’” (Cohen et al. 2010). But this claim doesn’t hold. Between 1959-1968, WHO documents list up to 24 “official” efforts as part of the GMEP, occurring in at least 21 different African countries.³ This number is most certainly an under estimation. Based on documents from African and WHO archives, it appears that many malaria programs occurring during these years were referred to as “pilots,” “schemes,” or “experiments” and not counted as formal parts of the eradication attempt.⁴ To date, there has been no comprehensive accounting of *all* these programs to properly acknowledge the size and scale of the effort, and very few of these programs have received close attention. (The Garki project in Nigeria is one of the few [Molineaux and Gramiccia 1980]).

On page 2 of the Lancet Report, the authors lay out another potential explanation for Africa’s failure, claiming “Malaria control programs were often overwhelmed and underfunded, and, especially across Africa, a sense of fatalism existed that substantial progress would never be made” (2). But archival materials from multiple programs indicate these African efforts were well-funded, used the best technologies of the day, mimicked the structure being used on other continents, and that scientists involved were optimistic at the outset. There was a great deal of enthusiasm and in the case of Zanzibar, it was written repeatedly by different scientists involved in the project that elimination was expected. As a private 1963 letter reflected, “There was every reason to expect a model malaria eradication program in Zanzibar which would have

³ The African locations with official GMEP programs are Cameroon, Dahomey, Ghana, Liberia, Mauritania, Mozambique, Nigeria, Reunion, Senegal, Sierra Leone, Togo, Uganda, Zanzibar, Cape Verde, Mauritius, South Africa, Southern Rhodesia, Swaziland, Liberia, Tanganyika, and Somaliland. Data was compiled from three distinct WHO documents: “1959 Present Status of the Worldwide Malaria Eradication Effort”; “1966 Report on Development of Malaria Eradication Program”; and “1968 Report on Development of Malaria Eradication Program.” Cohen et al. 2010 claims that “GMEP activities covered only approximately 3.2% of the populations at risk in Africa, and most of these programmes were concentrated at the margins of malaria’s geographical range.” However, there is no comparison about percentage of populations on other continents that were “covered,” nor any accounting of how the many experiments, schemes, and pilot programs factored into GMEP.

⁴ Examples include the Pare-Taveta Malaria Scheme in Tanganyika and Kenya, which ran from 1954-1959; a WHO-run pilot program in Liberia from 1953-1958

demonstrated the feasibility of malaria eradication in the presence of tropical African vectors and under tropical African climactic conditions” (Assessment of Zanzibar, 1963).

Yet even with money, technology, and a surplus of optimism, problems mounted. Vectors didn't disappear as easily as models predicted, and in some cases, scientists were surprised to discover new vectors. Insecticide resistance grew faster than expected, and wasn't recognized by scientists as quickly as it should have been. A multitude of scientific and managerial mistakes were made. In Zanzibar, documents show the wrong supplies ordered, spraying planned for the wrong months, maps poorly made, and data inaccurately collected, compiled, and interpreted. Very rarely do the official WHO reports mention what shows up frequently in the private, confidential memos: leadership failings in Geneva, gross errors in the modeling of malaria from leading European universities, scientific mis-steps around insecticide resistance, and unrealistic assumptions about how particular interventions would translate to varied African environments. As one private memo put it, “this report shows the great incompetence and complete lack of technical knowledge and critical minds of the WHO advisers” (Zanzibar 2nd Quarter Report).

Another explanation for the failure to eliminate is to blame Africans or African spaces. Frequently mentioned are tropes of recalcitrant or uneducated Africans (being unwilling to open houses to sprayers because they didn't understand the benefits of the intervention), unreliable African employees (sprayers, mappers, oilers), or African environments themselves (too many vectors, unexpected vectors, different soil/climate/rainfall patterns) presented challenges distinct from what scientists had predicted. These show up throughout the Lancet Report, and are among the 7 different explanations of the failure: “The biggest challenges at the time were considered to be complacency and absence of political will; poor leadership and management; inadequate tools to eliminate in high transmission areas, particularly sub-Saharan Africa; population movement and poor access to malaria services; minimal knowledge of vector behavior; insufficient funds; and the early development and spread of insecticide and drug resistance” (7). Having read many of the internal WHO documents related to the GMEP for different countries in Africa, we can say with certainty that the biggest challenges facing those programs were inadequate tools, minimal scientific knowledge about localized conditions, and the slow response to resistance. These were grave problems that prevented success.

As this historical section moves into the contemporary, there is positive news. Since 2000, there have been dramatic reductions in the number of cases globally and vast reductions in mortality across the African continent, though a few countries have seen increases (Bjorkman et al. 2019; Murray et al. 2012; World Health Organization 2020). Not since the late 1960s and the end of the GMEP has malaria been reduced in so many different places. Many of these reductions have come with the introduction of new technologies such as wi-fi access and cell phones that allow for outbreaks to be efficiently reported and contained. Yet, while the general trend of malaria reductions is agreed upon by all experts, there are disagreements about how much malaria has been reduced and where (Hay et al. 2004; Cibulskis et al. 2016). This is yet another example of where key terms and indicators—even those as basic as the number of infections, morbidity, and mortality—are less stable than they might first appear. As with other global health metrics, much of what is presented as quantitative fact is a mashup of incompletely collected data supplemented with models meant to accurately predict missing and biased data. The “cooked” nature of this data and generally “poor numbers” have been well documented and are not unique to malaria (Adams 2016; Biruk 2018; Gerrets 2012; Jerven 2013). Work by Tichenor shows how the very process of data production reinforces preconceived ideas about malaria and appropriate solutions (Tichenor 2017). Setting aside the murkiness of malaria

statistics, there is agreement that never before have such vast amounts of money, energy, and interventions targeted malaria in Africa. Promisingly, this focused attention has resulted in substantial reductions in the disease, saving millions of lives.

Malaria and Ethics: Risks of Rebounding Malaria

A closer look at efforts meant to control or eliminate malaria reveal a host of challenging ethical questions, including respect for persons by recognizing the autonomy of individuals and communities through appropriate consent practices; truth telling by sharing information about risks that may occur once the intervention ends in a form that is understandable to all; and more broadly, how to facilitate shared decision making. There are also many more ethical questions raised by malaria interventions, including those around what types of vector research to pursue (Ndebele and Musesengwa 2012), and how best to organize malaria vector trials while taking account of community concerns and the treatment of trial communities (Kilama 2010). This section explores these ethical issues by considering particular instances when biomedical determinations of risk may not match local conceptions. As one example of this mismatch, we examine the risks stemming from the loss of acquired immunity and epidemics of rebound malaria. In this case, though the African continent has been the site of multiple rebound epidemics, it does not seem most African participants recognize risks from short-term malaria programs or a loss of acquired immunity.⁵ We begin by explaining the basic science of acquired immunity and the epidemiology of rebound malaria before delving into the ethical implications and the significance of alternate moral frameworks.

Acquired immunity allows children born in endemic areas to develop a degree of protection by surviving repeated malaria infections while they are young. This makes malaria deadly in childhood but largely a disease of morbidity (sickness) in adulthood. It's been discovered that just as this partial immunity can be acquired, it can also fade when an individual of any age is no longer exposed to regular malaria infections. It remains an open question how quickly immunity wanes when a person is not exposed, and if it can be regained. What has been well documented is that when individuals, or whole communities, lose their acquired immunity through multi-year suppression of malaria infections, when malaria returns, it can be particularly severe and deadly (Trape et al. 2014; Griffin et al. 2015; Langhorne et al. 2008). These epidemics of "rebound" or "resurgent" malaria are so named because malaria rates are reduced during the interventions, then rebound and resurge, often to higher levels than before. Rebound malaria thus refers to when the disease returns to a place where it was successfully controlled and infects adults who have lost immunity and children who never gained it. (Children under five years of age are particularly vulnerable because their immune systems are not fully developed.) The main paper on this topic, by Cohen et al., recorded 75 unique cases of rebound malaria epidemics in 61 countries over 70-year time period (2012.). The most commonly assigned reason causing these rebound epidemics were a weakening of malaria control programs, mostly caused by funding constraints. While Cohen's paper is the most comprehensive accounting of rebound malaria done to date, it is incomplete—being entirely reliant on published papers indexed on major databases—and thus certain to be an underestimation. This threat remains very real in

⁵ Relying on published reports of rebound epidemics yields 75 events around the world, as captured by Cohen et al. in 2012. Yet it is likely that there are hidden or undercounted instances of rebound that are not captured in existing literature. In progress work by MG and a team of students suggests that by stringing together annual reports of case numbers from World Health Organization sources, previously uncounted instances of rebound malaria become apparent.

Africa, and new epidemics continue to occur despite the fact that they are largely—if not entirely—preventable with responsible planning.⁶

The realities and ethical questions associated with rebound malaria are not new. Dating back to the middle of the twentieth century, there have been well documented disagreements about the risks of programs that failed to fully eliminate the disease (Corbellini 1998; Webb 2009). As Mary Dobson, Maureen Malowany, and Robert Snow have shown, prominent malariologists at the 1950 WHO Malaria conference disagreed about the morality of stripping Africans of their acquired immunity, which would make malaria more dangerous if elimination campaigns failed and the disease returned (2000). This came with the burgeoning scientific understanding that Africans living in highly malarial zones could gain a degree of protection, but that it was dependent on regular exposure. While campaigns were ongoing, malaria was often reduced to such low levels for such long periods that adults lost their acquired immunity and children failed to gain it. Without proper measures taken as malaria returned (widespread testing, free, prompt and effective treatment), rebound epidemics could occur and be extremely deadly.

Even 70 years ago, general knowledge of the ill-effects that could occur when a malaria campaign ended abruptly wasn't limited to scientists— African leadership councils and British colonial health officers also spoke out about the potential dangers. In the Pare-Taveta Malaria Scheme that ran in Kenya and Tanganyika in the late 1950s, when the Taveta governing council heard the malaria intervention was coming to an abrupt end, they publicly stated it was "morally wrong" for the researchers to end the project and force them to "suffer the consequences unaided."⁷ Even though no one on the governing council could describe the precise risks of loss of immunity or the epidemiology of rebound malaria, they knew there would be consequences to ending the spraying, dispensaries, and malaria testing, and they questioned whether it was appropriate they had to endure and respond to those consequences alone.

The Taveta governing council's statement points to ethical questions about malaria that are largely ignored. Some of these relate to questions of truth telling about the risks of rebound and the realities of short-term funding cycles—how common is it that community members understand that a malaria program will only last a few years, or that it could cause malaria to worsen once that particular activity ends? Other questions arise about the obligations of global health agencies and those running malaria efforts to educate community members about the phenomenon of acquired immunity, so that risks can be better understood and considered. There are also broader questions of longer-term responsibilities of the agencies carrying out malaria control or elimination programs. Is there any responsibility to the community? Any obligation to monitor for rebound, to help respond if rebound occurs, or to acknowledge their own role in creating those conditions?

There is no good reason African communities on the receiving end of malaria programs aren't informed, understanding, and empowered to make decisions about the short, medium and

⁶ Cohen et al. 2012 only lists cases of rebound through 2000. On the African continent, this includes Zambia, South Africa, Sao Tome, Principe, Kenya, and Rwanda. Since that paper was published, there has not been any other publication seeking to provide an overview of rebound epidemics. This is an ongoing area of research for MG, who is leading a team of students through a replication and extension of Cohen.

⁷ District Commissioner Tanga to unknown recipient, "Pare-Taveta Malaria Scheme," September 1, 1960, Box 21, National Institute of Medical Research, Amani. Tanzania. More discussion in Graboyes, *The Experiment Must Continue*, chapter 6.

long-term risks of participating in malaria interventions. Recognizing the risk of rebound requires knowing about acquired immunity. The two terms explain the otherwise unexplainable shift from malaria merely making adults sick to killing them. In our review of the malaria literature, we have not found any research reporting on local understandings of acquired immunity or rebound malaria. In our own research in Zanzibar, in more than 80 interviews and informal conversations, we found that even highly educated Zanzibaris working in the medical field—doctors, nurses, professors, scientists—were hazy on how rebound differs from any other increase in malaria rates. The very few people we spoke with that recognized the causal relationship between a successful malaria intervention ending and rates spiking were those who worked for malaria control agencies.⁸

The most obvious reason why people in Zanzibar (and perhaps across the continent) remain unaware of acquired immunity and the risks of rebound epidemics is because scientists and global health workers have avoided explaining these concepts. Biomedical scientists have long discussed this risk at conferences, in published papers, in organizational memos, in private correspondences. Yet, there's no evidence these risks were shared with the communities in which they worked. This conclusion is based on multiple types of data: norms recorded in the archival documents of the WHO, information captured in the grey literature of contemporary global health organizations, and in direct observations of how information about malaria activities is shared today. In all of these realms, experts deliberated the risks only with other professionals, limiting the circulation of their concerns. There seems to be an unstated understanding that such information is not to be shared. The motivations for that could be many: because it's considered irrelevant, inappropriate, too complicated, or too dangerous for communities to know about. It is also true that even in the best of circumstances—when public health officials are committed to sharing information with community members—this can be challenging, as Mapua et al. have shown in relation to the somewhat simpler concepts of larviciding (Mapua et al. 2021). Even in the areas of shared assessment of “risk” from malaria, studies have found wide disparities in how community members understand the risk of infection (Koenker et al. 2013). Acquired immunity and rebound malaria are admittedly complex concepts, though complexity doesn't invalidate the responsibility to explain clearly and to be committed to understanding by community members.

While rebound malaria has been clearly documented, and likely under-reported globally, there is not consensus among malaria experts about its seriousness. In conversations with male malaria experts at the global level, nearly unanimously, they dismiss the relevance of historical cases of rebound and say that the risk of rebound happening today is exceedingly low. In making these arguments, they emphasize that the present is a clear improvement over the past and that the past is characterized by mistakes that won't be repeated. This allows for these experts to acknowledge that rebound epidemics occurred without seeing any contemporary relevance. This was the tactic taken by a top CDC official when quizzed about past rebound epidemics and how such information was integrated into planning contemporary campaigns. He was emphatic that such information was irrelevant and thus didn't factor into the organization's planning at all.

The issues surrounding rebound malaria are complex and important, and it is an area where social scientists—by paying attention to local forms of knowledge and understanding, and

⁸ An article analyzing this interview data is currently in preparation by MG and Judith Meta. “Zanzibari Understandings of Rebound Malaria and Acquired Immunity.”

profound silences in local discourse—may be able to make a particularly large impact. Rebound malaria requires us to pay close attention to “the role of human behavior in creating these new epidemiological trends,” since the tendency has been to focus only on the disease pathogen (Brown 1997). As one expert working in the field noted, the phenomenon of rebound malaria “remains relatively absent from discourses of malaria control and utterly neglected in the social science literature” (personal communication with author).

Malaria and Technology: Rhetoric, Adaptation & Alternate Moral Framings

This section considers technologies for malaria interventions and the rhetoric surrounded them over the past century. We specifically consider whether the rhetoric expressed in the Lancet Report is similar or different to the rhetoric around past elimination campaigns. We find that the narratives surrounding the introduction of new tools over the past century (whether it was Paris Green, DDT, long-lasting insecticide treated bed nets, rapid diagnostic tests, or the RTS,S malaria vaccine) are strikingly similar. We acknowledge a central paradox in global health efforts past and present: that the rhetoric of progress and success is a key component for mobilizing financial resources. These optimistic narratives are necessary to gather support, but they also create unrealistic expectations. The presence of these positivist narratives has allowed for a key assumption to persist: that technologies will be transformative, move seamlessly from the lab to the field, and that Africans communities will be grateful recipients. Recent work has shown how current malaria decision making structures make it almost inevitable that we arrive at technical-biomedical solutions (Eckl 2017). This section discusses some of the “new” and “old” strategies used for malaria control, while pointing out historical parallels about the expectations placed on these items to be radically transformative. We will end by pointing out how technologies may have alternate meanings and moral framings than what scientists may expect.

Technologies

One consistent theme over the last century is that many new technologies have had relatively short shelf-lives. The anopheles mosquito and the malaria parasite are frustratingly adaptive and have developed resistance to every intervention developed to date. That has included mosquito resistance to insecticides such as Paris Green, DDT, and pyrethroids. Parasite resistance to the pharmaceuticals sulfadoxine pyrimethamine (SP) and chloroquine have rendered those drugs largely useless, and even the WHO's currently recommended treatment regimen—artemisinin combination therapy—has documented cases of resistance in Asia and Africa.

However, there is no denying that the pace of scientific discoveries around malaria is brisk, and two recent findings demonstrate both the excitement and potential. A research team in Kenya and the United Kingdom discovered a naturally-occurring microbe, *Microsporidia* MB, inside mosquito vectors living on the banks of Lake Victoria that is effective in blocking malaria. The microbe is passed from one generation to the next through eggs. The finding has not yet been translated into a new intervention, but discussed possibilities include a mass release of the microbe into the wild to infect mosquitos, or the mass release of lab-infected male mosquitos that would then infect females through reproduction (Herren, et al. 2020). Another recent discovery about mosquito genetics identified that increased production in just three specific genes are associated with resistance to four different classes of insecticides used in malaria control. It also presents a new method to monitor insecticide resistance through molecular testing (Adolfi et. al 2019). More generally, new technologies such as CRISPR have raised the possibility of genetically modified mosquitos and gene drives, an area of great excitement within the scientific

community. In this area especially, there remain many uncertainties in how, where, and under what conditions African communities would approve of the use of this technology, and more broadly, how communities should be involved (Beisel & Ganle 2019). The ethical questions associated with genetically modified organisms are vast, and continue to be pertinent to sub-Saharan Africa (Nading 2015).

One tool that has been hoped for for decades, but which has only come online in the past few years, is a malaria vaccine. The first partially-effective malaria vaccine, RTS,S, is being tested in pilot programs in three African countries, involving approximately 360,000 children per year. In stage III human subjects testing, the vaccine reduced malaria cases by 30-55% depending on the age of the child. The current pilot is meant to determine the feasibility of delivering the vaccine as part of already existing vaccination clinics and campaigns, and whether wide-scale use across the continent is appropriate. Recent news of another stage II vaccine trial from Burkina Faso has returned even more promising results: 77% effective at preventing cases of clinical malaria over 12 months post-vaccine (Datoo et al. 2021).

In addition to new discoveries, there have also been innovations in how available tools are deployed. For many decades, prophylactic treatment has been given to foreigners visiting Africa, with the intent of preventing malaria infections before they occur. Those preventative therapies were rarely if ever given to Africans living on the continent. That has changed. In areas of high transmission, pregnant women are frequently put on intermittent preventative therapy to prevent malaria in both mother and fetus. Similarly, countries have begun to adopt new technologies to improve the basic strategies of case tracking, monitoring, and surveillance. Growing internet and wi-fi access has made it possible to utilize mobile phones, tablets, and geolocation to quickly transmit epidemiological data.

Rhetoric

Within the Lancet Report, a large part of their claim for eradication by 2050 hinges on new tools, and thus it's worthwhile to examine how they discuss malaria technologies. The authors are consistently optimistic about the likelihood that there will be dramatic improvements over what is currently available. Early in the report they write, "the tools needed to overcome these challenges...are rolling out, and the research and development pipeline for new technologies has never been stronger." On the same page they continue, "the research and development pipeline is expected to yield additional new drugs and insecticides, innovative vector control strategies, and more sensitive and precise diagnostics over the coming decade. Further in the future is the radical potential of gene drive technologies" (3). They are also clear to draw a line between past historical weakness and the vast improvements they see in the present. "Technological capacities have advanced beyond recognition compared with 1969... [with] widespread access to modern information and communications technology... New and highly effective tools, a strong product pipeline, five decades of scientific research and evidence generation, and invaluable lessons from previous and current disease eradication efforts are now available to guide decision making" (7)

What they neglect to point out is that during the 1960s eradication campaign, scientists also had a highly effective new tool (DDT), a strong product pipeline, and six decades of scientific research related to mosquito control and malaria transmission patterns. The optimistic tone of the Lancet Report, characterized by what some might call hubris or naivety, mirrors that of the 1950s and the WHO's global attempt. In both cases, there was an unrealistic faith in new technological solutions. In the 1950s, it was expected that DDT would lead to eradication; today,

hopes are pinned on vaccines and genetically modified mosquitos. Both then and now, there was an overreliance on still-to-be-developed tools, an unreasonable level of optimism about how fast new tools will become available, unwavering faith in scalability and portability into vastly different ecological settings, and a baseline assumption that local communities would adopt technologies in ways imagined by scientists.

Malaria is not the only disease targeted for eradication that has fallen victim to unreasonable expectations. In *Eradication: Ridding the World of Diseases Forever?*, historian Nancy Stepan shows how past eradication campaigns targeting hookworm, yellow fever, yaws, and malaria were all hobbled by the twinned evils of incomplete scientific knowledge and scientific hubris (2013). Stepan argues that the expert communities involved in the eradication efforts were too optimistic about what they could accomplish: falling into patterns of overestimating their own knowledge while assuming their tools were more effective than they actually were and that new ones would develop faster than they actually did. This rhetoric about new technologies have been the norm for 70 years, and even before. A 1927 in a League of Nations reports described the history of special antimalarial campaigns as “chiefly a record of exaggerated expectations followed sooner or later by disappointment and abandonment of the work” (Najera et al. 2011). In all cases it would be wise to assume that not all developments will be viable over the long term, that many things in the pipeline will never come to fruition, and that some otherwise viable tools may not be accepted by communities.

Adaptation and Alternate Moral Framings

Within the Lancet Report there is a large missing discussion of how technologies are received, understood, and adopted on the continent—a blank spot that ignores the actual Africans who use the items, the communities where they will be deployed, and the alternate moral frameworks in which these items are assessed. This glaring omission shows a lack of imagination and a willful ignoring of how past “new” tools were adopted, adapted, or rejected. This is a continuation of colonial-era thinking that imagined Africa as a blank landscape where technology would be received. As an innovative paper by Kelly et al. shows, even the “sites” of malaria control (community, neighborhood, household) are often overly simplified and don’t consider the many intermediary spaces that are neither public nor private, and thus complicate the doing of an intervention (2017). In the present, the assumption seems to be that Africans will gratefully receive whatever malaria programs arrives, following a rough logic of “beggars can’t be choosers.” This idea of passive acceptance of imported items wasn’t true in the colonial period, and certainly isn’t true today.

Most technologies aren’t adopted exactly as imagined by scientists or as developed in a laboratory. Individual adaptation is widespread, both in how a particular item is used and by whom. Nets are an interesting example: they are a simple barrier that has been around more than a century, recently updated with new long-lasting synthetic materials and impregnated with insecticides. But there are myriad potential analyses involving nets. We could consider how the item is valued within the community (Alidina et al. 2016), or as objects with their own set of political economy and species entanglements, and how they have been constructed as “humanitarian goods” (Beisel 2015). Global health considerations of the net typically focus on what is considered effective use: having the most vulnerable to malaria sleeping under it at night. The “most vulnerable” to malaria are often assumed to be children under five—those with the highest mortality rates. Yet even simple nets have been an area of active adaptation, with documented uses as fishing nets, protection for domestic animals, bridal wear, or to protect

members of the household that are not young children. These alternate use—which are often labeled as “improper” or examples of “non-compliance” in many global health articles—frequently don’t indicate a misunderstanding but a different valuation of the net and its potential uses. A study from Tanzania found that when decisions had to be made about which nets to repair, men saw their nets as being a priority because of their breadwinner status (Mboma et al. 2018). This hints at different moral frameworks and calculations of whose health needs protecting: children under 5 that are at high risk of mortality if they contract malaria, as compared with adults that would likely only become sick, but whose wage earner status could imperil the wellbeing of the entire household.

This same mis-alignment of who is most in need, or who should benefit from technology, is also apparent in other areas. In community discussions about the malaria vaccine, adults questioned the utility of protecting children without doing the same for adults. The adults presented examples of different ethical frameworks, drawing on the realities of daily life. They pointed out that if adults became ill, there would be no one to care for the children, and that if adults were not protected they could pass the disease to their children (Bingham et al., 2012). Whereas global health narrowly identifies children under 5 as high risk and a target for many interventions, information from African communities indicate different assessments of need, different valuations of who should get access to protective technologies, and evidence of how preserving the health of an adult could be considered more important than the health of a young child. That’s a painful decision born out of unfair scarcity, but it’s also a decision rooted in daily realities that must be respected.

While these examples have explored some of the adaptations and alternative moral calculations around net use and malaria vaccines, all technologies come enmeshed with a set of ethical and moral questions. Radically new developments like gene drives and genetically modified mosquitoes have particularly profound ethical questions. What does it mean for a species to be a “species”? Is trying to eradicate or permanently modify a living organism ever appropriate or justified? Even if we consider mosquitoes in their non-altered forms, communities may come to different answers about whether they are best thought about as “hosts” “vectors” or “companions”—and how those classifications change how we interact with mosquitoes (Beisel et al. 2013). Answers to these questions often come wrapped up with questions about African agency and the role of communities in making decisions about if and how new technologies should be tested, how malaria and mosquitoes are thought about, and how well risks are explained by scientists and understood by participating communities. Just as there remains profound ethical problems with how information about rebound malaria and the loss of acquired immunity has not been shared with participants, potentially graver ramifications exist in the areas of technological innovation.

Conclusions

This article is meant to show that without a doubt, we must have a broader set of social science knowledge integrated into our consideration of contemporary global health problems, and that historical data should shape the global health policies we view as feasible and beneficial. By engaging carefully with the Lancet Report, we find plenty of evidence that this type of knowledge isn’t being integrated. When history is evoked, it is often in a glib or functionalist manner. We are not the first to make a case for the inclusion of historical knowledge when it comes to running malaria intervention. Webb challenged policy makers to pay attention to the “historical epidemiology” of diseases as a way to more realistically understand how

mathematical models and scientific concepts would apply in unique cultural and historical contexts (2015). We see this article as additional evidence of the necessity of this task.

The unwillingness to integrate social science knowledge, or the take it seriously isn't necessarily a new phenomenon. Although the WHO commissioned social science research on malaria in the 1970s and 1980s, Malaria Program officials never felt the "right" questions were being addressed (Packard and Brown 1997). Into the present, we have to be aware of the "cycles of public health amnesia" and the "malarias that have been forgotten" (Kelly and Beisel 2011). Keeping a historical mindset encourages practitioners of global health to more critically engage with the structures upon which this field was built. As Nora Kenworthy, Lynn Hunt, Johanna Crane, and Iruka Okeke have pointed out, the partnerships upon which global health functions on are often inequitable, impermanent, and rooted in the histories of colonialism and racism (Crane 2010; Kenworthy et al. 2018; Okeke 2018).

A hard look at what we've already tried in terms of malaria interventions will allow us to more realistically imagine the future. Many historians of medicine and malaria experts believe eradication isn't feasible. Global health's myopic approach allows them to miss the striking similarities between the 1950s attempt and the situation today, to overlook problems that continue to exist, and to overestimate technological solutions that aren't fully materialized. We need to think carefully, proceed slowly, and more fully engage local communities where malaria is still present to better understand how they view malaria, and what interventions they believe are most appropriate. As a recent paper by Finda et al. has shown, when local residents are clearly asked about what malaria interventions they would like, their preferences take into consideration far more than just technical efficiency (2020). Without recognizing the hard realities of failed past interventions, and calling them as such, we run the risk of endangering people globally even while trying to do something good.

There are many other important themes related to malaria in Africa that are not touched on here. Climate change, in particular, is of paramount importance and has the potential to make vulnerable communities more vulnerable and to extend malarial zones by increasing mosquito habitats through warming climates and changing rainfall patterns. We also know that malaria is not the only disease afflicting people on the continent, and that there are unfortunate synergies between malaria, tuberculosis, HIV, and now Covid-19. These relationships play out in individual bodies as people suffer from multiple maladies; affect how governments can divide limited public health and medical resources; and change how communities judge the gravity of malaria in relation to other threats and uncertainties. We also have not touched on the disagreements between many malaria-endemic communities and funders from the Global North about how urgent, large and pressing of a problem malaria is (Gerretts 2010) or more creative approaches to considering malaria as an interspecies condition (Kelly and Lezaun 2014).

There is great value in conducting global health research that has direct application, but it can lead to a blindness toward broader social and historical conditions, which is apparent in the Lancet Report. Humanists and social scientists can serve as a bulwark against the global health tendency to always want to generalize from the particular and make all findings scalable and portable. As Clare Chandler and Uli Beisel noted, it is important to attend to "granularity and locality" and to "push beyond simplified, standardized tools for malaria control and measurement" (2017). Africanists can insist on the particularities and peculiarities, showing the value of zooming in on a single place at a single time. It's now time for social scientists to get more involved in these deliberations, to broaden the types of knowledge drawn upon and integrated, and to more forcefully integrate historical case studies and forms of vernacular

knowledge that challenge and complicate past conclusions. We should be thinking hard about the ethical questions raised by interventions, eradication attempts, and failures and the different moral worlds in which new technologies will circulate.

Global health policy is being made, important initiatives are being proposed, and billions of dollars spent, all trying to address the narrow topic of malaria and the broader topic of improvements to global health. It is worth pondering whether we, as humanists and social scientists with expertise on the African continent, have an obligation to join in this conversation, to insert ourselves into the dialogue and to help integrate forms of knowledge that are currently excluded, to write in more accessible ways, and publish outside of our discipline-specific journals where practitioners might be more likely to encounter our work. It's not a new sentiment. Susanna Hausmann-Muela and Julian Eckl rightly pointed out in 2015 that social scientists "have struggled in the past to find an appropriate platform within the malaria community that provides them the opportunity to address researchers from other disciplines, malaria practitioners, and policy makers." Unfortunately, their observation remains true. A case must be made for the value and importance of historical knowledge, anthropological knowledge, and local forms of knowledge. That case must be made by people like us.

References

- Adams, Vicanne. 2016. *Metrics: What Counts in Global Health*. Durham, N.C.: Duke University Press.
- Alidina, Zainab, Rajeev Colaco, Abdullah S. Ali, Juma H. Mchac, Charles D. Mwalimud, Narjis G. Thawera, Shabbir Laljia, Joshua Mutagahywaa, Mahdi M. Ramsana, Jessica M. Kafuko, et al. 2016. "Taking Local Ownership: Government and Household Contribution to Indoor Residual Spraying in Zanzibar and Mainland Tanzania." *Int Health* 8: 299-306.
- "Assessment of Zanzibar Map." Weeks to Regional Director AFRO. August 16, 1963. WHO/M2/372/3/TANZ. World Health Organization Archive.
- Beisel, Uli. 2015. "Markets and Mutations: Mosquito Nets and the Politics of Disentanglement in Global Health." *Geoforum* 66: 146-155.
- Beisel, Uli, and John Kuumuori Ganle. 2019. "The Release of Genetically Engineered Mosquitoes in Burkina Faso: Bioeconomy of Science, Public Engagement and Trust in Medicine." *African Studies Review* 62 (3): 164-173.
- Beisel, Uli, Ann H. Kelly, and Noémi Tousignant. 2013. "Knowing Insects: Hosts, Vectors and Companions of Science." *Science as Culture* 22 (1): 1-15.
- Benton, Adia. 2012. "Exceptional Suffering? Enumeration and Vernacular Accounting in the HIV-Positive Experience." *Medical Anthropology* 31 (4): 310-28.
- Bingham, Allison, Felisbela Gaspar, Kathryn Lancaster, Juliana Conjera, Yvette Collymore, and Antoinette Ba-Nguz. 2012. "Community Perceptions of Malaria and Vaccines in Two Districts of Mozambique." *Malaria Journal* 11 (1): 394.
- Biruk, Crystal. 2018. *Cooking Data: Culture & Politics in an African Research World*. Durham, N.C.: Duke University Press.
- Brown, Peter J. 1999. "Failure-as-Success: Multiple Meanings of Eradication in the Rockefeller Foundation Sardinia Project, 1946-1951." *Parassitologia* 40 (1): 117-130.
- Brown, Peter J. 1997. "Culture and the Global Resurgence of Malaria." In *The Anthropology of Infectious Disease: International Health Perspectives*, edited by Marcia C. Inhorn and Peter J. Brown, 119-141. London: Routledge.
- Chandler, Clare IR, and Uli Beisel. 2017. "The Anthropology of Malaria: Locating the Social." *Medical Anthropology* 36 (5): 411-421.
- Cohen, Justin M., David L. Smith, Chris Cotter, Abigail Ward, Gavin Yamey, Oliver J. Sabot, and Bruno Moonen. 2012. "Malaria Resurgence: A Systematic Review and Assessment of Its Causes." *Malaria Journal* 11 (1): 1-17.
- Cohen, Justin M., Bruno Moonen, Robert W. Snow, and David L. Smith. 2010. "How Absolute is Zero? An Evaluation of Historical and Current Definitions of Malaria Elimination." *Malaria Journal* 9 (1): 1-13.
- Corbellini, G. 1998. "Acquired Immunity Against Malaria as a Tool for the Control of the Disease: The Strategy Proposed by the Malaria Commission of the League of Nations in 1933." *Parassitologia* 10 (1-2): 109-115.
- Cueto, Marcos. 2007. *Cold War, Deadly Fevers: Malaria Eradication in Mexico, 1955-1975*. Baltimore, M.D.: Johns Hopkins University Press.
- Crane, Johanna T. 2010. "Unequal 'Partners'. AIDS, Academia, and the Rise of Global Health." *BEHEMOTH-A Journal on Civilisation* 3 (3): 78-97.
- Dattoo, Mehreen S. and Magloire Natama, Hamtandi, et al. April 20, 2021. "High Efficacy of a Low Dose Candidate Malaria Vaccine, R21 in 1 Adjuvant Matrix-M™, with Seasonal Administration

- to Children in Burkina Faso." Available at SSRN: <https://ssrn.com/abstract=3830681> or <http://dx.doi.org/10.2139/ssrn.3830681>
- Dobson, M.J., M. Malowany, and R.W. Snow. 2000. "Malaria Control in East Africa: The Kampala Conference and the Pare-Taveta Scheme: A Meeting of Common and High Ground." *Parassitologia* 42 (1-2): 149-66.
- Eckl, Julian. 2017. "The Social Lives of Global Policies Against Malaria: Conceptual Considerations, Past Experiences, and Current Issues." *Medical Anthropology* 36 (5): 422-435.
- Feachem, Richard GA, Allison A. Phillips, Jimee Hwang, Chris Cotter, Benjamin Wielgosz, Brian M. Greenwood, Oliver Sabot, Mario Henry Rodriguez, Rabindra R. Abeyasinghe, Tedros A. Ghebreyesus, et al. 2010. "Shrinking the Malaria Map: Progress and Prospects." *Lancet* 376 (9752): 1566–1578.
- Finda, Marceline F., Nicola Christofides, Javier Lezaun, Brian Tarimo, Prosper Chaki, Ann H. Kelly, Ntuli Kapologwe, Paul Kazyoba, Basiliana Emidi, and Fredros O. Okumu. 2020. "Opinions of Key Stakeholders on Alternative Interventions for Malaria Control and Elimination in Tanzania." *Malaria Journal* 19 (164): 1-13.
- Fleisch, Axel, and Rhiannon Stephens, eds. 2016. *Doing Conceptual History in Africa*. Vol. 25. New York: Berghahn Books.
- Gerrets, René P. 2010. "Globalizing International Health: The Cultural Politics of 'Partnership' in Tanzanian Malaria Control." PhD diss. New York University.
- Gessler, Monika C., D. E. Msuya, M. H. H. Nkunya, A. Schär, Michael Heinrich, and Marcel Tanner. 1995. "Traditional Healers in Tanzania: The Perception of Malaria and its Causes." *Journal of Ethnopharmacology* 48 (3): 119–130.
- Giles-Vernick, Tamara, Abdoulaye Traoré, and Sodiomon B. Sirima. 2011. "Malaria, Environmental Change, and a Historical Epidemiology of Childhood 'Cold Fevers': Popular Interpretations from Southwestern Burkina Faso." *Health & Place* 17 (3): 836-42.
- Graboyes, Melissa. 2015. *The Experiment Must Continue: Medical Research and Ethics in East Africa, 1940–2014*. Athens: Ohio University Press.
- Graboyes, Melissa. 2014. "'The Malaria Imbroglia': Ethics, Eradication, and Endings in Pare Taveta, East Africa, 1959-1960." *International Journal of African Historical Studies* 47 (3): 445-472.
- Griffin, Jamie T., T. Déirdre Hollingsworth, Hugh Reyburn, Chris J. Drakeley, Eleanor M. Riley, and Azra C. Ghani. 2015. "Gradual Acquisition of Immunity to Severe Malaria with Increasing Exposure." *Biological Sciences* 282 (1801): 2014–2657.
- Hausmann-Muela, Susanna, and Julian Eckl. 2015. "Re-imagining Malaria—A Platform for Reflections to Widen Horizons in Malaria Control." *Malaria Journal* 14 (1): 1-3.
- Herren, Jeremy K., Lilian Mbaisi, Enock Mararo, Edward E. Makhulu, Victor A. Mobegi, Hellen Butungi, Maria Vittoria Mancini, Joseph W. Oundo, Evan T. Teal, Silvian Pinaud, et al. 2020. "A Microsporidian Impairs *Plasmodium falciparum* Transmission in *Anopheles arabiensis* Mosquitoes." *Nature Communications* 11: 2187.
- Humphreys, Margaret. 2001. *Malaria: Poverty, Race, and Public Health in the United States*. Baltimore, M.D.: The Johns Hopkins University Press.
- Issa, Amina. 2011. "Malaria and Public Health Measures in Colonial Urban Zanzibar, 1900-1956." *Hygiea Internationalis* 10 (2): 35-51.
- Jerven, Morten. 2013. *Poor Numbers: How We Are Misled by African Development Statistics and What to Do about It*. Ithaca, N.Y.: Cornell University Press.
- Kamat, Vinay. 2008. "Dying Under the Bird's Shadow: Narrative Representations of *Degegede* and Child Survival Among the Zaramo of Tanzania." *Medical Anthropology Quarterly* 22 (1): 67-93.

- Kamat, Vinay R. 2013. *Silent Violence: Global Health, Malaria, and Child Survival in Tanzania*. Tuscon, A.Z.: The University of Arizona Press.
- Kelly, Ann H., Hermione N. Boko Koudakossi, and Sarah J. Moore. 2017. "Repellents and New 'Spaces of Concern' in Global Health." *Medical Anthropology* 36 (5): 464-478.
- Kelly, Ann H. and Javier Lezaun. 2014. "Urban Mosquitoes, Situational Publics, and the Pursuit of Interspecies Separation in Dar es Salaam." *American Ethnologist* 41 (2): 368-383.
- Kelly, Ann H. and Uli Beisel. 2011. "Neglected Malaria: The Frontlines and Back Alleys of Global Health." *Biosocieties* 6 (1): 71-87.
- Kenworthy, Nora, Lynn M. Thomas, and Johanna Crane. 2018. "Introduction: Critical Perspectives on US Global Health Partnerships in Africa and Beyond." *Medicine Anthropology Theory* 5 (2): i-ix.
- Kilama, Wen L. 2010. "Health Research Ethics in Malaria Vector Trials in Africa." *Malaria Journal* 9 (suppl. 3): 1-9.
- Koenker, Hannah M, Dana Loll, Datus Rweyemamu, and Abdullah S. Ali. 2013. "A Good Night's Sleep and the Habit of Net Use: Perceptions of Risk and Reasons for Bed Net Use in Bukoba and Zanzibar." *Malaria Journal* 12 (1): 1-12.
- Kresse, Kai. 2018. *Swahili Muslim Publics and Postcolonial Experience*. Bloomington: Indiana University Press.
- Langhorne, Jean, Francis M. Ndungu, Anne-Marit Sponaas, and Kevin Marsh. 2008. "Immunity to Malaria: More Questions Than Answers." *Nature Immunology* 9 (7): 725-732.
- Langwick, Stacey. 2011. *Bodies, Politics and African Healing: The Matter of Maladies in Tanzania*. Bloomington: Indiana University Press.
- Livingston, Julie. 2007. "Productive Misunderstandings and the Dynamism of Plural Medicine in Mid-Century Bechuanaland." *Journal of Southern African Studies* 33 (4): 801-810.
- Litsios, Socrates. 2015. "Re-Imagining the Control of Malaria in Tropical Africa During the Early Years of the World Health Organization." *Malaria Journal* 14 (1): 1-9.
- Mapua, Salum A., Marceline F. Finda, Ismail H. Nambunga, Betwel J. Msugupakulya, Kusirye Ukio, Prosper P. Chaki, Frederic Tripet et al. 2021. "Addressing Key Gaps in Implementation of Mosquito Larviciding to Accelerate Malaria Vector Control in Southern Tanzania: Results of a Stakeholder Engagement Process in Local District Councils." *Malaria Journal* 20 (1): 1-14.
- Mavhunga, Clapperton. 2018. *The Mobile Workshop: The Tsetse Fly and African Knowledge Production*. Cambridge: MIT Press.
- Mboma, Zawadi M., Angel Dillip, Karen Kramer, Hannah Koenker, George Greer, and Lena M. Lorenz. 2018. "'For the Poor, Sleep Is Leisure': Understanding Perceptions, Barriers and Motivators to Mosquito Net Care and Repair in Southern Tanzania." *Malaria Journal* 17 (1): 375.
- Molineaux, Louis and Gabriele Gramiccia. 1980. *The Garki Project: Research on the Epidemiology and Control of Malaria in the Sudan Savanna of West Africa*. Geneva: World Health Organization.
- Murray, Christopher JL, et al. 2012. "Global malaria mortality between 1980 and 2010: a systematic analysis." *The Lancet* 379 (9814): 413-31.
- Nading, Alex M. 2015. "The Lively Ethics of Global Health GMOs: The Case of the Oxitec Mosquito." *Biosocieties* 10: 24-47.
- Nájera, José A., Matiana González-Silva, and Pedro L. Alonso. 2011. "Some Lessons for the Future from the Global Malaria Eradication Programme (1955-1969)." *PLoS medicine* 8 (1): e1000412.
- Nash, Linda. 2007. *Inescapable Ecologies: A History of Environment, Disease, and Knowledge*. Berkeley, C.A.: University of California Press.

- Ndebele, P and R. Musesengwa. 2012. "View Point: Ethical Dilemmas in Malaria Vector Research in Africa: Making the Difficult Choice Between Mosquito, Science, and Humans." *Malawi Medical Journal*, 24 (3): 65-68.
- Okeke, Iruka. 2011. *Divining without Seeds: The Case for Strengthening Laboratory Medicine in Africa*. 1st ed. Ithaca: N.Y.: Cornell University Press.
- Okeke, Iruka. 2018. "Partnerships for Now? Temporality, Capacities, and the Durability of Outcomes from Global Health 'Partnerships.'" *Medical Anthropology Theory* 5 (2): 7-14.
- Osero, J. S. O., M. F. Otieno, and A. S. S. Orago. 2006. "Mothers' Knowledge on Malaria and Vector Management Strategies in Nyamira District, Kenya." *East African Medical Journal*, 83 (9).
- Packard, Randall. 1996. "Agricultural Development, Migrant Labor and the Resurgence of Malaria in Swaziland." *Social Science and Medicine*. 22 (8): 861-867.
- Packard, Randall. 2007. *The Making of a Tropical Disease*. Baltimore: Johns Hopkins University Press.
- Packard, Randall M., and Peter J. Brown. 1997. "Rethinking Health, Development, and Malaria: Historicizing a Cultural Model in International Health." *Medical Anthropology* 17 (3): 181-194.
- Smith, DL, Cohen JM, Chiyaka C, Johnston G, Gething PW, Gosling R, Buckee CO, Laxminarayan R, Hay SI, Tate AJ. 2013. "A Sticky Situation: the Unexpected Stability of Malaria Elimination." *Philosophical Transactions of the Royal Society*. 368.
- Snowden, Frank M. 2006. *The Conquest of Malaria: Italy, 1900-1962*. New Haven, C.T.: Yale University Press.
- Stepan, Nancy Leys. 2013. *Eradication: Ridding the World of Diseases Forever?*. Ithaca, N.Y.: Cornell University Press.
- Tichenor, Marlee. 2017. "Data Performativity, Performing Health Work: Malaria and Labor in Senegal." *Medical Anthropology* 36 (5): 436-448.
- Tilley, Helen. 2011. *Africa as a Living Laboratory: Empire, Development, and the Problem of Scientific Knowledge, 1870-1950*. Chicago: University of Chicago Press.
- Trape, Jean-François, Adama Tall, Cheikh Sokhna, Alioune Badara Ly, Nafissatou Diagne, Ousmane Ndiath, Catherine Mazenot, Vincent Richard, Abdoulaye Badiane, Fambaye Dieye-Ba, et al. 2014. "The Rise And Fall Of Malaria In A West African Rural Community, Dielmo, Senegal, From 1990 To 2012; A 22 Year Longitudinal Study." *The Lancet Infectious Diseases* 14 (6): 476-488.
- Webb, James. 2009. *Humanity's Burden: A Global History of Malaria*. Cambridge, M.A.: Cambridge University Press.
- Webb J. L. Jr . 2011. "The First Large-scale Use of Synthetic Insecticide for Malaria Control in Tropical Africa: Lessons from Liberia, 1945-1962." *Journal of the History of Medicine and Allied Sciences*, 66 (3): 347-376.
- Webb, James. 2014. *The Long Struggle against Malaria in Tropical Africa*. Cambridge, U.K.: Cambridge University Press.
- Webb, James. 2015. "The Art of Medicine: The Historical Epidemiology of Global Disease Challenges." *The Lancet*, 385: 322-323.
- Whyte, Susan R. 1997. *Questioning Misfortune: The Pragmatics of Uncertainty in Eastern Uganda*. 1st ed. Cambridge, U.K.: Cambridge University Press.
- World Health Organization. 1958. Present Status of the World-wide Malaria Eradication Effort. Executive Committee Session 23 Documents. Collection EB23. World Health Organization, Geneva. <https://apps.who.int/iris/handle/10665/132647>.

- World Health Organization. 1966. Report on the Development of Malaria Eradication Programme. World Health Assembly 19 Documents. Collection WHA19. World Health Organization, Geneva. <https://apps.who.int/iris/handle/10665/137297>.
- World Health Organization. 1968. Report on the Development of Malaria Eradication Programme. World Health Assembly 21 Documents. Collection WHA21. World Health Organization, Geneva. <https://apps.who.int/iris/handle/10665/143487?locale-attribute=es&>.
- World Health Organization. 2019. "Countries and Territories Certified Malaria-free by WHO." Last Modified May 22, 2019. <https://www.who.int/malaria/areas/elimination/malaria-free-countries/en/>.
- World Health Organization. 2020. *World Malaria Report 2020*. Geneva: World Health Organization. <https://www.who.int/publications/i/item/9789240015791>.
- Yip, Ka-che, ed. 2009. *Disease, Colonialism, and the State: Malaria in Modern East Asian History*. Hong Kong, China: Hong Kong University Press.
- "Zanzibar 2nd Quarter Report." Undated. Handwritten Memorandum. From EA to PP. WHO/M2/372/3/TANZ. World Health Organization Archive.

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