**Perspective**

Nigeria’s War on Terror: Fighting Dracunculiasis, Onchocerciasis, Lymphatic Filariasis, and Schistosomiasis at the Grassroots


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**Abstract.** Africa’s populous country, Nigeria, contains or contained more cases of dracunculiasis, onchocerciasis, lymphatic filariasis, and schistosomiasis than any other African nation and ranks or ranked first (dracunculiasis, onchocerciasis, schistosomiasis) or third (lymphatic filariasis) in the world for the same diseases. After beginning village-based interventions against dracunculiasis 20 years ago and confronting onchocerciasis a few years later, Nigeria has nearly eliminated dracunculiasis and has provided annual mass drug administration for onchocerciasis to over three quarters of that at-risk population for 7 years. With assistance from The Carter Center, Nigeria began treating lymphatic filariasis and schistosomiasis in two and three states, respectively, over the past decade, while conducting pioneering operational research as a basis for scaling up interventions against those diseases, for which much more remains to be done. This paper describes the status of Nigeria’s struggles against these four neglected tropical diseases and discusses challenges and plans for the future.

**INTRODUCTION**

With ~20% of the population of sub-Saharan Africa, Nigeria (estimated 2006 population of 140 million) is or once was the most highly affected country in Africa for dracunculiasis (Guinea worm), onchocerciasis (river blindness), schistosomiasis (Bilharziasis), and lymphatic filariasis (elephantiasis) in numbers of cases, while also ranking among the top three endemic countries globally. Although effective ways to prevent dracunculiasis have been known since early in the 20th century, practical annual mass drug administration (MDA) for the other three diseases became available only in the past few decades. Despite its significant political challenges in modern times, Nigeria began waging war on two of these microbial terrorists (dracunculiasis and onchocerciasis) about two decades ago and began a similar community-based combat against the others subsequently.¹⁻⁴ This paper describes the current status of these four struggles in Nigeria and their implications for Africa and the world.

**COMBATTING THE FOUR TERRORISTS**

**Dracunculiasis.** Two- or 3-ft long worms (*Dracunculus medinensis*) emerging through the skin are the painful hallmark of dracunculiasis, which people contract by drinking water from open sources such as stagnant ponds that contain immature parasites in tiny copepods (water fleas). There is no treatment or cure for dracunculiasis, but it can be prevented by filtering drinking water through a finely woven cloth, by teaching villagers to avoid entering water sources when a worm is emerging, by using a mild larvicide (ABATE, temephos; BASF, Mount Olive, NJ) to kill copepods and parasites in the water, and by providing safe sources of clean water, such as from borehole wells. Affected persons are incapacitated for an average of 4–8 weeks, reducing agricultural productivity and school attendance.³

Nigeria’s national Guinea Worm Eradication Program (NIGEP) got underway after a national conference in March 1985 publicized qualitative evidence that showed for the first time that dracunculiasis was a problem throughout the country,⁶ and underscored the fact that there were effective ways to prevent it. Medical geographer Susan Watts⁵ estimated in 1986 that Nigeria (estimated 1986 population of 98 million) accounted for 2.5 million (75%) of 3.32 million Africans with dracunculiasis and 25% (30/120 million) of the African population at risk. Nigeria conducted the first quantitative nationwide village-by-village search for cases of the disease in Africa in 1988–1989,⁸ which documented 653,492 cases of dracunculiasis (more than any other country) in 5,872 Nigerian villages (Figure 1).⁷ Systematic interventions began immediately, and starting in 1991 were based on village-based volunteers who were trained to conduct health education, distribute cloth filters, and report cases monthly. ABATE larvicide was applied monthly during the transmission season to water sources in the most highly affected villages by special teams, and water supply agencies were urged to give priority to villages where Guinea worm disease was endemic. Supervision, surveillance, and supplies were organized around administrative levels from village to local government area (LGA), state, zone, and nation.¹ The political and financial leadership provided by former Nigerian Federal Minister of Health, the late Prof Olikoye Rasosme-Kuti, resulted in several infusions of Nigerian cash at key points during the program, including $2 million donated to The Carter Center by the Federal Government of Nigeria to help support NIGEP. The willingness of Nigeria to invest in its program stimulated further investment by outside donors.

Cases of dracunculiasis fell rapidly from 653,492 in 1989 to 39,774 by 1994, but this was followed by 5 years of inadequate funding and poor program execution, during which reported annual incidence hovered between 12,000 and 17,000 cases. Progress resumed after The Carter Center appointed a Nigerian country director in 1998, recruited former Nigerian head of state General (Dr) Yakubu Gowon as the chief

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advocate for the program in 1999, and obtained adequate external funding through a generous grant from the Bill & Melinda Gates Foundation in 2000. General Gowon visited local officials and affected communities to press for action and also encouraged the water sector to focus more on provision of safe water points for endemic communities. By 2007, Nigeria reported only 73 cases of dracunculiasis, from four villages, after a small unexpected outbreak that was discovered early that year, while ~6.2 million Nigerians are still at risk of the disease. A complete report of this campaign will be published later.

**Onchocerciasis.** Microscopic infectious larvae of the filarial worm *Onchoerca volvulus* enter humans with the bite of tiny *Simulium* black flies, which breed in fast-flowing rivers. Onchocerciasis (river blindness) is manifest as the larvae mature to adults, gather in nodules, mate, and produce millions of microfilariae that migrate to the skin, where they cause intense itching and are available to be picked up by subsequent black flies and continue the cycle, and to the eye, where they may cause blindness after several years of repeated infections. The itching may prevent victims from working, or concentrating in school, and causes some to disfigure their skin by repeated scratching. Onchocerciasis can be controlled by annual MDA with ivermectin (Mectizan; Merck, Rahway, NJ) at a dose of 150 μg/kg, estimated by height.

Nigeria was not included in the regional Onchocerciasis Control Program (OCP) that began helping control the disease by insecticidal spraying in 11 other West African countries from 1974. After Merck began donating the microfilaricidal drug Mectizan (ivermectin) for MDA of onchocerciasis in 1987, however, several non-governmental organizations (NGOs) started helping local Nigerian health authorities provide some of the first MDA programs in Africa in 1989 after surveys to determine the extent and intensity of onchocerciasis began in Kaduna State in 1989. Plateau State launched its program in 1992 (Plateau was divided into Plateau and Nasarawa States in 1997). After Nigeria and 18 other African countries were included in the new African Program for Onchocerciasis Control (APOC), which was launched in December 1995 to help support MDA of Mectizan, the Rapid Epidemiological Mapping of Onchocerciasis (REMO) methodology developed by APOC was completed nationwide.
in Nigeria with support from APOC in 2003 (Figure 1; www.who.int/apoc/countries/nga/en/index.html). The APOC strategy is to treat only communities in areas where REMO estimated the prevalence of onchocerciasis skin nodules to be 20% or more; populations living in villages where nodule prevalence is 19% or less are not eligible for mass treatment. Based on that treatment threshold, it is estimated that 30 million persons require MDA for onchocerciasis in Nigeria, which is almost 36% of the 82 million Africans at risk of the disease, making Nigeria the most endemic country in the world for onchocerciasis. 16

With APOC’s financial assistance to Nigeria beginning in 1996, the Nigerian Onchocerciasis Control Program (NOCP) and its many NGO partners 17, 18 shifted from a strategy of village-based volunteers that included some volunteers inherited from the Guinea Worm Eradication Program, 14 to the Community-Directed Treatment with Ivermectin (CDTI) strategy advocated by APOC. 2, 19 Like their predecessors, volunteer CDTI workers educated their neighbors about onchocerciasis and distributed the annual mass treatment with Mectizan, but unlike their predecessors, the CDTI workers were chosen by the community (not by the village chief or health workers), who also decided when and how Mectizan would be distributed in their community.

The number of mass Mectizan treatments administered in Nigeria increased from < 0.6 million in 1992 to > 20 million treatments in 2007 (Figure 2), thus reaching ~77% of the estimated 30 million Nigerians who are at risk of onchocerciasis (Figure 3). Nigeria has administered a cumulative total of > 175 million treatments for onchocerciasis in 1989–2007. The Carter Center has helped document the impact of MDA for onchocerciasis in a few sites in Nigeria (Figure 4), which confirmed 95% reductions in onchocercal nodules between 1992/93 and 2005 in Plateau and Nasarawa States (Umaru J, personal communication) and 94% reduction in poor visual acuity between 1995 and 2002 in Imo State. 20

**Lymphatic filariasis.** The swollen legs, arms, and scrotums of persons affected by advanced lymphatic filariasis (LF), caused in Africa by *Wuchereria bancrofti*, are a constant source of suffering and ostracism to its victims and an unforgettable sight to others. These filarial worms are transmitted to humans in Africa by bites of *Anopheles* (which also transmit malaria) and *Culex* mosquitoes. Recognition that simultaneous annual oral administration of ivermectin (Mectizan; donated by Merck for treatment of LF in sub-Saharan Africa at 150μg/kg, estimated by height) and albendazole (donated by GlaxoSmithKline, Brentford, Middlesex, UK; at 400 mg/dose) could suppress microfilaremia and interrupt the transmission cycle by blocking vector infection, availability of rapid diagnostic tests (immunochromatographic card tests [ICT]) 21 that detect specific filarial antigen and do not require nocturnal blood sampling (in Africa microfilariae only circulate at night), which allowed for rapid mapping of the condition, together with the large donation of mectizan and albendazole, allows great opportunity for elimination of LF transmission. 22, 23 Of the estimated 400 million Africans at risk of LF, 24 80 million (20%) are believed to be Nigerians, and Nigeria contains 25 million (54%) of the estimated 46 million Africans with the disease. 25

![Figure 2](image-url)  
**Figure 2.** MDA for onchocerciasis, LF, and schistosomiasis in Nigeria: absolute numbers of treatments provided in 1989–2008. Schistosomiasis treatments with praziquantel began in 1999, and LF treatments with combined ivermectin and albendazole in 2000, although in amounts too small to be easily seen relative to onchocerciasis treatments (with ivermectin) bars of graph. Overlapping LF and onchocerciasis treatments are counted twice: once in the LF bar and again in the onchocerciasis bar. * Schistosomiasis and LF 2008 figures are provisional through July reports for Carter Center–assisted programs. The 2008 national onchocerciasis treatment numbers are projections.
Given the similar modes of intervention by annual MDA and health education, The Carter Center and officials in Plateau State and the Federal Ministry of Health began planning in 1997 to study whether control measures against LF and urinary schistosomiasis (see below) could be safely, effectively, and more efficiently combined with interventions against onchocerciasis as a pilot test for possible expansion to other areas of the country. Mapping of lymphatic filariasis began in Plateau and Nasarawa States in 1999 and extended to other states beginning in 2001, with mobile teams using ICTs on a sample up to 100 randomly chosen adults per village. LF mapping has now been completed in 33 of Nigeria’s 36 states and is underway in the 3 remaining states and Federal Capital Territory, with a goal of completing the whole country by early in 2009 (Figure 1). Mapping thus far has confirmed that LF is more widespread than onchocerciasis. For example, although 12 of the LGAs of Plateau and Nasarawa States met APOC requirements for MDA for onchocerciasis, all 30 LGAs required MDA with Mectizan and albendazole for lymphatic filariasis.

Health education and MDA for LF began in two LGAs of Plateau and Nasarawa States in 2000 and expanded to all 30 LGAs by 2003, using the same village volunteers as for onchocerciasis, where available, and training new volunteers where necessary. In 2007, Plateau and Nasarawa (combined population now ~4.5 million) administered >3.4 million combined treatments with Mectizan and albendazole, a year that was the fifth, sixth, or seventh year of MDA exceeding 85% coverage of the treatment population. A cumulative total of >19 million treatments for LF have been administered in 2000–2007 (Figure 2). Assessments of impact in sentinel villages in Plateau and Nasarawa States showed that, as of 2007,
the prevalence of positive ICT serologic tests for LF had been reduced by 83% (Miri E, personal communication) (Figure 4), and average mosquito infection rates had been reduced by 92%. The program is actively assessing whether transmission of LF in some LGAs has been interrupted and whether MDA with Mectizan and albendazole might be able to be stopped in those LGAs in 2009. More rapid and earlier national expansion of MDA for LF did not take place because of the absence of additional funding to complete LF mapping and the initial difficulties in integrating LF activity with APOC-funded nationwide MDA with Mectizan. In 2007, however, MDA programs for LF (integrated within onchocerciasis program areas) were finally launched in states outside of Plateau and Nasarawa, beginning in Ekiti, Ondo, and Osun, but this still represents only about 5% of the estimated at-risk population (Figure 3). In 2008, ~4.7 million persons (~6%) are expected to be treated in the five states, and in 2009, LF MDA should reach 7.5 million treatments, with expansion planned for selected LGAs in Oyo, Bauchi, Benue, Gombe, Ogun, Taraba, and Adamawa States.

Schistosomiasis. School-aged children playing in ponds and rivers comprise the group most important to transmission of schistosomiasis, which in Nigeria is caused mainly by infection with Schistosoma hematobium and S. mansoni, which cause urinary and intestinal schistosomiasis, respectively. Either or both forms of this parasite occur throughout Nigeria. This disease is an occupational hazard for fishermen and rice farmers and a potential threat to anyone exposed to freshwater that has been contaminated by human feces or urine containing the parasite’s eggs from previous victims. The larval stages of this parasite emerge from specific snails that serve as intermediate hosts, penetrate the skin, and mature in veins serving the bladder (S. hematobium) or intestines (S. mansoni). Adult female worms lay thousands of tiny spiked eggs that damage blood vessels before emerging in feces or urine that may be deposited in fresh water where the eggs hatch, and emerging parasites infect and multiply in the snails, thus completing that parasite’s life cycle. Patients may experience bloody urine or stools, and after several years, scarring of the intestines, bladder, kidneys, liver, and/or lungs, with potential complications of anemia, liver failure, heart failure, renal failure, or bladder cancer. Schistosomiasis can be controlled by annual MDA with praziquantel (40 mg/kg). The estimated 101 million Nigerians at risk of schistosomiasis account for ~21% of the estimated 477 million Africans at risk of that disease; this makes Nigeria the most endemic country in the world for schistosomiasis.

Nigeria’s FMOH conducted a qualitative questionnaire survey of health officials, and teachers nationwide in 1991 aimed at reporting bloody urine to determine crude distribution for S. hematobium throughout the country. Plateau and Nasarawa States began quantitatively mapping urinary schistosomiasis with mobile teams using heme reagent dipstick tests of urine (to detect hematuria) on randomly selected school children 5–14 years of age in each village in two LGAs in 1999, whereas similar dipstick surveys began in Delta State in 2003 and in Ekiti and Ondo States in 2008 (Figure 1). Mapping of intestinal schistosomiasis has lagged because of the absence of a rapid diagnostic test and the requirement of a stool examination for eggs conducted by a trained microscopist, although some S. mansoni mapping has recently taken place in Plateau and Nasarawa.

Health education and MDA with praziquantel against urinary schistosomiasis began in 1999 in Plateau and Nasarawa States, in 2004 in Delta State, and in 2008 in Ekiti, integrated with the existing network for combating onchocerciasis and LF in Plateau and Nasarawa and onchocerciasis in Delta, using WHO treatment criteria (communities with hematuria rates in children of 20–49% receive mass treatment of school age children, and communities where ≥50% of school age children have hematuria receive MDA for the entire community). The integrated MDA program has ultimately evolved into a complex mosaic of different drug combinations of mass treatments that were indicated for onchocerciasis, LF, and schistosomiasis (Figure 5).

Nigeria treated 202,941 persons for schistosomiasis using praziquantel in 2007 and a cumulative total of 1 million treatments in 1999–2007 (Figure 3). A major donation of praziquantel from E-Merck (Germany) through WHO allowed Nigeria to treat another one million school-aged children in 2008, which still comprises only ~1% of the estimated 101 million Nigerians believed to need treatment for schistosomiasis, which is more than any other country in the world. MDA with praziquantel was provided at least 1 week before or after MDA with Mectizan and albendazole (or Mectizan alone), until October 2006, after WHO provided data showing that simultaneous administration of all three drugs was safe. Monitoring of children in the first two districts where interventions began in Plateau and Nasarawa States has shown an average reduction of 94% in the prevalence of bloody urine as measured by dipstick (Figure 4).

Other operational research conducted in Nigeria includes rotation of praziquantel MDA to other schistosomiasis-endemic communities after three to five annual rounds of treatment in individual communities, assessment of missed opportunities for mass treatment of S. mansoni in communities that do not qualify for MDA because of absent or lower rates of S. hematobium, and combined surveys for schistosomiasis and trachoma.

**DISCUSSION**

Nigeria’s success and leadership in combating two of these four diseases (dracunculiasis and onchocerciasis) by nationwide mapping, community-based interventions, monitoring coverage and impact of the interventions, and conducting operational research are significant in their own right, but gains even more importance when Nigeria’s continental prominence is considered. Dracunculiasis’ extensive prevalence, available control measures, the early political and financial leadership provided by former Nigerian Federal Minister of Health, the late Prof Olikoye Ransome-Kuti, and later advocacy by former Nigerian Head of State General (Dr) Yakubu Gowon were critical ingredients in Nigeria’s success against dracunculiasis. The fact that Nigeria has nearly eradicated dracunculiasis and has provided treatment of onchocerciasis to over three quarters of its at-risk population for several years now (well above APOCH’s target threshold coverage of 65%), despite obvious challenges, are noteworthy triumphs. Eradication of dracunculiasis will be assured in perpetuity, but sustaining MDA and health education for onchocerciasis for as long as necessary is a major ongoing challenge, because Nigeria’s onchocerciasis program remains greatly dependent on support provided by international NGOs and APOCH.
The successful dracunculiasis and onchocerciasis programs and the demonstration of successful integrated interventions against onchocerciasis, LF, and schistosomiasis should be the foundation for rapid national scaling up MDA and health education for LF and schistosomiasis. A successful national attack on lymphatic filariasis and schistosomiasis will require at least as much financial and political commitment as Nigeria invested in its Guinea Worm Eradication Program, particularly because praziquantel, for the most part, still must be purchased. The cost to treat 101 million Nigerians annually (at US$0.20/dose) would be more than US$20 million per year and is the major constraint to scaling up schistosomiasis control. Because schistosomiasis cannot be eradicated in the foreseeable future, this investment will need to continue indefinitely. In contrast, medicines for LF are donated. In addition, if, in the near future, LF is confirmed to be eradicable in sub-Saharan Africa, that could obviate the need to invest in nationwide interventions against LF indefinitely.

The International Task Force for Disease Eradication was the first international body to declare LF to be potentially eradicable and is closely monitoring the possibility that onchocerciasis might 1 day become eradicable. Scaling up MDA with Mectizan and albendazole to eradicate LF also would intensify impact on onchocerciasis by adding a second anti-helminthic (albendazole) drug and extending MDA to many untreated communities where onchocerciasis is below APOC’s 20% prevalence threshold for MDA. The LF program would also extend the ancillary benefits of these anti-helmintics by reducing the burden of ascariasis, hookworm infection, and trichuriasis significantly, at least for the duration of the LF program.

Long-lasting insecticidal nets (LLINs) for malaria control, as an adjunct to MDA for LF or alone, represent another tool to help eliminate LF from Nigeria. Nigeria’s insecticide-treated bed net use among children younger than 5 years old was 4% in 2007, but village volunteers in Plateau and Nasarawa States have proven to be very effective at distributing bed nets (provided by Nigeria’s Malaria Program) during LF MDA, having increased coverage to 80% among households with vulnerable groups (pregnant women or children younger than 5 years of age).
age) in two Nigerian LGAs in 2004. 56 The challenge to scale up distribution of LLINs to simultaneously fight malaria and LF, both of which are widely endemic throughout Nigeria and share the same Anopheles mosquito vector, by using village volunteers, is a special opportunity that Nigeria intends to seize, beginning in 2009, building on the largest everrecorded distribution system in the world for onchocerciasis. In southeastern Nigeria, where LF MDA cannot be used as yet because of risk of adverse events associated with Mectizan treatment of the co-endemic filarial parasite Loa loa there, LLIN alone at full coverage (as opposed to targeting only vulnerable groups) may also be useful to attack LF in the absence of MDA. Thus, scaling up LF MDA wherever possible and providing full LLIN coverage throughout the Federation conceivably would have a better chance of eliminating LF from Nigeria than either MDA or LLINs alone, while strengthening the war on malaria and the fight against onchocerciasis.

The battle against schistosomiasis has the greatest scale up challenges of the four diseases.4 Potential options are to undertakethe expensive and labor-intensive approach to mapping both intestinal and urinary schistosomiasis nationwide and adopt a policy to administer praziquantel MDA presump-tively and broadly without mapping,29 or perhaps also use rotation of MDA and health education to extend the benefits of limited and costly praziquantel supplies to the maximal number of communities. In any event, Nigeria will need to buy, manufacture, and/or secure adequate donated supplies of praziquantel to attack schistosomiasis nationwide.

Much remains to be done to strengthen overall primary health care services in rural areas of Nigeria that could facilitate the war on these four terrorizing worms.37 The full engagement of communities and use of village volunteers would be a tremendous resource for helping people to rid themselves of some of their microbial tormentors. Indeed, the community-directed approach to integrated disease management as a way of tackling up to four diseases efficiently and cost-effectively was piloted in Kaduna, Ogun, and Taraba States and is being replicated as another means of strengthening primary health care.38 The important contributions of health education and community mobilization to the success of all four programs in Nigeria thus far must be emphasized, because these key elements tend to be overshadowed by the more tangible tools such as miracle tablets and longlasting bednets, to the detriment of some programs elsewhere.39

The on-going work summarized in this paper provides the knowledge and foundation for scaling up efforts throughout Nigeria for LF and schistosomiasis and lends tested strategies and tactics for potential use in other countries. Better tools are still needed, and continued research in support of Nigeria’s efforts is important. A macrofilaricide that would kill adult Onchocerca parasites could bring to possibility the eradication of river blindness.52 A less expensive test to diagnose LF infection (ICT tests cost more than USD$2.00 each) and a simple inexpensive diagnostic test for S. mansoni infection would facilitate the struggles to verify LF elimination and map intestinal schistosomiasis, respectively. However, the progress summarized here shows that much can be done with the tools that are available right now, where there is the will and support to do so.

Received November 14, 2008. Accepted for publication January 21, 2009.

Acknowledgments: The authors thank Shandal Sullivan, Renn McClintic-Doyle, and Lauri Hudson-Davis for assistance in preparing this manuscript. We are deeply grateful for the support provided by Past President and Mrs. Jimmy Carter, and by General Dr. Yakubu Gowon in the work described here. We also acknowledge the work of Dr. Munirah Y. Jinadu, former national coordinator for schistosomiasis control and LF elimination.

Financial support: Major external support for the dracunculiasis eradication program was provided by The Carter Center, the World Health Organization (WHO), the United Nations Children’s Fund (UNICEF), Centers for Disease Control and Prevention (CDC), and many other donors. The Japan International Cooperation Agency (JICA) and UNICEF helped support safe water sources in some dracunculiasis-endemic villages. Nigeria appreciates the support and partnership with Lions Clubs, UNICEF, Afiricare, the River Blindness Foundation, Helen Keller Worldwide, Christoffel Blindenmission, SightSavers International, MITOSATH, IFEISH, and The Carter Center for Nigeria’s onchocerciasis activities. Additional support for the onchocerciasis activities is provided by the African Program for Onchocerciasis Control, with Mectizan donated by Merck. Albendazole was donated by GlaxoSmithKline, and praziquantel was donated by E-Merck (Germany) through WHO. GlaxoSmithKline also provided financial support for LF work in Plateau and Nasarawa States. The Izumi Foundation provided some support for schistosomiasis control in Plateau, Nasarawa and Delta States. The Bill and Melinda Gates Foundation has provided some support for all four programs. WHO’s Regional Office for Africa, the Mectizan Donation Program, the Liverpool Lymphatic Filariasis Support Center, and The Carter Center are helping to support mapping of LF.

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