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Nigeria's Triumph: Dracunculiasis Eradicated

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ABSTRACT

This report describes how Nigeria, a country that at one time had the highest number of cases of dracunculiasis (Guinea worm disease) in the world, reduced the number of cases from more than 653,000 in 1988 to zero in 2009, despite numerous challenges. Village-based volunteers formed the foundation of the program, which used health education, cloth filters, vector control, advocacy for safe water, voluntary isolation of patients, and monitored program interventions and cases reported monthly. Other factors in the program's success were strong governmental support, advocacy by a former head of state of Nigeria, technical and financial assistance by The Carter Center, the U.S. Centers for Disease Control and Prevention, the United Nations Children's Fund, the World Health Organization, and many other partners and donors. The estimated cost of the Nigerian program during 1988ï 2009 is $37.5 million, not including funding for water supply projects or salaries of Nigerian governmental workers.

INTRODUCTION

Populous Nigeria (estimated population = 90 million in 1992 and 148 million in 2008) was the country with the highest endemicity for dracunculiasis (Guinea worm disease) in the world at the beginning of the global eradication program. The Swiss traveler who first gave the name Guinea worm to the

parasite *Dracunculus medinensis* after visiting the west African coast in approximately 1611 was probably referring to what he had seen in areas bordering the Gulf of Guinea, including the area that is now southeastern Nigeria.[1] The infection was often recognized as a specific malady during the Atlantic slave trade (1501ï 1888),[2] and Oldfield reported having seen the unmistakable disease on the shores of the Niger River in 1835.[3] Sporadic reports of dracunculiasis in northern Nigeria in the 1920s and 1930s were followed by the pioneering studies of Sanya Onabamiro in southwestern Nigeria in the 1940s and 1950s, and by many other local studies by other investigators in the 1970s and 1980s, before information provided by delegates to the first national conference on the disease in Nigeria in 1985 confirmed for the first time that dracunculiasis was present throughout the country.[4] In 1986, medical geographer Susan Watts estimated that Nigerians accounted for approximately two-thirds of the world's dracunculiasis cases.[5] When Nigeria finally conducted a nationwide village-by-village search for cases in 1988ï 1989, it reported more than 650,000 cases in nearly 6,000 villages, more than three times as many as the next highest disease-endemic country.[6] This report summarizes the achievement of zero cases in Nigeria by 2009.

Dracunculiasis is transmitted when humans drink water containing tiny freshwater copepods that harbor infective stages of the nematode parasite *D. medinensis*, which the copepods would have ingested a few weeks earlier after a person with an emerging adult Guinea worm entered and contaminated the stagnant water source. A year after a human is infected, the next generation of mature parasites begin to emerge through the skin of infected persons on any part of the body, but predominantly on the lower limbs. There are no symptoms during the year-long incubation period. When the adult worms are immersed in water, they release hundreds of thousands of immature larvae to begin the cycle anew. Each infection lasts only one year, but more than one Guinea worm may emerge simultaneously or sequentially over the course of weeks, depending on the number and intensity of infection the preceding year. Humans do not develop immunity, and there is no cure or vaccine for the infection. Dracunculiasis can only be prevented by teaching persons to always filter drinking water from unsafe sources through a fine cloth and to avoid entering such sources when they have a worm emerging or about to emerge from their body, by treating contaminated water with ABATE® larvicide (temephos; BASF, Mount Olive, NJ), or by providing safe drinking water from underground sources. Hopkins and others[7] recently described the overall status of the global initiative to eradicate dracunculiasis, which began in 1980.

MATERIALS AND METHODS

A previous publication describes in detail the early stages of the Nigerian campaign, including numerous local studies (documentation) of the nature and extent of dracunculiasis in Nigeria, demonstration of the efficacy of interventions applied in Nigeria, and mobilization of community and political support for the beginning of nationwideinterventions.[6] Convening the first national conference in 1985 after two years of preparation, establishing the first state task force in Anambra State in 1986, conducting the first nationwide village-by-village search for cases in 1988ï 1989, and hosting an international donors conference in 1989 were major highlights of the early stages, which included two visits by former U.S. President Jimmy Carter after The Carter Center began spearheading the global eradication campaign in 1986 (Table 1 and Figure 1). Although the impact of dracunculiasis on school attendance was recognized earlier, a United Nations Children's Fund (UNICEF)ï sponsored study released in 1987 that documented huge losses of agricultural productivity in a fertile, but highly disease-endemic area of southeastern Nigeria provided important additional evidence of the hidden costs of this disease.[8]

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TABLE 1
Major milestones in the Nigerian Guinea Worm Eradication Program*


Jimmy Carter here to battle guineaworm
Defence minister calls for dynamic policy

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FIGURE 1. Nigerian newspaper headline on President Carter's first visit to Nigeria for Guinea worm eradication, March 14, 1988. View this figure.

Beginning with an extensive and highly graphic cover story in the Nigerian national newsmagazine *Concord* in 1987,[9] the events in 1987ï 1989 launched Guinea worm disease and the fledgling national eradication effort from medical journals into the national mass media. Involvement of the prolific mass media in Nigeria included print, radio, and television, continued throughout the campaign by using press conferences, publicized visits to disease-endemic villages, annual celebrations of National Guinea Worm Eradication Day, visits by former President Carter, and release of progress reports. The federal minister of health or his or her representative participated in most of these events, and the vice president presided at the Guinea Worm Day celebration in 1991 to unveil a set of commemorative postage stamps. A pinnacle was reached when former President Carter joined the military president of Nigeria and the Sultan of Sokoto in presiding over an international donor's conference in Lagos in 1989, during which President Ibrahim Babangida presented Carter with a check for the equivalent of US$1 million from the Government of Nigeria for the campaign. (The Nigerian Government donated another $1 million to The Carter Center for the program in 1999.)

The Carter Center assigned an expatriate resident advisor (co-author PCW) to the Federal Ministry of Health (FMOH) to assist the campaign full time beginning in July 1988, and also funded four zonal facilitators (one for each of the then four geopolitical zones in Nigeria), who were jointly selected by the ministry and the Center to work with the states and local government areas (LGAs = districts) in their respective areas. Three of the four zonal facilitators (co-authors OOK, LDE, and EIB) were academics from Nigeria who had already studied the disease and/or were involved in earlier activities to start the campaign. All four persons were eventually succeeded by younger non-academic colleagues from Nigeria (the first facilitator for one zone was replaced within a few months after failing to show up for an important meeting without explanation). Until the ministry moved from Lagos to the new federal capital of Abuja in October 1996, the resident advisor and his successors worked in an office in the federal ministry side by side with ministry of health officials, together comprising the secretariat for the Nigerian Guinea Worm Eradication Program (NIGEP).

Since 1998, the resident advisor at the Carter Center has been a person from Nigeria (ESM). During the critical first two and a half years of the program, the ministry convened a National Task Force for Guinea Worm Eradication, comprising representatives of the ministry of health and a few other federal ministries and agencies (e.g., those responsible for water supply), one affected state from each of the four regions, and the major external partners (The Carter Center, UNICEF and the World Health Organization [WHO]) at quarterly intervals. The FMOH also

established a nine-member National Steering Committee (consisting of one representative from the Carter Center, the National Coordinator, representing the FMOH, UNICEF, WHO, and the Federal Ministry of Science and Technology, and four zonal facilitators) that was locally responsible for driving the program and formulating and ensuring adequate compliance with policies concerning the program. This steering committee functioned well at first but fell into disuse after the tenure of the first National Coordinator.

By enlisting the support of federal, state, and local health authorities, The Carter Center, local representatives of UNICEF and WHO, and others, NIGEP conducted its first nationwide village-by-village search for cases of dracunculiasis during August 1988ï February 1989. The results were announced at the Second Nigerian National Conference on Dracunculiasis Eradication in March 1989. The National Council on Health in Nigeria, the ministry's highest policy-making body, declared dracunculiasis to be an officially reportable disease in 1988. The high cost (time, labor, and logistics) and limited value of point-prevalence nationwide case searches precluded continuation of annual searches and underscored the need for village-based surveillance, including monthly reporting from each village with endemic dracunculiasis identified during these case searches.

The program in Nigeria followed the general strategy described by Hopkins and Ruiz.[10] After two annual nationwide case searches that each visited more than 94,000 villages and included evaluations to verify the results, the program began implementing health education and distributing some cloth filters systematically as part of the third search in 1991 by enlisting village-based volunteers in endemic villages, who were trained to report cases of the disease monthly, educate their neighbors about how to prevent Guinea worm disease, and to distribute cloth filters. Their work to bandage and help prevent (contain) transmission from individual patients began in 1993. Village leaders or entire communities selected many of the volunteers for these tasks (usually one volunteer per village except in larger communities), but some were already designated as village health workers.

Over the years, much attention was paid to motivating these village-based volunteers and health workers, who were the backbone of the program, by providing incentives such as meals and travel allowances for in-service training and re-training, special Guinea worm T-shirts, printed cloths, and book bags, and by providing health education materials, cloth filters, other supplies, constructive supervision, and feedback. Some LGAs in southeastern Nigeria provided small monetary incentives to village volunteers, but most did not, during the first decade of the program. Later, payment of a small monetary stipend to village volunteers by the LGA was actively encouraged in all disease-endemic LGAs as recognition of NIGEP by LGAs and appreciation of the work of volunteers by their local government. Dozens of

Nigerian National Youth Service Corps workers (e.g., 94 in 1992) fulfilled their mandatory year of service to the nation after finishing college by helping to supervise village volunteers. During 1992ï 1995,several U.S. Peace Corps volunteers also assisted the program (e.g., 12 in 1992) before the U.S. Peace Corps withdrew from Nigeria. Short-term consultants provided by The Carter Center helped strengthen supervision to improve active surveillance and the quality of interventions. This nearly parallel health system, which relied on regular ministry health workers as supervisors at state and LGA levels to a degree (but not completely), sustained the NIGEP during the difficult years of the administration of General Sani Abacha (1993ï 1998) when little else functioned in the public health system in Nigeria.

Health education methods included as many channels of communication as possible as often as possible, including personal and group talks by village volunteers, traditional, religious, and political leaders; town criers; radio jingles, posters and flip charts; short plays or skits by amateur theater troupes; school lectures and contests. Messages were tailored to different audiences (e.g., leaders, school children, general public), but focused on how Guinea worm is transmitted and how to prevent it by always filtering drinking water and not entering sources of drinking water when a worm was emerging or about to emerge.

Special attention was also given to showing villagers how to filter water through a cloth filter, and how to clean and care for the cloth filters properly, and to prevent or allay any concerns about use of ABATE® larvicide. Before nylon filters became available late in 1990, a locally available cotton cloth (gray baft) distributed by the program was more difficult to use (nearly impervious to water at first, it had to be washed a few times before being serviceable as a filter) and less durable.

Serious objections to use of ABATE® larvicide in drinking water sources were rare but occasionally intense and usually involved concerns about offending water-associated deities or polluting sacred ponds in parts of the Southeast Zone of Nigeria. No instance of harm to humans from ABATE toxicity has been known in any of the Guinea worm programs, and local concern about potentially direct harm to humans by ABATE was hardly an issue in Nigeria. The most challenging aspects of vector control were teaching workers to measure ponds correctly so as to use the right amount of ABATE, and convincing villagers to identify all sources of drinking water to workers (during the dry season, sources of drinking water are scarce and highly valued by villagers, even if not considered sacred). Reluctance of villagers to identifyall sources of drinking water was overcome through 1) a patient and persistent dialogue with residents, including community leaders about the purpose, use, and safety of ABATE to gain their trust; 2) constant demonstration of concern and provision of patient care for residents with dracunculiasis; 3) education of children in school and/or in the community at large about the importance of not contaminating

sources of drinking water and in the process eliciting information about sources of water known to the children and how these sources were used by the community at different times during the year; and 4) gaining better understanding of seasonal farming activities, including visits to the farming areas, often very distant from the community, to inventory and treat sources of drinking water used by those farmers. In the later stages of the program, NIGEP workers conducted spot checks to verify the levels of copepods in ponds before and after treatment.

In Nigeria as elsewhere, village residents' most desired intervention to prevent dracunculiasis was the provision of safe sources of drinking water, usually by borehole wells or hand-dug wells. Clean drinking water prevents many other diseases such as diarrhea in addition to preventing dracunculiasis, and such sources also reduced the considerable time, energy, and drudgery otherwise required to secure water for household use from more distant ponds. However, this intervention was also the most expensive and slowest one and the one most susceptible to political diversion. The advocacy of NIGEP with water sector organizations for provision of safe water was secondary to implementing the other interventions. The program co-funded construction of borehole wells in a few special circumstances (e.g., high endemicity in an isolated community or where several communities shared the same contaminated source). More commonly, NIGEP encouraged willing residents of some disease-endemic villages to dig protected hand-dug wells (geology permitting) by offering to provide the necessary sand and cement. With similar supplementary assistance provided by UNICEF, The Carter Center, or other sources (e.g., embassies of the United Kingdom, Canada, Japan, Netherlands, and the United States), villagers in the Southeast Zone constructed more than 400 hand-dug wells by 1998. However, the usual role of NIGEP was to provide updated lists of prioritized disease-endemic villages to appropriate governmental bodies and international agencies such as UNICEF and the Japan International Cooperation Agency, which provided safe water to many disease-endemic villages in Nigeria. In parts of the highest disease-endemic area in southeastern Nigeria, local geology made borehole wells particularly difficult, expensive, and sometimes impossible. However, emphasis on provision of safe drinking water was intensified during the past decade or so of the program when the number of eligible communities was fewer and more manageable.

Once the main village-based interventions were in place, in 1993 village volunteers and their supervisors began to be trained to implement the case-containment strategy, which the U.S. Centers for Disease Control and Prevention (CDC) and The Carter Center had developed in Pakistan,[11] to start focusing on stopping transmission from individual patients, as a supplement to village-based interventions. A contained case was defined as one in which the patient was detected within 24 hours of emergence of the worm, had not immersed the worm in a water source, had had the wound cleaned

and bandaged, and in which those criteria were verified by a supervisor within seven days. Late in 2002, the program introduced the first two case-containment centers, in which patients were voluntarily isolated in existing health posts or clinics where possible, or in specially constructed temporary structures, with food provided by the program. By the end of 2003, 23 centers were in operation. Treatment in the case-containment centers helped villagers recover more quickly from wounds caused by the infection, and prevented further contamination of drinking water sources. It also helped patients avoid the traditional practice of shekiain which a hot poker was applied to treat abscesses caused by Guinea worms in some northern areas of the country. The case-containment strategy was a supplement, not a substitute for the other village-based interventions. In 2003, the Northeast Zone adapted this approach in its cultural milieu as a case confinement strategy, in which patients were voluntarily isolated in their own homes under the eyes of watchmen to ensure they would not enter any water source.

During 1989ï 1991, reductions in the numbers of cases reported in the annual case searches were the main means of monitoring the program. After village-based volunteers were introduced, program impact and interventions were monitored primarily by reviewing monthly reports that originated from each of the more than 5,000 known disease-endemic villages (all villages that reported one or more case since January 1 of the previous year), which were compiled and supplemented by the zonal facilitators before submission to the national secretariat during the first week of the following month. The monthly tallies of cases in geographic areas were compared with the number of cases reported for the same area in the same month of the previous year, and percentages of known disease-endemic villages that had a trainedvolunteer and each of the interventions were tracked assiduously.

The first Program Review for NIGEP was held in Atlanta, Georgia, in 1991. On this occasion, former President and Mrs. Carter announced the initiation of an annual Jimmy and Rosalynn Carter Award for Guinea Worm Eradication to be awarded annually to recognize and encourage exceptional contributions and innovations in the programs in Nigeria and Ghana. Subsequently, biannual reviews were conducted in Africa at an annual meeting of representatives from all disease-endemic countries in March, and at a more thorough program review for the smaller group of English-speaking disease-endemic countries each September or October. Starting in 2000, Nigeria conducted its national program reviews (except for a joint review of the big three disease-endemic countries, Sudan, Ghana, and Nigeria, in Atlanta in 2003) to facilitate participation of as many health workers in Nigeria as possible and to maximize local publicity about the status of the national program. The in-country reviews of NIGEP were also part of an annual review of all health programs being assisted by The Carter Center in Nigeria (including onchocerciasis, lymphatic

filariasis, schistosomiasis, and trachoma) to also promote cross-fertilization and inspirationamong staff of the different programs. Reports by external short-term consultants from CDC, The Carter Center, or WHO and periodic supervisory visits by staff from Carter Center headquarters were other means used to track the status of the program. In 1996 CDC, The Carter Center, WHO, and UNICEF conducted a joint in-country evaluation that cited inadequate frequency and quality of supervision as the weakest component then in NIGEP. Regular public feedback and analysis of data on surveillance and interventions from Nigeria and all other disease-endemic countries was provided in periodic issues of the *Guinea Worm Wrap-Up* newsletter issued by the WHO Collaborating Center for Research, Training, and Eradication of Dracunculiasis at CDC.

National, state, and local health authorities from Nigeria and Cameroon met several times each year on alternate sides of the border during 1995ï 1998 to review the status of dracunculiasis and control measures in Borno State in Nigeria and the adjacent Far North Department in Cameroon, which was the most frequent recipient of internationally exported cases from Nigeria. Similar meetings were held less frequently with counterparts in Niger.

In 1998, The Carter Center asked popular former Nigerian head of state General (Dr.) Yakubu Gowon to consider assisting the program in an effort to end a four-year-long pause in annual reductions of cases (Figure 2). By then, the first National Program Coordinator of NIGEP had been succeeded by another coordinator in 1995, and he in turn was succeeded by the current national program coordinator in 2007. General Gowon joined the fight against Guinea worm disease in Nigeria enthusiastically in March 1999, making 22 visits to 16 states before the end of that year. By the end of 2009, he had made a cumulative total of 82 visits to 135 disease-endemic communities in 18 of the 35 states in Nigeria and urged that medical, traditional, and administrative authorities in those states, LGAs, and villages intensify control measures against the disease. After extracting promises on an initial visit, he wrote reminders and made follow-up visits to ensure that appropriate actions were taken, to help inaugurate new wells and/or to congratulate all concerned on their Guinea worm-free status. He also advocated for the program with national government officials and international donors. Former President Carter visited Nigeria 11 times during 1988ï 2008, including twice for election observations, but mostly for advocacy and to help publicize the program.

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FIGURE 2. Former Nigerian head of state General (Dr.) Yakubu Gowon addressing a group about Guinea worm eradication.

With the support of General Gowon, the re-energized NIGEP steadily tightened interventions under the effective leadership of the newly appointed (August 1998) Carter Center resident advisor, who was from Nigeria. External consultants assisted Southeast and Southwest Zones in 1998 (4.6 person-months), and all four zones in 1999 (17.7 person months), increasing to 31.7 person-months in 2003. Operations were decentralized within successive zones in 1998ï 2000, and the four zones were restructured into five zones in 2002. As mentioned above, case-containment centers were introduced in 2002 and expanded 10-fold in 2003. Worm Weeks, periods of intensive health education, community mobilization, and demonstrations in targeted disease-endemic areas, usually in villages where the impact of interventions was weakest (an innovation first devised by a Peace Corps Volunteer in the Guinea Worm Eradication Program in Niger that involved Peace Corps Volunteers and Guinea worm program staff living in targeted villages for one week) were introduced in 6 LGAs in 2002 and implemented in 11 high-priority LGAs in 2003.

Cash incentives for reporting and isolation of new cases were introduced in Northwest Zone in 2001 (jointly with neighboring areas of Niger) and extended nationwide in 2006, with support from The Carter Center, as a way to improve the sensitivity of surveillance for dracunculiasis as increasingly vast areas became Guinea worm-free. The amount of the reward for reporting a case of dracunculiasis was 1,000 Naira (approximately U.S. $8) in 2007, 5,000 Naira in 2008, and 10,000 Naira in 2009. Nigeria established a National Certification Committee on Guinea Worm Eradication in May 2005 that began to also advocate for improved surveillance in Guinea wormï free areas of the country. The program began recording lists of suspected cases that were investigated (rumor registers), and occasionally arranged for a query about presence of Guinea worm cases to be included during visits to villages as part of National Immunization Days for polio. The numbers of investigated rumors of Guinea worm cases increased from 27 (1 of which was confirmed) in 2005 to 176 in 2006, 192 in 2007, 526 (none of which was confirmed) in 2008, and 238 in 2009.

With assistance from WHO, NIGEP worked to sustain active surveillance as part of the Integrated Disease Surveillance and Reporting System in Nigeria in 50 priority Guinea wormï free villages that had reported cases since the beginning of 2005. The rate of monthly reporting from these villages via the Integrated Disease Surveillance and Reporting System increased from an annual average of 16% in 2006 to 53% in 2007, 75% in 2008, and 89% in 2009.

RESULTS

During the early years of the program, dracunculiasis was widely dispersed in Nigeria, affecting virtually every part of the nation, but unevenly (Figure 3). In 1993, for example, 7 of the then 30 states accounted for more than 75% of the reported cases[12]: Abia, Benue, Enugu, Katsina, Kebbi, Ondo, and Sokoto. Densely populated, highly disease-endemic Enugu State (formerly part of Anambra State) was confirmed in its reputed position as the world's capital of Guinea worm disease.

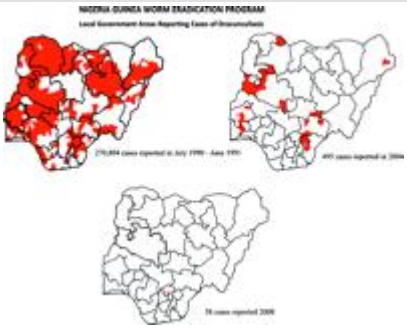

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FIGURE 3. Local government areas reporting cases of dracunculiasis in Nigeria.

Monthly reporting of cases showed year-round transmission of dracunculiasis with bimodal peaks, making Nigeria the only disease-endemic country in which bimodal peaks were so pronounced. In northernareas of the country, transmission peaked during the rainy season in mid-year (Juneï August), and in southern areas transmission peaked in the dry season months of Novemberï March (Figure 4). Thus, peak transmission coincided with the only times of year when surface water is common in northern regions. However, in southern regions, which had heavier rainfall

during its longer rainy season when flowing sources of surface water were unsuitable habitat for copepods, transmission was highest in the dry season when surface water sources were scarcer and more likely to be stagnant, contaminated, and contain concentrated populations of copepods. The program exploited these alternating peaks in transmission during the past decade by shifting personnel from northern to southern regions and *vice versa* during the respective periods of peak transmission.

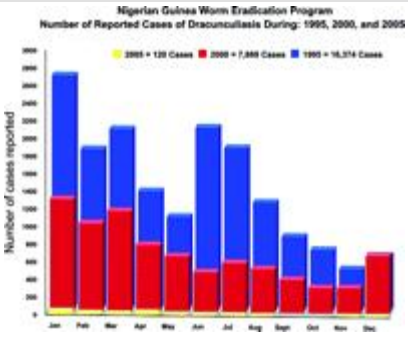

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FIGURE 4. Number of cases of dracunculiasis reported by month in Nigeria in 1995, 2000, and 2005.

The initial case searches and routine surveillance did not include data on age, sex, or other features of individual cases throughout most of the program. Data from published reports in various parts of the country generally documented highest incidence of cases among persons 15ï 45 years of age,[13] with slight majorities of sex-specific annual incidences among males (57.1:52.3, 50.5:45.4, and 33.7:31.3)[14]i [16]or females (47.8:42.1),[17] depending on the population studied. These general patterns were still valid when specific data were collected on cases during the final few years of the program. Of the 120 casesreported in 2005, for example, 52% were female, and 48% were male.

Numbers of cases and disease-endemic villages reported in Nigeria, and the percentage coverage of disease-endemic villages with interventions over the years are summarized in Table 2. Routine reporting rates reached minimally acceptable levels (75%) in 1992. Essentially all villages reportedly received specific health education about dracunculiasis from 1992 onward, with ≥ 87% receiving cloth filters after the following year, except in 1998ï 2000. Use of ABATE® larvicide ranged from 29% to 57% of disease-endemic villages beginning in 1996, and the proportion of disease-

endemic villages with at least one functioning source of safe drinking water increased slowly but steadily. Case-containment rates also increased sharply after 2000 (Table 2). Moreover, by 2003, 39% (564) of 1,490 cases in Nigeria were admitted to case-containment centers, and in 2004, 91% (449) of 495 cases were admitted to case-containment centers, although not all cases met the official criteria for case containment.

View this table at the American Journal of Tropical Medicine and Hygiene	TABLE 2 Numbers of cases and disease-endemic villages and status of interventions against dracunculiasis in Nigeria, Nigerian Guinea Worm Eradication Program 1988ï 2008

The impact of these measures on dracunculiasis in Nigeria is shown in Figures 3ï 6. After steep reductions in 1990ï 1995, there was a plateau in the numbers of cases in 1996ï 1999, after which reductions resumed and accelerated. The mid-year peak in transmission, which reflected conditions in northern Nigeria, disappeared in 2002 (Figure 4). The number of cases exported from Nigeria to Cameroon peaked at 18 cases in 1997 and 21 cases in 1998 and decreased to 3 cases in 2002 (Table 3). In 2003, Nigeria exported no cases to Cameroon (which reported its last indigenous case in 1997) in an entire calendar year for the first time since the two programs started and Cameroon began reporting imported cases. The Northwest and Northeast Zones reported their last indigenous cases in September 2004, followed by Northcentral Zone in 2005, Southwest Zone in 2006, and Southeast Zone in 2008. (Nigeria divided the four former health zones, Southeast, Southwest, Northeast, Northwest, into six geopolitical zones in 2003, Southeast, Southsouth, Southwest, Northcentral, Northeast, and Northwest, but NIGEP operations were subsequently based on five zones.)

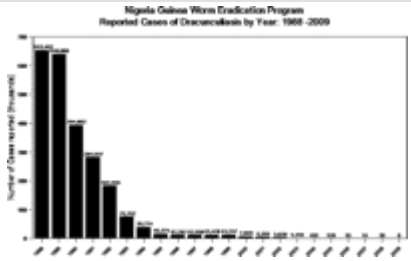

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FIGURE 5. Reported indigenous cases of dracunculiasis in Nigeria, 1988ï 2009.

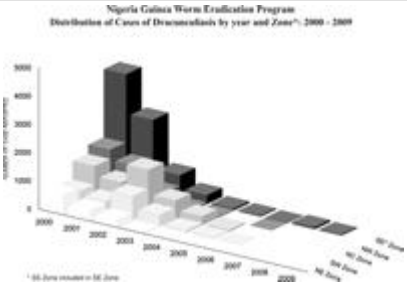

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FIGURE 6. Numbers of dracunculiasis cases reported in Nigeria by zone, 2000ï 2009.

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TABLE 3

Dracunculiasis cases exported from Nigeria, 1993ï 2008*

Nigeria appeared to be on the verge of interrupting transmission of dracunculiasis in

2007 before a surprise outbreak was discovered in two villages in Enugu State in January of that year. Investigation showed that the outbreak included 28 active cases in Ezza Nkwubor village and 2 cases in nearby Ezza Ugwuomu village (both persons were residents of Ezza Nkwubor village), and had begun in approximatelyOctober 2006, but only came to attention of health authorities when a patient sought treatment at a clinic in mid-January 2007. It was claimed that no one in the village was aware of the cash reward for reporting of a case of dracunculiasis. (A check of 2,076 randomly selected respondents from all disease-endemic zones of Nigeria in 2006 had found that 51% knew about the rewards announced through radio broadcasts alone, and 83% had heard of the rewards by radio or other means such as posters or health workers) (Huang CL and others, unpublished data). All interventions were implimented, including active searches for cases in surrounding LGAs. The last person in Nigeria with Guinea worm disease was a 65-year-old woman in Ezza Nkwubor village of Enugu East Local Government Area of Enugu State whose worm emerged at a case-containment center on November 11, 2008.

A study of the impact of 150 borehole wells provided by the Japan International Cooperation Agency in 135 disease-endemic villages in Enugu State found a decrease of 62.5% in dracunculiasis between 1989ï 1990 and 1990ï 1991, compared with an increase of 6.8% in villages that were not covered by the water project. School absenteeism decreased by 50% and enrollment increased by 12% in the villages that received the new wells over the same period. However, by 1992ï 1993, the average number of dracunculiasis cases per village without safe water supply had decreased to similarly low levels, reflecting the slower uptake but comparable impact of intensive health education and distribution of cloth filters.[18]

This program cost approximately $37.5 million during 1988ï 2009, including $30.2 million by The Carter Center, $4.4 million by the government of Nigeria, (in addition to $2 million donated by the government of Nigeria to The Carter Center), with the remainder provided by Japan, UNICEF, WHO and the A.G. Leventis Foundation. The Carter Center support included in-kind donations of nylon filter material and ABATE® larvicide, provision of short-term consultants, and major funding from the Bill and Melinda Gates Foundation. The total additional costs of providing clean drinking water sources to disease-endemic villages is unknown because existence of such projects was hard to monitor, many water projects announced in the name of preventing Guinea worm disease never materialized, many borehole wells provided in Guinea worm areas broke down within months after construction, and projects that actually provided water in Guinea worm areas included many villages that were never or no longer endemic for this disease. The known costs of targeted water supply projects in Guinea worm-endemic villages in Nigeria were $35.6 million, including

$25.6 million from the government of Japan in 1988ï 1992, and the remainder from UNICEF, the government of Canada, and Rotary International, but other costs for water projects by UNICEF, the United Nations Development Program, Canada, theNetherlands, the United States, and the United Kingdom are not known.

DISCUSSION

Readers are referred to a previous report[6] that describes the critical earliest stages of this program in more detail. In retrospect, NIGEP was fortunate in the transitory coincidence of a few supportive personalities who were in key positions during this vulnerable formative phase of the program, when Guinea worm eradication was neither as obviously successful nor as popular as it is now. Chief among that early honor roll were the then Federal Minister of Health, the late Professor Olikoye Ransome-Kuti and his disease control director Dr. Gabi Williams, Nigerian academician Alphonsus Nwosu (later commissioner for health of Anambra State, then federal minister of health), the UNICEF representative to Nigeria Richard Reid, The Carter Center/Global 2000's first two resident representatives, the first national program coordinator, and the first three zonal coordinators. The early decision of Professor Ransome-Kuti to include the equivalent of more than $100,000 (600,000 Naira or U.S. $156,000 in 1988) for the program in the budget of his ministry, much of which was made available to the program, opened the door to several times as much funding when external donors saw evidence that he regarded Guinea worm eradication as a priority in Nigeria. This prioritization in Nigeria benefited the young global eradication effort in other ways because this influential minister and his disease control director advocated the cause at World Health Assemblies and hosted the international donors conference. The early manifest commitment in Nigeria was also a major component of successful appeals of The Carter Center to American Cyanamid and E. I. DuPont for large donations of ABATE® larvicide and nylon filter material, respectively, and to the government of Japan for $1 million worth of four-wheel drive vehicles, motorcycles and spare parts for the program in Nigeria.

Even with the national confluence of an all-star cast, the generally successful conduct of the first nationwide village-by-village search for cases of dracunculiasis in Nigeria, beginning a few weeks after formation of the NIGEP secretariat in the Federal Ministry of Health in July 1988, and when NIGEP had no vehicles of its own, was an impressive feat that now seems almost miraculous. The NIGEP staff begged, borrowed, and rented vehicles and motorcycles from vendors, friends, and other

programs, used personal vehicles and public transportation, rode bicycles, and walked in a powerful display of determination and dedication.

The results of the first case search were incomplete to an unknown extent because not all villages were visited, and it undoubtedly also overestimated cases in some of the areas that were canvassed, given the one year retrospective nature of the search, but it served its main purpose, which was to document the geographic extent of dracunculiasis in Nigeria. We cannot know the true number of cases that still occurred in Nigeria at that time, but it may have been more than the 653,492 cases enumerated in the first case search because a similar case search in Ghana that was conducted around the same time and judged fairly accurate in limited spot checks[19] yielded a national prevalence rate (180,000 cases in a population of approximately 10 million) nearly 2.5 times as high as that in Nigeria (18 cases/1,000 versus 7.3 cases/1,000). In contrast, Nigeria had officially reported an average of only approximately 2,600 cases (range = 0ï 8,777 cases) of dracunculiasis to WHO annually during 1980ï 1986[20],[21] based on passive surveillance. Although the first qualitative indications that Guinea worm disease occurred all over Nigeria derived from the first national conference in 1985 had gotten many people's attention, the quantitative data from the first national case search, which attributed large numbers of cases to specific states and LGAs throughout the regionally sensitive federal republic, generated much more pressure, and willingness of national leaders to act.

The statistics from the first national case search fed directly into the voracious national media apparatus of Nigeria when the data were released publicly during the second national conference and the international donors conference in Lagos in March and July 1989. Before this time, during and after 1989, the mass media in Nigeria helped publicize the inequalities that Guinea worm disease illustrated and successive achievements of NIGEP. The conduct of the first case search in Nigeria, its substantial results, and evidence of support for the program by persons in Nigeria also helped demonstrate to the international community that Guinea worm disease could be addressed and provided some credibility to the global eradication effort.

After the ministry of health moved to the new capital at Abuja in October 1996, coordination of activities between the ministry and The Carter Center became less intimate than it had been in Lagos. Inadequate space at the new federal buildings in Abuja and the high cost of scarce rental space elsewhere in Abuja meant that Carter Center staff were re-located more than two hours away in Jos as of January 1998, and the official head of the program was the national program coordinator at the Federal Ministry of Health in Abuja. At this stage, given the challenges the entire country faced under the Abacha regime, the ministry provided little support beyond paying the salaries of its staff. The ministry appointed four Zonal Coordinators of its

own in 1999, but provided no additional support for them to work alongside the zonal consultants, who were supported by The Carter Center.

The disappointing plateau in numbers of cases in 1996ï 1999 reflected an unfortunate combination of inadequate funding (including the end of donated filter material) and weak national leadership that coincided with the national administration of General Sani Abacha in the mid-late 1990s. The three most important factors in reversing those deficiencies were the appointment by The Carter Center of a new resident advisor in 1998 with consequent administrative changes, the assumption of former head of state General Gowon of his extraordinary and invaluable role as passionate chief advocate early in 1999, and the first large grant for global Guinea worm eradication made by the Bill and Melinda Gates Foundation to The Carter Center in May 2000. One early manifestation of funding from this foundation was the resumed high coverage of disease-endemic villages in Nigeria with nylon filter material in 2001 (89%) after three years of coverage levels averaging 59% (Table 2). Two examples of the aggressive new attitude were apparent in 1999 when the head of the highest disease-endemic village in an LGA of Borno State made all the villagers swear on the Holy Koran that they would not allow any patient with Guinea worm disease to contaminate the drinking water source of the village, and in 2002 when the emir in an LGA of Gombe State mobilized more than 600 women to help fight Guinea worm disease, the latter in direct response to advocacy by General Gowon.

Because the senior author had headed the assistance of The Carter Center to the Onchocerciasis Control Program of Nigeria, his appointment as the resident advisor for The Carter Center facilitated sharing resources (e.g., transport, personnel) between that program and dracunculiasis eradication workers, especially in the Southeast Zone. Apart from his targeted advocacy on behalf of the campaign, the most valuable role of General Gowon was to help hold officials accountable for their work. As levels of dracunculiasis decreased, General Gowon successfully urged several states to use experienced workers from the Guinea Worm Eradication Program in other health programs.

Overall, the strategies deployed by NIGEP transitioned from annual surveys and village-based interventions to increasingly stringent monthly, then weekly and daily village- and household-based surveillance and reporting, combined with the patient-based case-containment strategy. Although the global eradication effort was launched as a sub-goal of the International Drinking Water Supply and Sanitation Decade (1981ï 1990), with elimination of dracunculiasis as a desired outcome of providing safe drinking water to disease-endemic communities, in Nigeria as elsewhere other village-based interventions, especially health education and provision of cloth filters, quickly became the most emphasized control measures because they were effective, and cheaper, faster, and easier for health authorities and villagers to implement than

water projects. The study by Cairncross and others[18] cited earlier documented the immediate effectiveness of providing safe drinking water to several communities in Nigeria, and health education and cloth filters eventually achieved similar reductions in prevalence of dracunculiasis two years later (without the other benefits of clean water from borehole wells). A more recent study from Ghana and Togo[22] documents the increased efficacy brought to bear by the case-containment strategy, but unfortunately, similar studies to compare the impact of different interventions (e.g., vector control, pipe filters) are generally lacking because funding (and time) for conducting such studies was usually not available and because programs sought to bring as many interventions to bear as possible in each disease-endemic village to stop transmission of the disease as fast as possible, without regard to the rigor required to compare the different combinations of interventions systematically.

Two perennial problems that plagued the program in Nigeria throughout its existence were recurrent instances of ethnic, religious, and/or political clashes or strikes, and expensive delays in clearances of commodities after arrival at the ports of entry. Insecurity caused by ethnic clashes in Ebonyi State prevented access to some highly disease-endemic areas in the southeastern region for a few years in the late 1990s, and again later for several months in 2002. Similar clashes in Nasarawa State in 2001 brought similar limitations, as did fighting between Christians and Muslims that affected several areas of the country in 2001, including The Carter Center headquarters at Jos, where one of the security guards was killed. The frequent delays in clearing vehicles, filter material, and other commodities at the seaport and airport of Lagos, sometimes for many months in the latter 1990s and 2000s, were expensive in assessed demurrage fees and even more costly in lost time and opportunities for the program. The physical separation of The Carter Center office from the Federal Ministry of Health contributed to some of the latter difficulties. In contrast, when port authorities at Lagos were informed late in 1987 that a recently arrived shipment of donated chemical (ABATE® larvicide, an early gift from American Cyanamid) was for combating Guinea worm disease (by the nascent program in Anambra State), the shipment was released immediately,and the dock workers waived their normal charges (former U.S. Ambassador to Nigeria Princeton Lyman, unpublished data). Compared with those persistent difficulties, the proliferation of new states and LGAs posed vexing, but less serious challenges for the program.

The Guinea Worm Eradication Program reached into extremely remote areas of Nigeria. At least once, NIGEP workers in pursuit of dracunculiasis discovered a village that was previously wholly unknown to any government authority. When the chairman of Paikoro LGA in Niger State visited every disease-endemic village in his district, the head of one village "wept openly because, according to him, Chairman

Danjuma Baba was the first government official ever to visit the village" (Edungbola LD, unpublished data). Maintenance of adequate surveillance for any indigenous or imported case of dracunculiasis in the increasingly vast Guinea wormï free areas of Nigeria was and still is an important concern, even though the risks of both are now small. The routine reporting system in Nigeria is still based on passive reporting and does not cover the entire country. Nationwide publicizing of the cash reward for reporting of any case of dracunculiasis beginning in 2006 is currently the main defense against transmission from an unreported case. Absorption or re-absorption of some former Guinea worm workers into other governmental public health programs is another hopeful component of the post-eradication surveillance strategy.

Although NIGEP reveled in surpassing the program of arch rival Ghana, which began with less than one-third of the total cases in Nigeria, Uganda, which started its program three years after Ghana and Nigeria and was the second-highest disease-endemic country in the world after Nigeria in 1993, recorded its last indigenous case of dracunculiasis in 2003. The programs in Uganda and Nigeria shared similar characteristics of a sound technical approach, innovations, willingness to replace non-performers promptly, strong political backing (less constant in Nigeria), and careful monitoring of surveillance and intervention data, with prompt appropriate response to such data, and adequate financial support.[23]

Among the Kanuris in northern Nigeria, the local term for Guinea worm disease (*ngudi*) means the impoverisher. In parts of southern Nigeria, it was called the silent magistrate in recognition of how people in disease-endemic areas once waited anxiously at the approach of the peak transmission season in each year to learn whether they would have dracunculiasis that year, and if so, how badly. Now persons in Nigeria can avoid having to call dracunculiasis anything, except to tell their children the heroic stories of how it was eradicated. Nigeria, the complex promising giant of West Africa and erstwhile colossus of the Guinea worm world, has slain the dragon and laid a foundation for attacking other problems. In 2010, Nigeria celebrates 50 years of political independence and one year of freedom from Guinea worm disease, but other public health challenges await.[24]

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