

## DRACUNCULIASIS ERADICATION: AND NOW, SUDAN

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**Abstract.** This paper summarizes the status of the global dracunculiasis eradication campaign as of early 2002. Of the 20 countries that were endemic when the campaign began, seven have already interrupted transmission, four countries reported less than 100 cases each, and only five countries reported more than 1,000 cases each in 2001. Only 14,000 cases remained outside Sudan in 2001. Sudan reported 78% of all cases of dracunculiasis in 2001, and virtually all of Sudan's cases were in the southern states, where the long-standing civil war limits accessibility to endemic areas. A political settlement of the war is now urgently needed, since it will be impossible to complete the eradication of dracunculiasis without peace in Sudan.

### INTRODUCTION

Since the previous review of the Dracunculiasis Eradication Program was published in this journal nearly three years ago,<sup>1</sup> much progress has been made towards the goal of total eradication. This paper summarizes the status of the global campaign as of early 2002, with a special emphasis on Sudan.

We have previously summarized the nature of the parasite, its transmission and prevention, and the earlier stages of the eradication program.<sup>1–3</sup> The parasite that causes Guinea worm disease (dracunculiasis), *Dracunculus medinensis*, is spread to humans who drink water from open ponds or other stagnant sources containing copepods (water fleas) that harbor infective stages of the immature parasite. The copepods become infected when people whose Guinea worms have matured over the course of about a year and begun to emerge through the person's skin, enter stagnant water sources, thus allowing the mature worm(s) to deposit thousands of immature larvae into the water to be ingested by the copepods. There is no known animal reservoir of the infection, no treatment to cure the disease, people do not become immune to infection, and each infection lasts only one year. However, spread of the disease can be prevented by preventing persons with emerging worms from contaminating sources of drinking water, by providing safe drinking water such as from bore hole wells or from protected hand-dug wells, by using temephos (Abate;<sup>®</sup> BASF Corporation, Mount Olive, NJ) to kill the copepods in surface sources of drinking water, or by convincing people to filter their drinking water through a finely woven cloth.

Although dracunculiasis is rarely fatal, it is of great socioeconomic importance because persons with this disease are incapacitated for periods averaging almost three months, often at the busiest time of the year when they need to plant or harvest their crops, and half or more of a village population may be affected at the same time. In addition to its impact on agricultural productivity, dracunculiasis also is a major cause of absenteeism from school. This eradication campaign began at the Centers for Disease Control and Prevention (CDC) in 1980. Since 1986, it has been led by The Carter Center (Global 2000), in close collaboration with CDC, the United Nations Children's Fund (UNICEF), and the World Health Organization (WHO).

### CURRENT STATUS OF THE CAMPAIGN

Of the 20 countries that were endemic when the campaign began, seven have interrupted transmission of the disease,

including all three recently endemic countries in Asia. The original target date for achieving eradication (1995) was not met, but progress towards eradication is accelerating. Figure 1 shows the distribution of cases remaining in 2001 by country, compared with 1998. In 2001, four of the 13 remaining endemic countries reported less than 100 cases each, and only five countries reported more than 1,000 cases each. Overall, the number of reported cases has been reduced by 98% from the 3.2 million that Watts estimated in 1986.<sup>4</sup> Sudan reported the majority of cases by far in 2001. As of March 2002, seven of the endemic or formerly endemic countries that have not yet been certified as free of the disease by WHO (Benin, Cameroon, Cote d'Ivoire, Ethiopia, Mauritania, Uganda, and Yemen) had established or were preparing to establish national commissions to begin the pre-certification process.

For the 12 endemic countries remaining outside Sudan, cases were reduced by 1% between 1998 and 1999 (to 30,196), by 30% between 1999 and 2000 (to 20,333), and by 30% between 2000 and 2001 (to 14,246) (Figure 2).<sup>5</sup> In the first half of 2002, cases outside Sudan have been reduced by 33% (provisional) compared with the same period of 2001. Nigeria and Ghana together accounted for 71% of the cases reported outside Sudan in 2001. Programs in both countries have improved their performance in the past three years. Nigeria has especially increased the rate of reduction of its reported cases to 45% during the first half of 2002 compared with the same period of 2001. The reductions in Nigeria were led by a decrease of 84% in cases in Ebonyi State, which reported more cases (39% of the national total) than any other state in Nigeria during 2001. Togo, Mali, and Cote d'Ivoire experienced temporary setbacks in 2001 due to previously unrecognized outbreaks that were detected too late to prevent further spread. The number of villages reporting one or more cases outside Sudan was reduced from 3,208 in 1998 to 2,174 villages in 2001 (more than 23,000 villages reported cases outside Sudan in 1991). The geographic distribution of the remaining endemic areas is shown in Figure 3. Unfortunately, the question of whether indigenous cases of dracunculiasis are being transmitted in the Central African Republic, in addition to apparently sporadic cases imported from Sudan, is still unresolved, in our view, owing partly to insecurity in the this country. Unlike all of the other endemic or formerly endemic countries, over the past decade no foreign observer has actually seen a typical Guinea worm emerging from anyone in the Central African Republic without a history of external travel. The most recent attempt, by a team from CDC in July–August

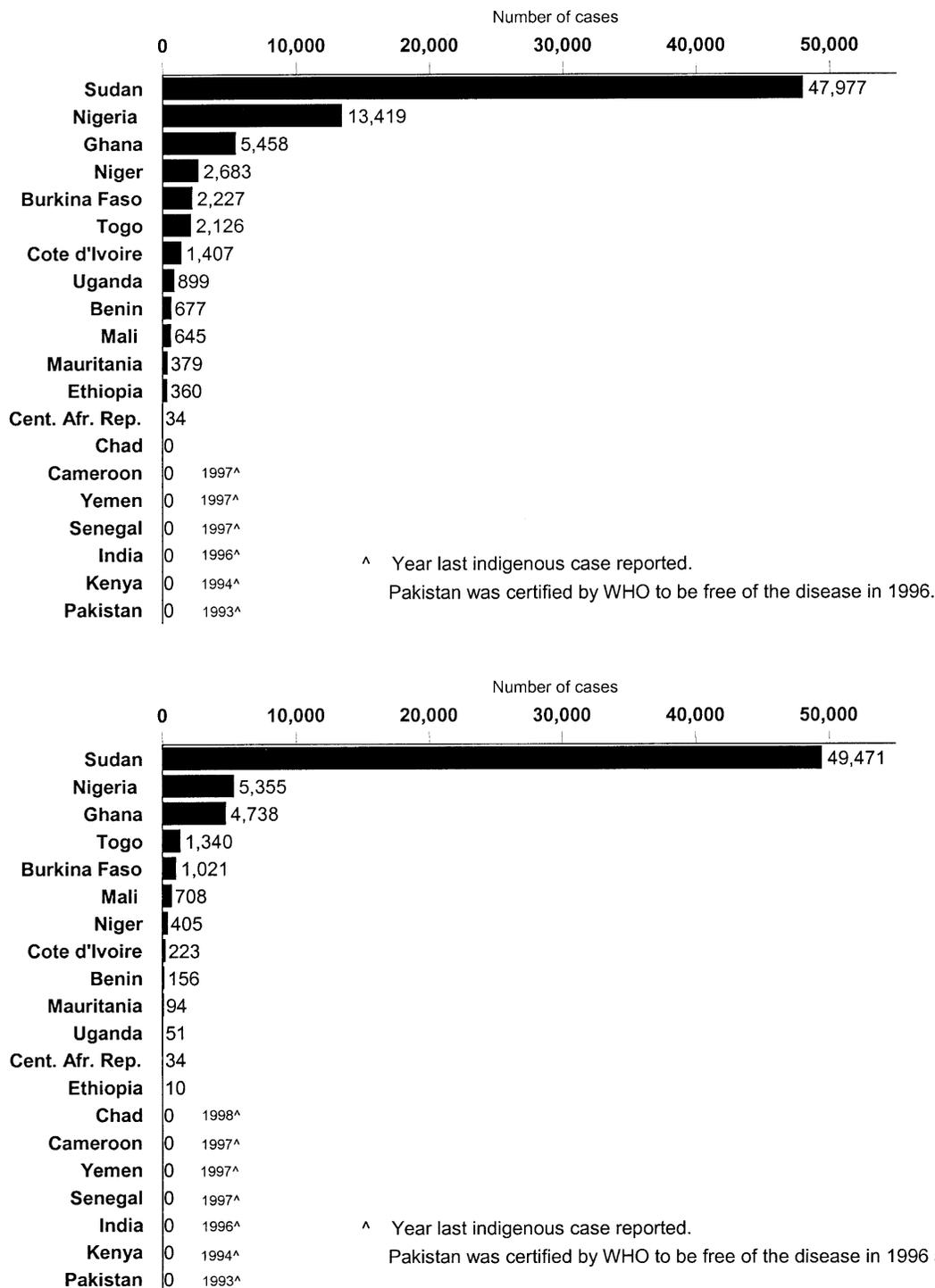


FIGURE 1. Distribution by country of 78,293 indigenous cases of dracunculiasis reported during 1998 (**top**) and of 63,606 cases reported during 2001 (**bottom**). Cent. Afr. Rep. = Central African Republic; WHO = World Health Organization.

2000, examined three persons who had been diagnosed as dracunculiasis, but whose worms were later identified at CDC as *Onchocerca volvulus*.<sup>6</sup>

A total of 108 cases were reportedly exported from one country to another during 2001. Of these, Sudan exported 31, Ghana 17, Togo 17, Niger 11, Nigeria 11, Mali 5, Burkina Faso 5, Cote d'Ivoire 4, and Benin 3. Two alleged imported cases in the Central African Republic may also have come from Sudan.

The status of interventions as of the end of 2001 in all endemic countries except the Central African Republic is summarized in Table 1. Programs are now monitoring the status of these interventions much more closely than before, in addition to tracking the monthly reductions in cases reported compared with the previous year. Line-listings of endemic villages or districts, ranked in order of decreasing level of endemicity, are used to forecast the onset and duration of transmission in specific villages or geographic areas, and to

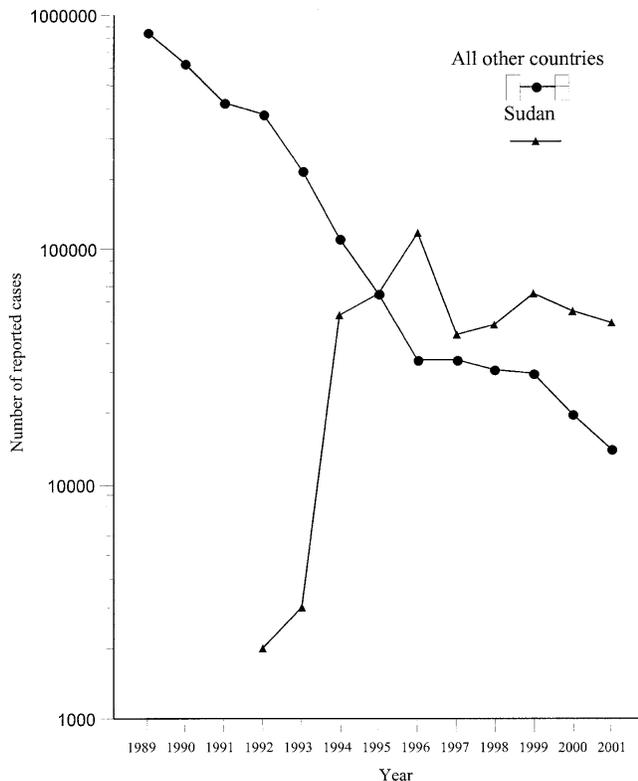


FIGURE 2. Number of cases of dracunculiasis by year, 1998–2001.

monitor the status of interventions. Programs in Burkina Faso, Cote d'Ivoire, Ghana, Niger, Nigeria, and Togo are implementing "Worm Weeks", which are 5–7 days of intensive health education and community mobilization, during which U.S. and sometimes Japanese Peace Corps Volunteers or former volunteers live in endemic villages with national counterparts of the country concerned. During that week, they talk with villagers about how to prevent dracunculiasis, put on plays, arrange public ceremonies with prominent officials, help dig wells, distribute and demonstrate how to use cloth filters, and carry out other activities. A study of the impact of such Worm Weeks in Ghana in 2000 found an 80% reduction in cases the following year in villages that had had Worm Weeks, compared with an average reduction of 45% in nearby communities that only had the usual interventions. Several programs are now using specially constructed containment houses and/or existing medical facilities to temporarily isolate persons while their worms are emerging. The amount of technical assistance provided by external workers (including many former Peace Corps Volunteers), to assist field supervision in endemic countries, has risen from 18 person-months in 1998, to 28, 88, and 164 person-months in 1999, 2000, and 2001, respectively. In December 2001, the Voice of America began broadcasting Public Service Announcements (by former U.S. President Jimmy Carter, former Malian head of state General Amadou Toumani Toure, and former Nigerian head of state General [Dr.] Yakubu Gowon) containing messages about dracunculiasis prevention in English, French, and Hausa as a part of its programming in Africa. These same messages are now being retransmitted via local radio stations using local dialects in many of the endemic countries.

## SUDAN

In our previous review, we reported that "Sudan remains the major challenge to eradication."<sup>1</sup> That is even truer now, but it is the war that is the greatest obstacle, not the country itself. Since former U.S. President Jimmy Carter negotiated a four-month "Guinea Worm Cease-Fire", which allowed Sudan's eradication program to escalate its efforts in 1995, Sudan has reported 50% or more of all cases of dracunculiasis each year. Sudan's proportion of global dracunculiasis cases has steadily increased over the past seven years as cases are reduced in all other endemic countries. As shown in Figure 2, Sudan reported 49,471 or 78% of all cases in 2001.

Within Sudan, the northern states already have almost interrupted transmission of dracunculiasis, which is not unexpected since with few exceptions, the civil war is being fought mostly in the southern part of the country. Only 85 indigenous cases were reported from seven of the 16 northern states in 2001, compared with 4,053 cases reported from the northern states in 1995. The distinction between indigenous versus imported cases was only made beginning in 1999, but most cases reported from the northern states before then were indigenous to the northern states. However, the continuing cauldron of dracunculiasis in southern Sudan is a concern for neighboring areas well. In addition to the indigenous cases reported in the northern states in 2001, another 47 imported cases were reported there among persons displaced from one of the 10 southern states (111 and 49 cases were imported into northern states in 1999 and 2000, respectively). Southern Sudan has also been the source of 28, 175, 7, 16 and 32 cases exported annually to adjacent countries (Ethiopia, Uganda, Kenya, and the Central African Republic) in 1997–2001. Figure 4 shows the origin and destination of 60 cases exported from southern Sudan in 2001 for which such data are available.

Health workers on both sides of the war in Sudan have gradually increased their efforts to control dracunculiasis, although at great expense and often at considerable personal risk, since the 1995 cease-fire. These include staff from the Federal Ministry of Health, state and local authorities of the Government of Sudan, workers in the humanitarian organizations of the opposing rebel groups, some 19 international Non-Governmental Organizations (NGOs) operating in the south under the auspices of the United Nations' Operation Lifeline Sudan, including UNICEF and WHO. The Carter Center, which has maintained offices in Nairobi and Khartoum since 1995 for this purpose, is responsible for coordinating the dracunculiasis activities in the south. Some of the specific causes of insecurity in 2001 included evacuations, flight bans, bombings, and withdrawal of some NGOs due to a dispute with rebel forces over signing of a Memorandum of Understanding.

More than 278,000 cloth filters for household use in preventing the infection were distributed in Sudan in 1995 (compared with 93,000 the year before), and approximately 600,000 or more have been distributed each year since then. In 2001, however, in addition to distributing nearly 850,000 filters for household use, more than 7.8 million pipe filters were also distributed throughout endemic areas in March–August in an effort to reach every person at risk of dracunculiasis. The pipe filters are made of polyvinyl chloride (PVC) tubing approximately 2 cm in diameter with nylon filter cloth

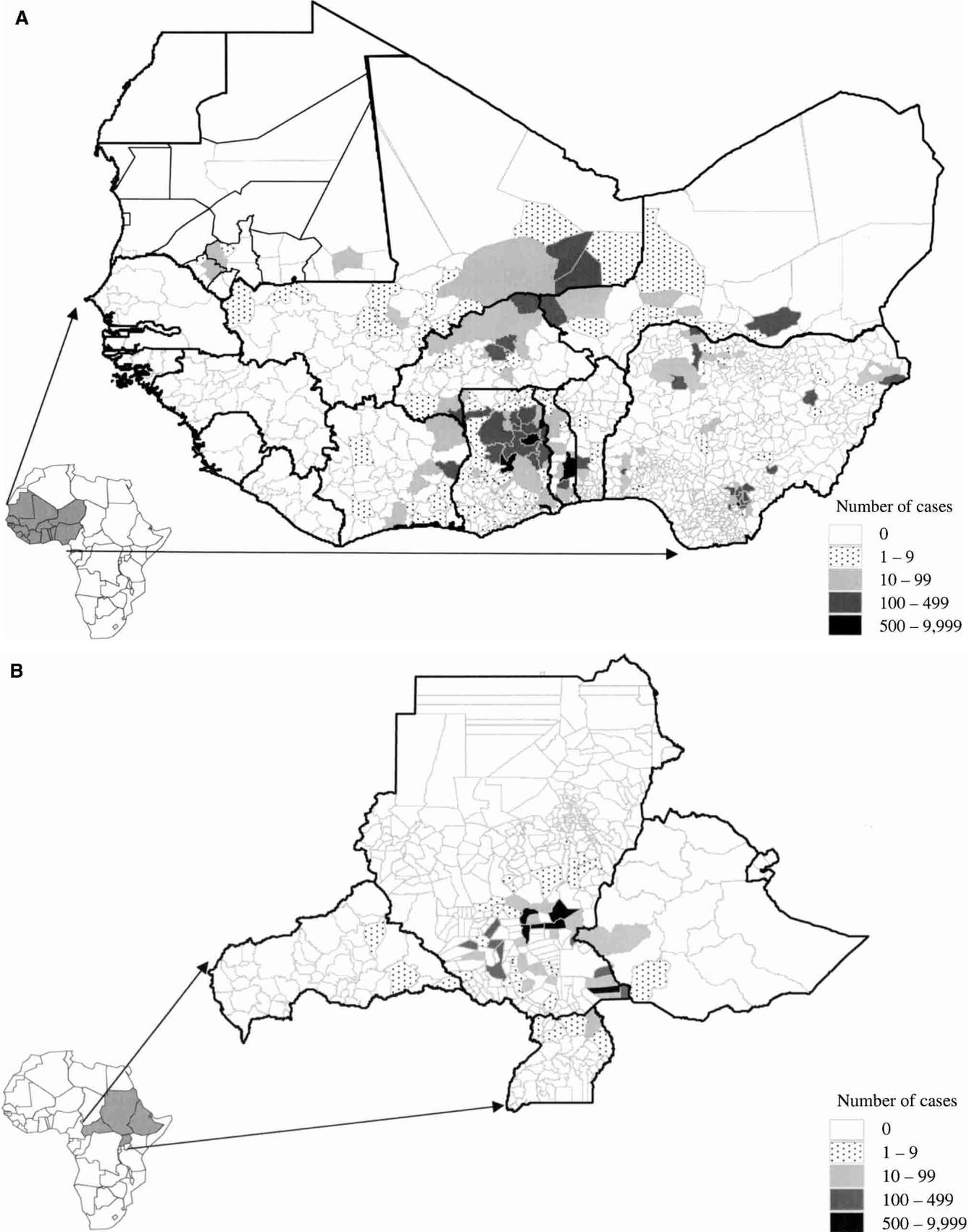


FIGURE 3. **A**, Distribution of 14,112 cases of dracunculiasis in western Africa, 2001. **B**, Distribution of 49,591 cases of dracunculiasis in Sudan, Uganda, the Central African Republic, and Ethiopia, 2001.

TABLE 1  
Dracunculiasis eradication campaign: status of interventions as of December 31, 2001\*

Country	Number of cases reported in 2001	% Change	Number of villages		Percentage of endemic villages				
			Reporting one or more cases	Reporting only 1 case each	With filters in 100% of households	Using Abate®	With 1 or more sources of safe water	Provided health education	% of all cases contained
Sudan	49,471	<b>-10</b>	3,921	649	<b>62</b>	<b>2</b>	61	85	49
Nigeria	5,355	-32	733	172	100	55	50	96	65
Ghana	4,739	-35	779	270	85	72	34	100	68
Togo	1,354	<b>65</b>	180	36	<b>78</b>	76	47	NR	62
Burkina Faso	1,032	-47	202	103	98	86	75	100	73
Mali	718	<b>147</b>	120	39	99	<b>21</b>	<b>15</b>	100	<b>51</b>
Niger	417	-64	160	80	100	78	<b>25</b>	100	<b>57</b>
Cote d'Ivoire†	223	<b>-22</b>	28	13	<b>61</b>	82	100	100	<b>55</b>
Benin†	156	-8	39	23	85	90	74	90	95
Mauritania†	94	-31	25	12	100	40	76	92	<b>52</b>
Uganda†	51	-45	8	6	100	97	85	100	64
Ethiopia†	10	-81	10	10	100	45	39	100	72
Total (- Sudan)	14,149	-30	2,284	764	85	65	45	98	66

\* Numbers in **bold** indicate country-specific program indicators in urgent need of improvement. NR = not reported.

† Indigenous cases only.

fixed over one end, and a string through the other end to allow the owner to wear it around his/her neck constantly, and thus have a filter that they can use like a straw to drink filtered water when farming or traveling away from home. This special intervention was initiated by the Norwegian founder of Health and Development International (HDI), who persuaded Norwegian workers at Hydro Polymers of Norsk Hydro and the Norwegian Chemical Workers Union to donate PVC pipe for the project, and mobilized additional support for the project from the Government of Norway, Norwegian Church Aid (NCA), and The Carter Center, as well as HDI itself. Some 9.2 million pipe filters were assembled in Nairobi by a group of more than 1,000 Sudanese, Ethiopian, and Kenyan workers. The Carter Center and NCA coordinated implementation of the project, the impact of which will be evaluated in 2002.

The Sudan Guinea Worm Eradication Program and its partners have also worked hard to increase other interventions, despite the constraints imposed by the war. Between 2000 and 2001, for example, the percentage of known endemic villages with a village-based health worker who has been trained to help prevent dracunculiasis increased from 54% of 7,898 villages in 2000 to 84% of 6,040 villages in 2001. Similar improvements were achieved in the same period in the rate of monthly reporting of cases (from 39% to 66%), provision of health education about the disease (from 54% to 85%), availability of cloth filters in all of a village's households (from 28% to 62%), and availability of at least one source of safe drinking water (from 45% to 61%). Only use of Abate® for vector control decreased, from 3% to 2% over that year. Meanwhile, the data management system of the program in Sudan is the envy of some countries that are not at war. A special effort began in 2001 to intensify interventions, especially in two southern states that are relatively stable, being mostly controlled entirely by the opponents to the government, namely West Equatoria and Lakes (Buheirat).

Representatives of all 13 endemic countries convened in Khartoum on March 4–7, 2002 for the Seventh Meeting of Program Managers of Guinea Worm Eradication Programs. This annual meeting, the venue of which rotates among the

endemic countries, was co-sponsored by the Government of Sudan, The Carter Center, UNICEF, and WHO. The choice of Sudan for this year's meeting was intended to help focus Sudanese and international attention on Sudan's overwhelming share of the world's remaining cases of dracunculiasis, to publicize the fact that dracunculiasis eradication cannot be completed without an end to the 19-year war in Sudan, to help mobilize the other endemic countries for their final push towards eradication, and provide an opportunity for political discussions related to the Sudanese civil war. It succeeded in all four objectives. The Sudanese head of state, General Omar Al-Bashir, presided over the Opening Ceremony, which was attended by more than 1,000 persons, and also featured remarks by former U.S. President Jimmy Carter, former Nigerian head of state General (Dr.) Yakubu Gowon, and the Federal Minister of Health of Sudan. President Bashir unveiled three commemorative postage stamps in honor of the occasion (Figure 5). The conference generated massive national and international publicity by radio, television, newspapers, and the Internet before, during, and after the meeting itself. More than 10 ministers or deputy ministers of health or their representatives, including a few from formerly endemic countries, participated in a two-hour Round Table Meeting organized by WHO and adopted a Khartoum Declaration committing themselves to completing eradication as soon as possible.<sup>7</sup> This meeting also inaugurated a new format in which the national program managers gave more detailed written and verbal reports, describing separately the epidemiology of the disease in their country, the status of each intervention during 2001, and plans to intensify interventions during 2002. After leaving the conference, President Carter visited an area of southern Sudan controlled by the rebel forces (the Sudanese People's Liberation Movement [SPLM]), held discussions with other political leaders, and met the head of the SPLM, Dr. John Garang, at The Carter Center two weeks later.

## DISCUSSION

After only modest reduction of cases outside Sudan between 1996 and 1999, the global campaign regained momen-

Number of Cases Exported by State

Jonglei	19
W. Bahr al Ghazal	9
N. Bahr al Ghazal	6
Unity	6
Upper Nile	5
W. Kordofan	2
E. Equatoria	3
Buheirat	1
Warab	1
Sinnar	1
White Nile	1



FIGURE 4. Exportation of cases of dracunculiasis in Sudan by state, 2001. C.A.R. = Central African Republic.

tum in 2000 and is now accelerating towards zero cases. The current strategy is to complete eradication outside Sudan as quickly as possible, then turn full attention to finishing off the disease in Sudan. The speed and success of reaching the goal outside Sudan will depend on how well national programs, national political leaders, and village volunteers execute what

needs to be done, as well as on the technical and financial assistance provided by external supporters.

We believe that at least four or five years will be required to completely eradicate dracunculiasis from Sudan, even after the war ends, because of the high level of endemicity, the vast size and geographic barriers in southern Sudan, and the poor



## The 7<sup>th</sup> Dracunculiasis Program Managers' Meeting

The Final Push For Eradication of Dracunculiasis

March 4 – 7 – 2002

Khartoum – Sudan

FIGURE 5. First day cover of Sudan postage stamps commemorating the program for the eradication of dracunculiasis.

infrastructure there. In the meantime, recently increased global attention to helping to find a political solution to the complex war in Sudan is welcome and timely, since achieving a political settlement will be difficult and take time, and the other endemic countries are all very close to finally interrupting transmission of the disease. One tangible epidemiologic gain from the recent diplomatic activity has been access by health workers from the Sudan Guinea Worm Eradication Program to the contested Nuba Mountains area (in South Kordofan State), which was previously highly endemic but inaccessible to health workers for more than a decade. The survey teams found that almost no cases of the disease remain there. The Carter Center and CDC are also continuing to search for any antihelmintic drug(s) or antibiotic that could prevent or cure dracunculiasis to shorten the time needed to interrupt transmission in Sudan when peace does come there.

Reasons for the plateau in cases in the late 1990s, which has delayed attainment of eradication, include political instability and war, inadequate funding, complacency, and apathy. Even outside Sudan, political and ethnic conflicts have significantly impeded program activities in Central African Republic, Ethiopia, Ghana, Mali, Nigeria, Togo, and Uganda in recent years. The problem of inadequate funding was removed as an important constraint by a major grant of \$28.5 million from the Bill and Melinda Gates Foundation to The Carter Center, WHO, and The World Bank, beginning in 2000. Under the division of labor agreed for in that grant, The Carter Center has lead responsibility for assisting programs in countries reporting more than 100 cases annually, WHO has lead responsibility for countries with fewer than 100 cases annually as well as for activities related to pre-certification and certification of eradication, and UNICEF focuses on assisting selected endemic countries with funds from other sources, with an emphasis on helping to provide safe drinking water to affected communities. The Gates grant is administered through The World Bank by a committee of representatives from WHO, The Carter Center, UNICEF, and the Bank.

Complacency and apathy by health workers in endemic countries and by representatives of some national and international agencies has become harder to avoid, especially as the end of the campaign has been delayed. Recruitment of the popular former Nigerian head of state, General Gowon, to the campaign made an immediate and significant difference in

that important country, in addition to personnel changes, better funding, increased technical assistance, and strong support by the new head of state. Beginning in 1999, General Gowon has visited endemic villages in all of the major endemic foci remaining in Nigeria, engaging political and public health leaders, extracting promises of action and re-visiting to check on progress made. The program in Ghana is benefiting from similar improvements, although without the strong advocacy of a former head of state. The turn around in these two highest endemic countries outside Sudan, and the continued advocacy in Mali and other French-speaking endemic countries by former Malian head of state, General Amadou Toumani Toure, have paced the new momentum. As already mentioned, one of the objectives of the meeting in Khartoum in March 2002 was to help rejuvenate the interest, political support, and participation by other supporters of the campaign.

The one-year incubation period of dracunculiasis infections is an immovable constraint in this campaign. It exacts a stiff penalty for every mistake and negligence of duty, and it is a major reason why the disease has not been eradicated as soon as expected. Program managers and others involved are being urged to focus on the status of current interventions, rather than concentrating all their attention on monthly reductions in cases compared with reported incidence the previous year. Detecting deficiencies in this year's interventions allows programs to correct those short comings now, before they are manifest a year later by increased cases or lack of a decrease in cases. The level of this year's cases, on the other hand, has already been irreversibly determined by the efficacy of control measures taken last year. Programs are also challenged to constantly escalate the intensity and diversity of the control measures being brought to bear in the remaining endemic foci.

We hope that the recent increase in diplomatic attention to settling the war in Sudan will bear fruit quickly, since the southern part of that country will soon be the last refuge of endemic dracunculiasis on earth, and because the cost to neighboring countries of sustaining the vigilance required in remote border areas until Sudan is free of Guinea worm is high. As stated by a village elder in the Nuba Mountains less than two years ago: "The main thing we need is for this war to be solved. You can bring whatever you like here. If this war continues, it will mean nothing."<sup>8</sup>

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#### REFERENCES

1. Hopkins DR, Ruiz-Tiben E, Ruebush TK, Diallo N, Agle A, Withers PC Jr, 2000. Dracunculiasis eradication: delayed, not denied. *Am J Trop Med Hyg* 62: 163–168.
2. Hopkins DR, Ruiz-Tiben E, 1991. Strategies for eradication of dracunculiasis. *Bull World Health Organ* 69: 533–540.
3. Hopkins DR, Ruiz-Tiben E, Ruebush TK, 1997. Dracunculiasis eradication: almost a reality. *Am J Trop Med Hyg* 57: 252–259.
4. Watts SJ, 1987. Dracunculiasis in Africa in 1986: its geographic extent, incidence, and at-risk population. *Am J Trop Med Hyg* 37: 119–125.
5. World Health Organization, 2002. Dracunculiasis eradication: global surveillance summary, 2001. *Wkly Epidemiol Rec* 77: 143–152.
6. Eberhard ML, Melemoko G, Zee AK, Weisskopf MG, Ruiz-Tiben E, 2001. Misidentification of *Onchocerca volvulus* as guinea worm. *Ann Trop Med Parasitol* 95: 821–826.
7. World Health Organization, 2002. Dracunculiasis eradication: Khartoum Declaration of Guinea Worm Eradication, 2002. *Wkly Epidemiol Rec* 77: 141–143.
8. Fischer I, 2001. Can international relief do more good than harm? *The New York Times Magazine* February 11.