CASE 10

Reducing Guinea Worm in Asia and Sub-Saharan Africa

Geographic Area: 20 countries in Asia and sub-Saharan Africa

Health Condition: Before the start of the campaign in the early 1980s, an estimated 3.5 million people in 20 endemic countries in Africa and Asia were infected with guinea worm, and an estimated 120 million were at risk.

Global Importance of the Health Condition Today: In 2003, fewer than 35,000 cases of guinea worm were reported. Just three countries have reported more than 1,000 cases—and the vast majority of the cases are in Sudan, where civil war has impeded progress.

Intervention or Program: Through the global eradication campaign led by the Carter Center, the United Nations Children's Fund, the US Centers for Disease Control and Prevention, and the WHO, 20 countries implemented national Guinea Worm Eradication Programs, run through the ministries of health. The primary interventions of the campaign include the provision of safe water (through deep well digging, applying larvicide, and purifying water through cloth filters); health education; and case containment, management, and surveillance.

Cost and Cost-Effectiveness: The total cost of the program between 1986 and 1998 was $87.4 million. The estimated cost per case was $5 to $8. The World Bank determined that the campaign has been highly cost-effective and cost-beneficial. The economic rate of return based on agricultural productivity alone has been estimated at 29 percent.

Impact: The eradication efforts have led to a 99 percent drop in guinea worm prevalence. In 2003, fewer than 35,000 cases were reported, compared with an estimated 3.5 million infected people in 1986. By 1998, the campaign prevented between 9 million and 13 million cases of guinea worm.

Dracunculiasis, or guinea worm disease, is an ancient scourge that once afflicted much of the world, including the Americas. Documented in Egyptian medical texts as early as the 15th century BC, it is thought to be the "fiery serpent" referenced in the Old Testament. One of the most preventable of all parasitic diseases, guinea worm has vanished from developed countries since the introduction of safe drinking water. Today it is truly a disease of the poor, debilitating many of the world's most remote and disadvantaged communities in Africa, where access to potable water is limited. Before the start of the eradication campaign in the early 1980s, an estimated 3.5 million people in 20 endemic countries in Africa and Asia were infected with the disease, and an estimated 120 million remained at risk (Carter 1999).[1]

The fight against guinea worm represents one of the most successful international collaborations and is particularly interesting because the intervention is, at its heart, behavior change. Success hinged on the steady commitment of donors and technical supporters, as well as national governments, resulting

1. The endemic countries in 1985 included Pakistan, Ghana, India, Nigeria, Cameroon, Burkina Faso, Senegal, Togo, Uganda, Iran, Benin, Côte d'Ivoire, Mali, Mauritania, Niger, Chad, Ethiopia, Kenya, Sudan, and Yemen.

in dramatic improvements in health. Moreover, success depended on the campaign's ability to reach poor, isolated communities and convey essential messages about how to handle water and prevent the disease.

How the Worm Turns

Guinea worm disease is contracted when a person drinks stagnant water from a well or pond that is contaminated with tiny fleas called copepods carrying guinea worm larvae. Once inside the human, the larvae mature in the abdomen and, unbeknownst to their host, grow to an average of two to three feet in length. A year later, the fully grown female worm rises to the skin in search of a water source to lay her larvae. A painful blister forms, usually in the person's foot. To ease the burning pain, infected individuals frequently submerge the blister in cool water, causing the blister's rupture and the release of tens of thousands of larvae into the water. A vicious cycle of reinfection occurs when sufferers inadvertently contaminate public waters and set the stage for further infestations.

The worm, about the width of a match, gradually emerges from the blister in a painful process that can last 8 to 12 weeks. Numerous worms can emerge simultaneously. The most common treatment used by infected individuals during this agonizing period is a rudimentary technique that dates back to ancient times. Worms are coaxed out of the blister by being slowly wound around a narrow stick, a few centimeters each day—a process that is represented in the medical symbol "Caduceus." The patient must take extreme caution to avoid breaking the worm, else risk painful inflammation caused when a broken worm retreats into the body.

Disease of the Empty Granary

Guinea worm disease takes its toll not through death, since the disease is rarely fatal, but rather through devastating disability and infection. The pain associated with the emerging worm is extremely debilitating. Two studies in Nigeria, for example, reported that 58 to 76 percent of patients were bedridden for at least one month following the worm's emergence. The pain is also long lasting, evidenced by the fact that in one study 28 percent of infected individuals in Ghana experienced pain 12 to 18 months later (Cairncross, Muller, and Zagaria 2002). The disease's other symptoms, including nausea, vomiting, diarrhea, and dizziness further exacerbate this burden. Secondary bacterial infections occur in about half of all cases and can lead to arthritis, "locked" joints, tetanus, and permanent crippling (Kim, Tandon, and Ruiz-Tiben 1997).

While the disease afflicts all age groups, it particularly harms children. The likelihood of a child under the age of 6 in Sudan being malnourished is more than three times higher when the adults in the household are infected with the disease. School absenteeism rises when the debilitating symptoms render children incapable of walking the often long distance to school and when children forgo school to take on the agricultural and household work of sick adults. As a result, schools in endemic areas frequently shut their doors for a month each year (Cairncross, Muller, and Zagaria 2002).

Guinea worm disease is not only a symptom of poverty but also a perpetrator. The economic burden inflicted on poor rural communities is severe and is compounded by the seasonal nature of the disease and its high prevalence in affected communities. Cyclical weather patterns and harvesting and planting seasons lead to peak periods when water in contaminated ponds and wells is widely consumed. A year later, an entire community can be debilitated and unable to work—a period that often cruelly coincides with the busiest agricultural seasons. This phenomenon explains the disease's nickname among the Dogan people in Mali—"the disease of the empty granary."

The economic damage is extreme. The annual economic loss in three southern rice-growing states in Nigeria was calculated at $20 million. Further research in Mali found that overall production in that country of sorghum and peanuts, two critical subsistence crops grown in northeast Mali, was reduced by 5 percent (Cairncross, Muller, and Zagaria 2002).

Planting the Seeds of Eradication

In 1980 the US Centers for Disease Control (CDC) first planted the seeds of the global guinea worm

eradication campaign. At the time, many in the global health community considered the disease to be an unlikely candidate for eradication. Unlike the eradication campaign that successfully wiped out smallpox, a guinea worm campaign would not have in its arsenal a vaccine to prevent the disease; the campaign also lacked a medical cure to treat a person once he or she had been infected. Instead, eradicating guinea worm would require the disruption of the worm's transmission for one year through either of the three principal interventions: construction of safe water sources; vector control through the use of larvicides in water sources; and health education and awareness campaigns promoting behavior changes, including the filtration of water with a cloth filter, self-reporting of infestations, and avoidance of recontamination of public water sources.

Skeptics pointed out the numerous challenges facing the implementation of the interventions in Asia and Africa. First, the construction and maintenance of safe water sources is a time- and resource-intensive process requiring considerable external financing. Furthermore, many of the remote, endemic villages were outside the national public health infrastructure and in some instances were not even known to the government. The task, then, of coordinating an effort to change the behavior of millions of poor, illiterate, and geographically isolated villagers throughout Asia and Africa appeared exceptionally daunting.

In 1981, an important event prompted the CDC to spearhead eradication efforts. The launch that year of an international initiative to provide universal access to safe drinking water presented an unprecedented opportunity for the fight against guinea worm. Dr. Donald Hopkins and his colleagues at the CDC recognized the implications of the International Drinking Water Supply and Sanitation Decade for the prospects for guinea worm eradication and persuaded the initiative to include the eradication of the disease as a subgoal of the decade. The decision ensured that priority would be placed on the construction and maintenance of safe water sources in endemic communities and provided an important foundation for further eradication efforts. With the prospects for eradication now considerably stronger, the CDC launched a more than 10-year advocacy campaign to catalyze a global eradication effort (Cairncross, Muller, and Zagaria 2002).

Momentum, however, was extremely slow to build. Lack of data on disease prevalence and weak political commitment impeded progress. Skepticism mounted in the public health community and among African leaders when, after recognizing the slow pace of the water decade in providing safe water to endemic communities, the campaign began emphasizing the important role of public health campaigns and behavior change in the eradication efforts. By the end of the water decade in 1991, just four of the 20 endemic countries had initiated full-scale national Guinea Worm Eradication Programs, which were to have formed the backbone of the global campaign.

Turning the Tide

Key events in the 1980s helped overcome these obstacles and turn the tide in the fight against guinea worm. In 1986, the World Health Assembly (WHA), the highest governing body of the WHO, passed a resolution that set the elimination of guinea worm as a goal of the organization and bestowed greater international legitimacy to the campaign. That same year, a meeting of public health leaders from 14 African countries helped make important strides toward filling the gaps in data, awareness, and political commitment on the continent.

A major turning point in the campaign occurred later in 1986 when US President Jimmy Carter began his nearly 20-year involvement in the campaign and became a powerful advocate for eradication. That year, President Carter persuaded Pakistan's head of state, General Zia ul Haq, to follow India as the second country to launch a national eradication effort. He then focused on Africa and in 1988 attended a regional conference in Ghana of African guinea worm program coordinators. His high-profile presence and personal persuasion helped propel the campaign forward in Africa and prompted the involvement of Ghana's president, Jerry Rawlings. Rawlings subsequently toured highly endemic villages in northern Ghana and launched the first African eradication program.

Political commitment in Africa was firmly consolidated thanks to the advocacy efforts of two popu-

lar former African leaders whom President Carter recruited to the campaign. In 1992, General Amadou Toumani Touré, the former head of state of Mali, began an extensive campaign to raise awareness and to persuade the nine other endemic Francophone countries in Africa to also launch eradication programs. Likewise, Nigeria's former head of state, General Yakubu Gowon, was recruited in 1998 and has played an important role in galvanizing political support for efforts in Nigeria, a country that then had the highest number of guinea worm cases outside of Sudan. General Gowon visited villages in all the major endemic regions in Nigeria and mobilized the commitment of political and public health leaders.

As national commitment was being harnessed, the essential technical and financial resources of the donor community were also successfully marshaled. By 1995, national eradication programs had been established in all 20 endemic countries and a global effort to eradicate the disease was fully under way. Under the stewardship of Dr. Hopkins and in close collaboration with the United Nations Children's Fund (UNICEF), the CDC, and the WHO, the Carter Center has led the eradication effort and has worked directly with and through the ministries of health in each endemic country to provide support to the national eradication efforts. The campaign is truly a global partnership and has drawn on the participation of an impressive range of groups: donor countries, international agencies, foundations, nongovernmental organizations (NGOs), African governments, the private sector, village volunteers, and even the infected individuals themselves.

The Eradication Campaign

The goal of the national campaigns, operated by the ministries of health, has been to wipe out the disease by stopping the worm's transmission, effectively bringing the case incidence to zero. Because there are no nonhuman carriers of the disease, guinea worm would thereafter be eradicated. The primary interventions of the campaign include the provision of safe water (through deep well digging, applying larvicides, and purifying water through cloth filters); health education; and case containment, management, and surveillance.

Safe Water

To improve the safety of water in endemic regions, the national programs facilitated the construction and maintenance of accessible water sources (mainly wells) and the selective application of a cyclopcide called Abate™, which can effectively kill the tiny fleas in ponds and water sources. Construction of safe water sources is the most expensive and long-term option of all the available interventions and has received sizable financial support from UNICEF and the government of Japan. Because the cost of this intervention can exceed $40 per person (plus additional maintenance costs), and the cost of constructing a borehole well can exceed $10,000, it is not considered cost-effective in many villages with small and/or nomadic populations and instead has been most effective in more concentrated areas. Voluntary participation has allowed hundreds of endemic communities to improve their water supply; in southeast Nigeria alone, villagers hand-dug more than 400 wells (Hopkins 1999).

One of the most cost-effective ways of improving the safety of drinking water is by passing it through a filter. At the start of the eradication campaign, efforts relied on cloth filters. However, the cloth fabric clogged frequently, and the filters often were used instead as decorations (Cairncross, Muller, and Zagaria 2002).

A new nylon cloth that was less prone to clogging was developed in the early 1990s. Through the Carter Center, Precision Fabrics and DuPont donated several million square yards of nylon for filters, valued at more than $14 million (Cairncross, Muller, and Zagaria 2002). Initial take-up rates were low because the filters were originally sold for a small fee to instill a value in ownership. Because of low initial ownership rates, all the national programs now distribute filters for free. Health education campaigns have promoted the use of filters and explained the health benefits of the simple intervention, helping bolster their popularity and use.

Health Education

Essential to the campaign has been the voluntary participation of the residents of endemic communities in preventing, treating, and containing the dis-

ease. As President Carter (1999) explained, "it is the affected villagers who must act in order to free themselves of this disease." Despite the initial skepticism, one of the most remarkable accomplishments has been the success of the locally targeted public education campaigns, which Dr. Hopkins considered to be the "fastest and most effective intervention" (Hopkins 1998).

The public education interventions have convinced individuals and communities that they can prevent the contraction and spread of guinea worm. Individuals are encouraged to clean drinking water by passing it through a nylon filter, to avoid recontamination of ponds, and to report infestations. An extensive social marketing campaign has been employed with the goal, in the words of Dr. Hopkins, that "no individual would be able to approach a drinking water source without thinking of guinea worm disease." The simple, targeted messages are communicated through radio, t-shirts, posters, banners, stamps, sides of vehicles, and videos.

A popular communications tool has been "worm weeks"—weeks of intensive health education and community mobilization during which local and international volunteers (including US Peace Corps volunteers) perform plays, arrange ceremonies with prominent officials, and demonstrate how to use cloth filters and prevent the disease (Hopkins et al. 2002). Research in Ghana demonstrated the success of the worm weeks: The communities that had participated in worm weeks showed an 80 percent decrease in cases versus a 45 percent reduction in neighboring villages without the intervention (Hopkins et al. 2002).

Surveillance and Case Management

The one-year incubation period leaves little room for mistakes so the campaign has required careful case identification, containment, and management. Because many of the remote endemic villages lack primary healthcare workers, these efforts have relied heavily on the help of "village volunteers" in more than 15,000 communities. Trained and supervised by representatives from the ministry of health, the volunteers form the bulk of the eradication staff and perform a range of key functions including the distribution of free filters, participation in public awareness campaigns, and assistance with case identification and containment. They have also pioneered a monthly reporting system that has provided national coordinators with data necessary for tracking the disease and monitoring the campaign's progress. The village-based reporting system, virtually nonexistent in countries such as Ghana and Nigeria at the start of the campaign, is now considered a model for the surveillance of other diseases such as tetanus, lymphatic filariasis, and leprosy (Hopkins 1998).

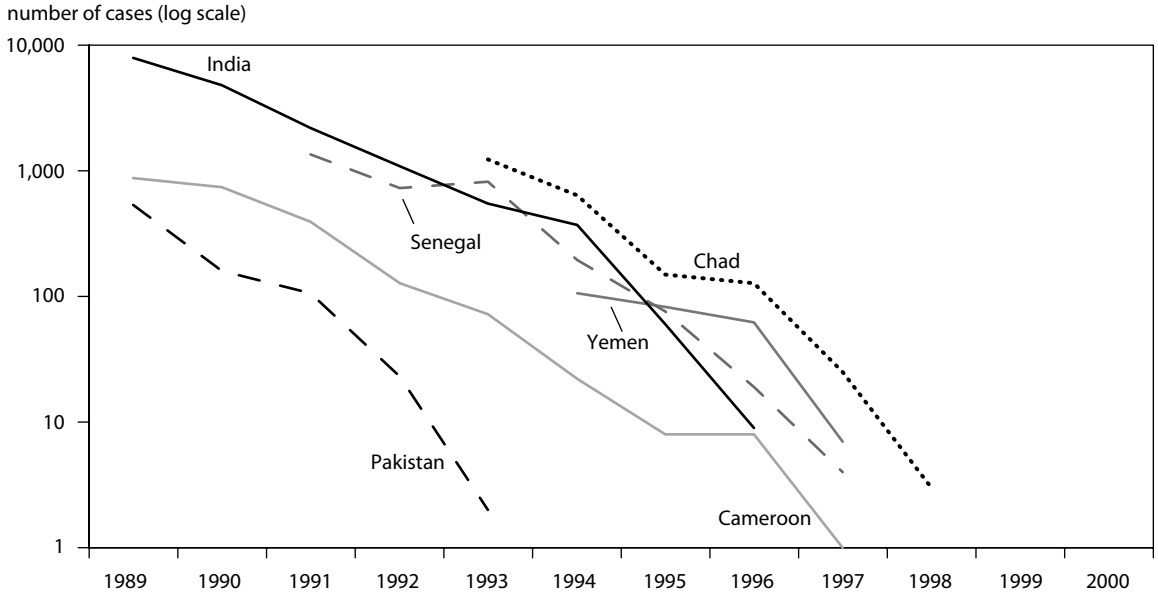
A 99 Percent Drop in Guinea Worm Prevalence

The result of the campaign's efforts has been a 99 percent drop in the prevalence of guinea worm. In 2003, fewer than 35,000 cases were reported, compared with an estimated 3.5 million infected people in 1986. All three countries in Asia are now free of guinea worm: Pakistan (1993), India (1996), and Yemen (1997). Overall, by 2003, seven of the original 20 endemic countries halted transmission of the disease; six had fewer than 50 cases each; and just three had more than 1,000 each (figure 10.1). The vast majority of remaining cases are in Sudan, where the country's civil war has impeded progress (box 10.1). The World Bank estimated that the campaign prevented between 9 million and 13 million cases of guinea worm by 1998 (Kim, Tandon, and Ruiz-Tiben 1997).

Cost and Economic Returns

The estimated cost of the global campaign between 1987 and 1998 is $87.5 million (Kim, Tandon, and Ruiz-Tiben 1997). The effort received major financial support and donor support from the governments of Canada, Denmark, Finland, Japan, the Netherlands, Norway, Qatar, Saudi Arabia, Spain, Sweden, United Arab Emirates, the United Kingdom, and the United States (Carter 1999). The private sector also contributed to the campaign: BASF (formerly American Home Products) donated more than $2 million worth of insecticide to the campaign, and E.I. DuPont Corporation donated more than $14 million worth of cloth for filters. The an-

Figure 10.1 Countries that have interrupted transmission of guinea worm disease



Source: Cairncross, Muller, and Zagaria (2002).

nouncement of a $28.5 million grant from the Bill & Melinda Gates Foundation in 2000 helped ensure that the campaign remains funded.

A World Bank study determined that the financial investment made by the campaign has yielded considerable financial returns. According to the study, the economic rate of return based on agricultural productivity alone has been estimated at 29 percent—an impressive figure many consider to be an underestimate, especially if the goal of eradication is achieved and the benefits accrue in the future at no additional cost. The cost per case prevented was estimated at $5 to $8 (Kim, Tandon, and Ruiz-Tiben 1997).

Keys to Success

Dr. Hopkins identified the following strategies that contributed to the campaign's impressive success:

- **coordination.** Interagency meetings, held three to four times a year, and annual meetings of coordinators of national eradication programs facilitated exemplary coordination of major partners and donors.

- **power of data.** The data provided by the village volunteers through the monthly reporting system helped with what Dr. Hopkins calls the "Disneyland effect"—that people will stand in long lines if they see that the line is moving and that no one is "cutting" ahead of others. Data published in the CDC's monthly publication, *Guinea Worm Wrap-Up*, demonstrating the progress and success of the national programs, has helped keep countries motivated and focused on the efforts—and has pressured countries lagging behind. The campaign has actively promoted competition between rivals such as Ghana and Nigeria, and India and Pakistan.

- **high-level advocacy and political leadership.** High-level advocacy and political leadership from current and former heads of state helped prevent the "problem" of success—that resources and support tend to dwindle as time passes, and progress is made. The political support of President Carter, General Toumani Touré, General Gowon, and

Box 10.1 Sudan: The final bastion

The biggest obstacle facing the guinea worm eradication campaign is not the tenacious parasite but rather the civil strife in Sudan—a country that is home to more than three of every four remaining cases of guinea worm. The challenge of eliminating the disease in what may soon be its final bastion has been exacerbated by the more than 20-year civil war that has divided Sudan, particularly in the south, where disease prevalence is highest. Ernesto Ruiz-Tiben, technical director of the Carter Center's Guinea Worm Eradication Program, explains that "the war and the absence of infrastructure in southern Sudan makes it very difficult to organize a program in endemic villages."

Despite the constraints, some progress has been made in the country. In 1995, former US President Jimmy Carter negotiated a four-month Guinea Worm Cease-Fire, which allowed health workers to distribute more than 200,000 cloth filters to nearly 2,000 villages. (The cease-fire also provided a precious window for providing other life-saving health interventions: 100,000 people at risk of river blindness were treated; 41,000 children were vaccinated for measles; 35,000 received a polio vaccine; 35,000 doses of vitamin A were distributed; and 9,000 children were treated with oral rehydration therapy [Hopkins 1999].) Since the cease-fire, government authorities, the United Nations, the Carter Center, and more than 20 nongovernmental organizations have focused on combating the disease in the south. An estimated 600,000 cloth filters have been distributed each year, and in 2001, nearly 8 million pipe filters—a straw-like tube with a nylon filter cloth that can be worn around the neck and used when farming or traveling—were distributed. These efforts have been assisted by political commitment from the highest levels of Sudan's government and from the advocacy of President Carter, who visited parts of the rebel-controlled region in 2002 (Hopkins and Withers 2002, Hopkins et al. 2002).

Success in Sudan is not believed possible without an end to the conflict. Until then, the persistence of guinea worm there jeopardizes the residents, the populations of the neighboring countries, and the success that the national eradication programs have worked so hard to achieve.

others brought sustained attention and awareness to the remaining challenge—the cases that are the most difficult to reach—and kept programs on track. For example, General Gowon visited all the major endemic foci in Nigeria, extracted promises of action, and revisited the areas later to check on their progress. Largely thanks to his efforts, the number of cases in Nigeria fell by half.

The success of the guinea worm eradication campaign is remarkable and places the disease in line to be eradicated. As Sandy Cairncross, Ralph Muller, and Nevio Zagaria (2002) summarize, the guinea worm eradication campaign demonstrates that "it is possible, at affordable expense, to control and even eliminate a disease at a national level, even in the remotest and most neglected areas of some of the poorest countries in the world and in spite of the fact that the key interventions involve substantial changes in behavior."

References

Cairncross, Sandy, Ralph Muller, and Nevio Zagaria. 2002. Dracunculiasis (Guinea Worm Disease) and the Eradication Initiative. *Clinical Microbiology Review* 15, no. 2: 223–46.

Carter, Jimmy. 1999. The Power of Partnership: The Eradication of Guinea Worm Disease. *Cooperation South*, no. 2: 140–47.

Hopkins, Donald R. 1998. The Guinea Worm Eradication Effort: Lessons for the Future. *Emerging Infectious Diseases* 4, no. 3 (July–September). www.cdc.gov/ncidod/eid/vol4no3/hopkins.htm (accessed August 6, 2004).

Hopkins, Donald R. 1999. Perspectives from the Dracunculiasis Eradication Programme. *Morbidity*

and Mortality Weekly Report 48, SU01: 43–49. Atlanta, GA: US Centers for Disease Control and Prevention.

Hopkins, Donald R., and P. Craig Withers, Jr. 2002. Sudan's War and Eradication of Dracunculiasis. *The Lancet Supplement* 260 (December): 21–22.

Hopkins, Donald R., Ernesto Ruiz-Tiben, Nwando Diallo, P. Craig Withers Jr., and James H. Maguire. 2002. Dracunculiasis Eradication: And Now, Sudan. *American Journal of Tropical Medicine and Hygiene* 67, no. 4: 415–22.

Kim, Aehyung, Ajay Tandon, and Ernesto Ruiz-Tiben. 1997. *Cost-Benefit Analysis of the Global Dracunculiasis Eradication Campaign*. Policy Research Working Paper 1835. Washington: World Bank, Africa Human Development Department.