

Reducing Guinea Worm in Asia and Sub-Saharan Africa*

ABSTRACT

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

Health condition: Before the start of the campaign in 1986, an estimated 3.5 million people in 18 endemic countries in Africa and Asia were infected with guinea worm, and 120 million were at risk.

Global importance of the health condition today: In 2005, fewer than 11,000 cases of guinea worm were reported in the nine remaining endemic countries. 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: With the technical and financial support of a global coalition of organizations led by the Carter Center, the United Nations Children's Fund, the US Centers for Disease Control and Prevention, and the World Health Organization, 20 countries implemented national guinea worm eradication programs, run through their 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%. The estimated cumulative cost of the campaign as of 2004 was approximately \$125 million.

Impact: The eradication efforts have led to a 99.7% drop in guinea worm prevalence. In 2005, fewer than 11,000 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. As of 2005, the campaign has prevented more than 63 million cases of guinea worm disease, reduced the number of endemic villages by 91%, and stopped the transmission of the disease in 11 of the 20 endemic countries.

Dracunculiasis, or guinea worm disease, is an ancient scourge that once afflicted much of the world, including parts of 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 disease has van-

ished from developed countries since the introduction of safe drinking water. Today it is truly a disease of the poor, debilitating many of the most remote and disadvantaged communities in Africa, where access to potable water is limited and health care and education are lacking. In 1986, an estimated 3.2 million people in 20 endemic countries in Africa and Asia

were infected with the disease,[†] and an estimated 120 million remained at risk.¹ Estimates of cases of disease prevalence in India and Pakistan during 1986 raised the annual global burden to 3.5 million cases.

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

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 freshwater copepods carrying guinea worm larvae. Once inside the human, the stomach acid kills the copepods allowing the larvae to migrate into the small intestine, where they penetrate the intestinal wall into the abdominal cavity. After 60 to 90 days, male and female larvae mate and, unbeknown 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 lower limbs, although the worms can emerge from any part of the body. To ease the burning pain, infected individuals frequently submerge the blister in cool water, causing the blister's rupture and the release of hundreds of thousands of larvae into the water. A vicious cycle of reinfection occurs when sufferers inadvertently contaminate sources of drinking water and set the stage for themselves and other residents to contract the infection.

The worm, about the width of spaghetti, gradually emerges from the blister in a painful process that can last 8 to 12 weeks. Numerous worms can emerge simultaneously or may emerge sequentially over a period of many weeks. Lesions caused by guinea worms invariably develop secondary bacterial infections, which exacerbate the pain and duration of disability. 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 Caduceus—the symbol of medicine. The patient must take extreme caution to avoid breaking the worm, or they risk painful inflammation caused when a broken worm retreats into the body. No medication is available to treat guinea worm disease, and there is no vaccine to prevent it.

DISEASE OF THE EMPTY GRANARY

Guinea worm disease takes its toll not through death, as the disease is rarely fatal, but rather through devastating disability, pain, and infection. Two studies in Nigeria, for example, reported that 58% to 76% 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% of infected individuals in Ghana experienced pain 12 to 18 months later.² 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.³

Although the disease afflicts all age groups, it particularly harms children. The likelihood of a child under the age of 6 years 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.²

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 Dogon 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%.²

† The 20 endemic countries included Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Central African Republic, Ethiopia, Ghana, India, Kenya, Mali, Mauritania, Niger, Nigeria, Pakistan, Senegal, Sudan, Togo, Uganda, and Yemen.

PLANTING THE SEEDS OF ERADICATION

In 1980, the US Centers for Disease Control and Prevention (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 the principal interventions: provision of safe sources of drinking water; treatment of unsafe sources of drinking water with larvicide; and health education and social mobilization to keep those infected from contaminating sources of drinking water and to ensure filtration of household drinking water; and surveillance and monthly case reporting.

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.²

Momentum was extremely slow to build. Initially, lack of data on disease prevalence, inadequate funding, 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 4 of the 20 endemic countries (Ghana, India, Nigeria, and Pakistan) 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, with the Carter Center taking the role of lead nongovernmental organization providing financial and technical assistance to national eradication programs. 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 popular 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. Nigeria's former head of state, General Yakubu Gowon, was recruited in 1999 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 has 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 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 global partnership has drawn on the participation of an impressive range of groups: donor countries, international agencies, foundations, 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 from every locality where it occurs, 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 village-based surveillance and monthly case reporting; health education to prevent infected persons from contaminating sources of drinking water and to use free cloth filters to filter all drinking water; applying larvicide to contaminated sources of drinking water; and advocacy for the provision of safe water.

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 ABATE larvicide, which can effectively kill the copepods, or "water fleas," in ponds and other stagnant sources of drinking water. 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 areas with higher population density. Voluntary participation has allowed hundreds of endemic communities to improve their water supply; in southeast Nigeria alone, villagers hand dug more than 400 wells.⁴

One of the most cost-effective ways of improving the safety of drinking water (to prevent guinea worm disease) is by passing it through a cloth filter. At the start of the eradication campaign, efforts relied on filters made of local fabrics. However, the cloth fabric clogged frequently, and these filters often were used instead as decorations.²

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.² More user-friendly filters made from cotton-polyester cloth with nylon mesh filters in the center have been in use since 1999. 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 disease. As President Carter explained in 1999, "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 Hopkins considered to be the "fastest and most effective intervention."⁵

The public education interventions have convinced individuals and communities that they can prevent the disease and its spread. 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 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 in the most highly endemic communities during which local and international volunteers (including those from the US Peace Corps) perform plays, arrange ceremonies with prominent officials, and demonstrate how to use cloth filters and prevent the disease.⁶ Research in Ghana demonstrated the success of the worm weeks: The communities that had participated in worm weeks showed an 80% decrease in cases versus a 45% reduction in neighboring villages without the intervention.⁶

SURVEILLANCE AND CASE MANAGEMENT

The 1-year incubation period leaves little room for mistakes, so the campaign has required careful case identification, management, and containment of transmission. Because many of the remote endemic villages lack primary health care workers, these efforts have relied heavily on the help of "village volunteers" in more than 23,000 communities at its peak in 1993.⁷ Trained and supervised by representatives from the ministry of health, the village volunteers form the bulk of the eradication staff and perform a range of key functions including daily detection of cases, case management, containment of transmission, distribution and replacement of nylon cloth or pipe filters, and social mobilization and public awareness campaigns. These village volunteers are the keys to success of the monthly reporting system that provides 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.⁵

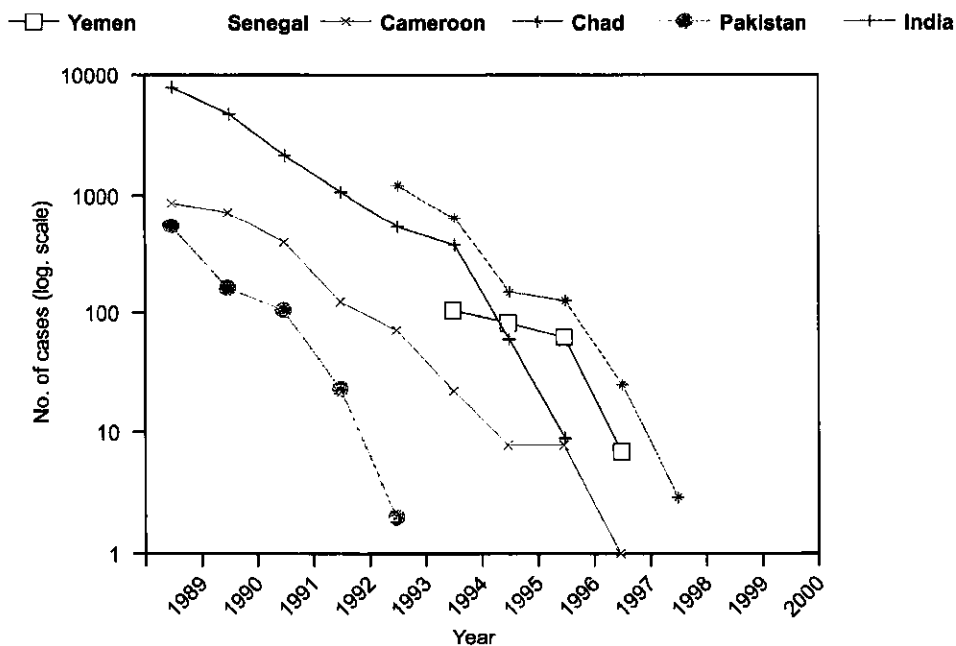
A 99% DROP IN GUINEA WORM PREVALENCE

The result of the campaign's efforts has been a 99% drop in the prevalence of guinea worm. In 2005, only 10,674 cases of the disease 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). As of 2005, 11 of the original 20 endemic countries halted transmission of the disease; 4 reported fewer than 100 cases each, and just 2 had more than 1,000 each. The vast majority (89%) of the cases reported in 2005 were from Sudan (5,569 cases) and from Ghana (3,981 cases) (see Box 11-1). In the absence of the eradication campaign begun in 1986, a total of 3.5 million cases of the disease would have presumably occurred annually. Therefore, the eradication campaign can be said to have prevented at least 63 million cases of guinea worm disease since 1987.

COST AND ECONOMIC RETURNS

The estimated cost of the global campaign between 1987 and 1998 is \$87.5 million.³ The effort received major financial support and donor support from the governments of Canada,

FIGURE 11-1 Countries that have interrupted transmission of guinea worm disease.



Source: Cairncross S, Muller R, Zagaria (2002).

Denmark, Finland, Japan, the Netherlands, Norway, Qatar, Saudi Arabia, Spain, Sweden, United Arab Emirates, the United Kingdom, and the United States.⁸ 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 announcements of a grant from the Bill & Melinda Gates Foundation in 2000 worth \$28.5 million and, more recently, a \$25 million matching grant, has helped ensure that the campaign remains funded through 2010.

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%—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 \$8.³

KEYS TO SUCCESS

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 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—resources and support tend to dwindle as time passes and progress is made. The political support of President Carter, General

BOX 11-1 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 disease. 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 make it very difficult to organize a program in endemic villages.”

Despite the constraints, some progress has been made. In 1995, President Carter negotiated a 4-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.⁴) Since the cease-fire, government authorities, the United Nations, the Carter Center, and more than 20 NGOs 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 strawlike 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.^{6,9} 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.

Toumani Touré, General Gowon, and 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 Cairncross and colleagues 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.”²