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DRACUNCULIASIS (GUINEA WORM DISEASE): CASE STUDY OF THE EFFORT TO ERADICATE GUINEA WORM

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10.1 INTRODUCTION

Dracunculiasis (Guinea worm disease) is a water-borne parasitic infection that is intimately tied to the environment and to human behavior. The campaign to eradicate this disease lasted nearly 30 years and provides many lessons that may be adapted for attacking other problems successfully, particularly where change in human habits is required in order to mitigate or interrupt transmission.

The adult parasite *Dracunculus medinensis* occurs only in humans, who become infected after drinking stagnant surface water from sources such as ponds where microscopic water fleas (copepods) have been infected by ingesting immature forms of the parasite. The parasite matures in humans over a period of 1 year, during which the infection evokes no symptoms or outward signs. After a year, the thin white adult worm, which measures up to 3 feet (1 m) long, emerges slowly and painfully through a ruptured blister that it raises on the skin (Fig. 10.1). Most worms emerge on the leg, ankle, or foot, but they may emerge from anywhere on the body, and a patient may have up to a dozen or more worms emerge around the same time. The emerging adult worms are all females, which spew hundreds of thousands of immature larvae into the water when the infected person enters a surface source such as a pond for any reason. Thus, the life cycle of the worm is perpetuated by humans who drink untreated water from such contaminated sources, as well as by those who enter sources of drinking water while a Guinea worm is emerging or about to emerge from their body.

Since only a few centimeters of a worm can usually be pulled out manually by rolling it on a small stick or rolled gauze in a day, the painful incapacitation associated with this infection normally lasts up to 1 or 2 months or more. The site of worm emergence often becomes infected secondarily with various bacteria, increasing the local inflammation and pain that are the hallmarks of this disease. Infection with tetanus bacilli at the site of the ulcer, which is the base of the ruptured blister caused by the emerging worm, is the most dangerous secondary complication of Guinea worm disease, which otherwise is not usually fatal. In about one-half of 1% of cases, a worm that emerges in or near a major joint such as the elbow or knee can cause permanent freezing of that joint, with consequences very similar to crippling damage from paralytic poliomyelitis. Past infections do not confer immunity, so people can be reinfected year after year.

There is no animal or any other environmental reservoir of *D. medinensis* outside of human beings and the infection has been recognized in ancient sources such as Egyptian mummies and the Old Testament. The immature larvae last only a few weeks outside of the human body, and only if they are ingested by a copepod. That is why this disease is vulnerable to complete eradication, even though copepods are ubiquitous in stagnant surface sources of freshwater.

The impact of Guinea worm disease on affected communities can be devastating, even though the infection is not usually fatal. This is a disease of remote, neglected rural populations that do not have easy access to clean drinking water. Before the eradication campaign began, up to 50% or more of a village's population could be infected at the same time, for periods averaging 1–2 months. Working age adults of both sexes are affected most of all because they tend to drink larger volumes of water. And the worms emerge

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FIGURE 10.1 Emerging Guinea worm. Savelugu, northern Ghana: Patient with a Guinea worm emerging, at the Savelugu Case Containment Center. (Photo credit: The Carter Center/Louise Gubb.) (*See insert for color representation of this figure*.)

seasonally, precisely during the time of year of peak agricultural labor, when villagers need to harvest or plant their crops. Hence, Guinea worm disease negatively impacts not only people's health but also their agricultural productivity and school attendance (1).

In drier areas such as the Sahel just below the Sahara Desert, the "Guinea worm season" coincides with the brief rainy season, because that is the time of year when sources of surface water are abundant, and available to receive and transmit new parasites. In better watered climates nearer the Atlantic coast in West Africa, for example, the dry season is the optimal period for the disease because that is when stagnant water sources are shrinking and most contaminated; the abundant rainy season causing rivers to flow (nonstagnant) and diluting any contamination. Areas where the period of peak prevalence of Guinea worm disease coincides with the rainy season are doubly handicapped, since that is also the time of year when travel into remote areas, and hence, provision and supervision of control measures, is most difficult.

There is no treatment, cure, or vaccine for Guinea worm disease, except to provide analgesics to relieve the pain and antibiotics to mitigate secondary infections. The ancient practice of carefully winding the emerging worm around a small stick is still the best way to try to shorten the period of disability. If a worm is broken while being coaxed to emerge, however, the remainder of the worm retracts into the body and spills larvae into the tissues, thereby causing severe inflammation and abscess formation, which is very painful and requires incisions and drainage by medically trained personnel, ideally at a clinic facility.

Although Guinea worm disease is not treatable, fortunately transmission of the infection can be prevented in several ways, by protecting drinking water from contamination by infected humans, and/or by protecting humans from drinking contaminated water. The most basic intervention is to teach people in endemic areas to avoid entering sources of drinking water when a worm is emerging or about to emerge from their body, and to always filter any water they drink from an open pond or other stagnant source through a finely woven cloth. Convincing conservative villagers that this disease is caused by water they drank a year ago, and that it is not because of any number of long and strongly held traditional beliefs, is easier said than done. One of the most effective ways to promote such understanding is to filter water from the usual local pond through a cloth and backwash the filtered material into a clear glass or jar, which is then held up to the light (with or without a magnifying glass) so villagers can see the tiny organisms moving around in the water they are drinking. That revelation is instinctively repulsive, and is persuasive to many. Distributing cloth filters free of charge for villagers to use to protect themselves and their families, and demonstrating how to use them properly, also serves as a tangible reminder to persons at risk of what they should do. Special attention is paid to educating women and girls, who are most often the ones who collect water for household use. As of 2008, about 40% of the workforce in the national Guinea Worm Eradication Programs (GWEPs) was female. Specially woven nylon material, which originally was donated by the E. I. DuPont Company, and which lasts longer and filters faster than cotton cloth, is most commonly used in the eradication campaign. Portable "pipe filters," a type of large plastic straw with a filter inside, can be hung on a string around the neck, and are provided to allow persons to filter the water they drink when traveling or farming away from home (Fig. 10.2).

Another effective intervention is to treat potentially contaminated ponds with ABATE® Larvicide, which at the recommended concentration is colorless, odorless, tasteless, and harmless to humans, fish, and plants, but lethal to copepods and the parasites they convey. This larvicide, which is donated to The Carter Center by BASF

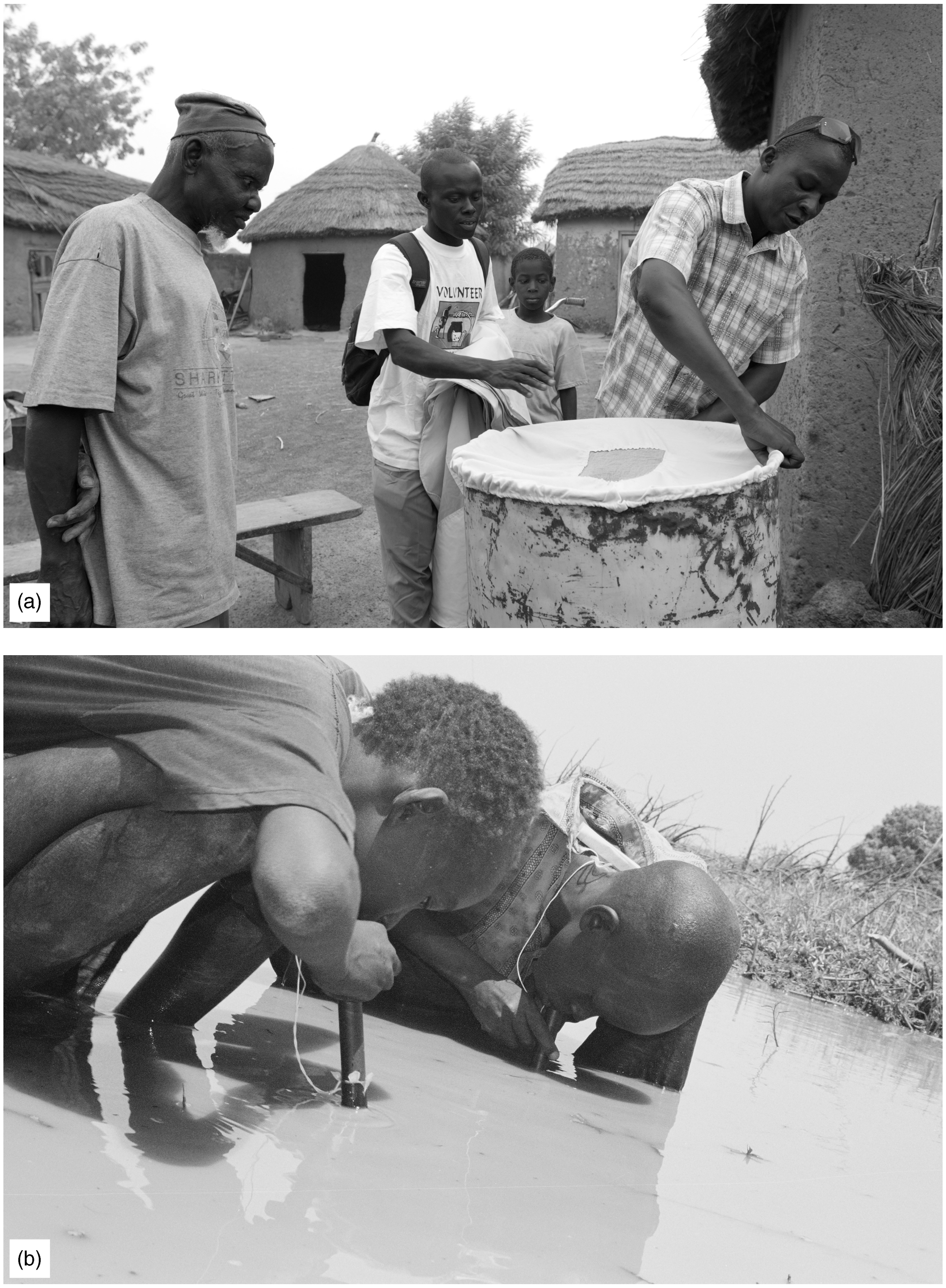

FIGURE 10.2 (a) Cloth filter. Savelugu, northern Ghana: Technical assistant Eugene Yeng and a young community-based surveillance volunteer, Abdulhai Idiris. (Photo credit: The Carter Center/ Louise Gubb.) (b) Pipe filters . (Photo credit: The Carter Center/Emily Staub.) (*See insert for color representation of this figure*.)

Corporation for use in the eradication campaign, is applied at a concentration of one part per million every 4 weeks during the transmission season. Providing clean water from underground sources by borehole wells or similar means is the ideal intervention, since such clean water prevents many other infections in addition to Guinea worm disease, and is often much more accessible than the traditional pond, which may be a mile or more away from the village. Unfortunately, this is also the slowest and most expensive of the available preventive measures, and assuring priority to specific villages for any reason, including Guinea worm disease, is difficult because of political influences, corruption, and powerlessness of residents in the remote villages concerned.

Once village-based interventions are in place in as many affected communities as possible, an additional barrier to transmission can be "case containment," designed to prevent transmission from each patient. This is done by individual health education to urge the patient not to enter any water source, by manual extraction of the worm (slowly wrapping around a stick) and daily bandaging and treatment of the wound, and by caring for the patient in a home, clinic, special "Case Containment Center" or other facility. This provides less disability and early return to normalcy for the patient, and discourages further contamination of water sources by ensuring voluntary isolation of infected individuals. Specific criteria, including detection of the patient before or within 24 h of emergence of the worm, have been developed for classifying cases as contained or uncontained (2).

10.2 IMPLEMENTING THE ERADICATION CAMPAIGN

The global Guinea Worm Eradication Program was conceived and initiated at the Centers for Disease Control and Prevention in Atlanta, Georgia, in October 1980, originally as an adjunct to the International Drinking Water Supply and Sanitation Decade (1981–1990), one of the goals of which was to provide safe drinking water to all who did not yet have safe water. Early in the twentieth century, dracunculiasis was widely prevalent in many Asian and African countries, from southern parts of the Soviet Union to British India, Persia, and Saudi Arabia, and much of North, East, and West Africa. By the time The Carter Center began leading the global campaign in 1986, an estimated 3.5 million persons were being infected annually, in 3 Asian and 17 African countries (3) (Fig. 10.3). Because of its remote habitat, marginalized affected population and lack of available treatment, dracunculiasis was vastly underreported before the campaign began. Although Nigeria and Ghana each officially reported about 3000–5000 cases of the disease to the World Health Organization annually in the 1980s, for example, when the two countries conducted nationwide village-by-village searches for the disease in 1989, they enumerated over 650,000 and almost 180,000 cases, respectively.

Village volunteers (VVs) are the bedrock of the GWEP. Sometimes selected by village chiefs or government health workers, but often chosen by fellow villagers, the VVs are trained by the program to do four things: educate their neighbors about how to prevent Guinea worm disease, distribute cloth filters, record and report cases monthly to a supervisor, and provide first aid care to villagers with Guinea worm disease. The immediate supervisors are peripheral governmental health workers or are national and international technical advisors who are specially hired and supported by The Carter Center for the national GWEP. This much-envied system comprised more than 6000 VVs each in Ghana and Nigeria in the early 1990s, for example, pioneering unprecedented monthly reporting and surveillance for cases of Guinea worm disease from every known endemic village, including some of the most remote villages imaginable. A few such villages were previously unknown to government authorities. The key to sustaining this system is and was assiduous attention to training, retraining, supply, constructive supervision, encouragement, and feedback of the VVs and their supervisors. Compilation, display, and regular monitoring of monthly surveillance data and of operational indices are other vital ingredients that are particularly important to motivating workers and to mobilizing financial support for the program. This combination of dedicated volunteers, their support, supply and supervision is what has brought this ancient loathsome disease to the brink of eradication.

Villagers are bombarded with simple messages via as many channels as possible (radio, videos, discussions

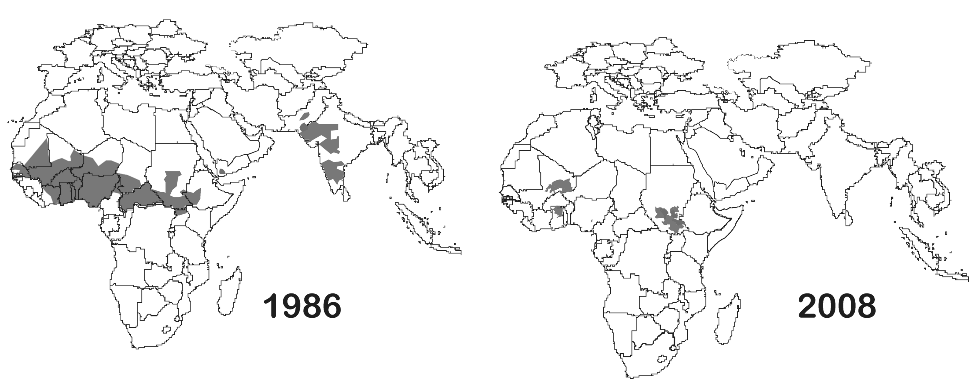

FIGURE 10.3 Guinea worm reduction over time. (*See insert for color representation of this figure*.)

illustrated with flip charts, drama, songs, posters, etc.), encouraging them to always filter unsafe drinking water, to avoid entering or allowing others to enter sources of drinking water when a Guinea worm is emerging or about to emerge, and to report any cases of the disease to a health worker. By these means, the GWEP seeks to engender a climate whereby undesirable behavior is communally regarded as an unneighborly act, without stigmatizing those infected, and where repeated messaging provides constant and involuntary reminders of what villagers should and should not do when they encounter a source of drinking water. More recently, behavior change communication techniques have been taught to more effectively engage communities in seeking agreement on what to do on their own to prevent Guinea worm disease from affecting their community. Political mobilization is equally important as community mobilization. Here, one seeks to motivate political, traditional, and religious leaders to actively support eradication efforts, by using data from the campaign to inspire, encourage, and if necessary, make the right people uncomfortable. The fact that Guinea worm disease is so visible, has important economic impact, and can be prevented, even *eradicated*, provides powerful ammunition for such political advocacy (4).

As mentioned earlier, the ecology and epidemiology of dracunculiasis is intimately bound to local environments where the infection thrives. Copepods are ubiquitous, but vary in their ability to transmit Guinea worms to humans. By definition, all humans must have some source of drinking water, but these also vary in their susceptibility to harbor copepods, which require stagnant, not flowing freshwater. Streams and small rivers that contain flowing water during the rainy season but become almost dry riverbeds from which humans collect drinking water from stagnant intermittent pools and excavated holes during the dry season are simultaneously transformed into effective potential sources of infection. In northern Ghana, small dams constructed in the 1950s and 1960s for watering cattle and irrigating crops inadvertently provided ideal habitat for undesirable contact between Guinea worms, receptive copepods, and many thirsty people (5). Moreover, many such sources of impounded water are too large to reasonably treat with ABATE. This well-intended ecological alteration caused much of northern Ghana to stand out most unfavorably as far as Guinea worm disease was concerned, from otherwise similar neighboring areas of Burkina Faso, Cote d'Ivoire, and Ghana itself. And just as surface sources of drinking water are determined by the environment and rainfall, the availability of safer underground sources, which are not at risk of contamination by people with emerging Guinea worms, is conditioned by geology. Some populations still manage to subsist in areas underlain by rock that prohibits or severely limits the drilling of wells, by collecting rainwater and/or traveling long distances to fetch surface water from far away. A result of these many factors is that Guinea worm disease is distributed sporadically, often being highly endemic or absent altogether, in adjacent villages and districts.

Despite the many environmental determinants of Guinea worm disease's occurrence and intensity, human agency has been a major factor in the eradication campaign in other ways besides health-related behavior, primarily because of insecurity and sporadic violence engendered neither by Guinea worms nor by copepods, but by people. Such disruptive insecurity has been most prominent in the GWEP during the civil war in Sudan, but has also been a significant impediment to control measures in many other affected countries in Africa at one time or another. In Ghana, an outbreak of ethnic violence in the Northern Region during the peak transmission season in 1994 and 1995 disrupted interventions, led to loss of supplies and equipment, and caused villagers and health workers to flee to district capitals, where some fleeing villagers contaminated the drinking water sources at local dams, causing the number of Guinea worm cases to double between January and April 1994 and the same period of 1995. Violence involving nomadic Tuaregs in northern Mali delayed the reporting and deployment of remedial measures to control an outbreak in 2006 and 2007. Between January and August 2009, 27 incidents of sporadic violence or petty banditry disrupted operations of the GWEP in southern Sudan, causing Guinea worm workers to be confined to their dwellings or evacuated for various periods, often in highly endemic areas. In addition to civil war in Cote d'Ivoire, other ethnic, political, or religious conflicts have also impeded Guinea worm eradication activities in Chad, Ethiopia, Niger, Nigeria, Togo, and Uganda.

Addressing the political issues effectively has been a critical component of the campaign that requires engagement of persons outside of the traditional public health arena. Involvement of former U.S. President Jimmy Carter has been key to mitigating or removing political barriers in the Guinea Worm Eradication Program. In 1995, as the global campaign sought to help Sudan launch its program despite the ongoing civil war between the north and south of that country, by drawing on his prior contacts with both sides, President Carter was able to negotiate a cease-fire. By then, Sudan was known to be among the most highly endemic countries, and it seemed wise to try to start working in accessible areas of the country, which included most of the north and some of the more highly affected southern states where most of the fighting was occurring. Eventually known as the "Guinea Worm Cease-Fire," the hiatus in the civil war lasted nearly 6 months, and was even more successful than we expected. Sudanese health workers and their foreign Non-Governmental Organization (NGO) partners on both sides surprised themselves by what they were able to accomplish, visiting almost 2000 endemic villages to inquire whether Guinea worm disease occurred there and beginning to educate local villagers where it did, and distributing over 200,000 cloth filters (6). And despite resumption of the fighting, in 1996 Sudan's GWEP distributed even more cloth filters without a cease-fire than it did the year before.

Another masterstroke was to engage two prominent African leaders in the campaign. In 1992 President Carter persuaded then former Malian head of state General Amadou Toumani Toure to help energize his country's listless eradication effort. General Toure eventually toured all the major endemic areas of Mali, and visited all nine other endemic francophone countries to lobby their heads of state and ministers on behalf of the campaign as well. His popularity enhanced, Toure was later elected president of Mali (he had ousted a military dictator in a *coup d'etat* in 1991 and turned the government over to an elected civilian a year later) and is now serving his second term. Popular former Nigerian head of state General (Dr.) Yakubu Gowon was recruited in 1998 to help reverse 5 years of stagnation due partly to sporadic insecurity and ineffectiveness of the military government in Nigeria, which had begun its program in 1988 with more reported cases than any other country. By the end of 2005, General Gowon had personally visited over a hundred endemic villages in 18 Nigerian states, urging local medical, traditional, and political leaders to intensify control measures, including giving priority to endemic villages for provision of safe drinking water (l). Nigeria's reported cases began declining again dramatically in 2000, and it is now on the verge of eliminating dracunculiasis entirely.

Marginalization and migration are two other human factors affecting Guinea worm disease and its eradication. Many of the most resistant foci of disease are thus characterized because the poor rural populations in them are disenfranchised and long neglected by others in the same country. Salient examples are the Nyangatom in southern Ethiopia, Konkomba in northern Ghana, and black Tuareg in Mali and Niger. Overcoming decades or centuries of such enmity in order to do the necessary in such circumstances, by paying careful attention to ethnicity of health workers, to language used for written and verbal messages, and to placement of case containment centers and borehole wells, for example, can be a challenge. The frequency and unpredictability of human travel to attend weddings and funeral ceremonies (often in distant neighboring villages or even other districts), and to farm or trade pose other challenges, in addition to more predictable transhumance and annual movements of some pastoral groups. In Mali, an infected Koranic student triggered an explosion of 85 cases in one village in a previously non-endemic area after having walked over 300 km from his home district. Similar exceptional treks by infected individuals have been reported in persons moving from southern Sudan into Ethiopia.

For all its potential benefits and seemingly irresistible logic, the global GWEP got underway very slowly, because of insufficient funding during the 1980s and early 1990s to assist national eradication programs. Although it was conceived in 1980 just before the launch of the International Drinking Water and Sanitation Decade (1981–1990), by 1990 only 4 of the 20 endemic countries (India, Pakistan, Ghana, and Nigeria) had actually launched nationwide Guinea Worm Eradication Programs. Twelve countries began their national programs in 1992–1994, and all but one (Central African Republic) got underway by the end of 1995 (1).

10.3 IMPACT AND FINAL CHALLENGES

As already noted, the numbers of reported cases of dracunculiasis increased rapidly as individual countries conducted their first nationwide surveys to count cases of the disease, starting in 1988. And as the same countries began implementing control measures successively, their numbers of reported cases began to decline significantly, but not as abruptly as they had risen. The relatively rapid initial reductions in cases reflected impact of control measures in the most receptive populations, gradually revealing the most resistant and difficult clusters of endemic villages, families, and individuals as the campaign progressed at the frustratingly stately pace dictated by the infection's 1 year long incubation period and aided by human mistakes, neglect, bureaucratic and financial shortcomings, and by the sporadic insecurity described above.

Although the global GWEP missed the original target date of 1995 for interrupting transmission of dracunculiasis, by 2003 the campaign had reduced the number of cases to 32,193 cases reported from 4659 villages in 12 countries, of which 20,299 cases were reported from Sudan, 8285 from Ghana, and 1459 from Nigeria. Heartened by the recent results, representatives of the 12 remaining endemic countries resolved during the World Health Assembly in May 2004 to intensify implementation of control measures so as "to free the world of *dracunculiasis* by the end of 2009" (7). Another major advance occurred in January 2005 when the Comprehensive Peace Agreement was signed to end the two-decade long civil war in Sudan, thus removing the single most important obstacle to complete eradication. Sustained and generous financial support provided to The Carter Center for the campaign by the Bill & Melinda Gates Foundation and other donors provided the wherewithal to capitalize on the favorable political developments. After a brief upsurge in the number of cases reported from Sudan in 2006 as that program gained access to previously inaccessible endemic areas, the newly constituted South Sudan Guinea Worm Eradication Program (SSGWEP) quickly began building on the momentum and experience gained since the Guinea Worm Cease-Fire in 1995 (8).

By the end of 2008, dracunculiasis had been eliminated from Asia altogether, the number of endemic countries had been reduced from 20 to 6, the number of endemic villages was down from over 23,000 in 1991 to 1025, and the number

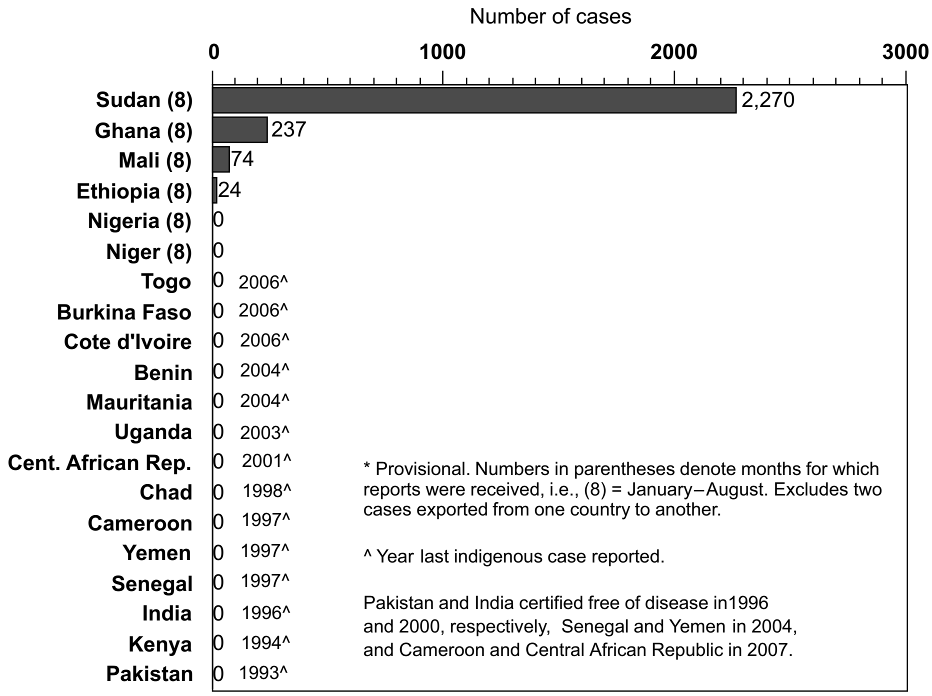

FIGURE 10.4 Distribution of indigenous 2604 cases of dracunculiasis reported during 2009.

of cases reported was reduced from an estimated 3.5 million in 1986 (and over 900,000 counted in 1989) to 4619. Most of the cases reported in 2008 were from Sudan (3618 cases), with Ghana (501 cases) and Mali (417 cases) reporting most of the remainder. The number of cases exported from one country to another declined from 154 in 2002 to 6 in 2008 (9).

A total of 2604 indigenous cases have been reported during January–August 2009, which is a reduction of 33% from the 3902 indigenous cases that were reported during the same period of 2008. Sudan reported 2270 (87%) of the cases so far in 2009, while Ghana reported 236 cases, Mali reported 74 cases, and Ethiopia reported 24 cases. Nigeria and Niger, which reported 38 and 2 indigenous cases in 2008, respectively, have reported no indigenous cases in January–August 2009 (Fig. 10.4). So far only two cases are known to have been imported from one country to another in 2009, one having traveled from Ghana to Niger and the other from Mali to Niger. At this stage of the campaign, the proportion of cases that were discovered before or within 24 h of emergence of the Guinea worm and are successfully contained is the single most important indicator of the effectiveness of national programs. As of the end of August 2009, Sudan had reportedly contained 83% of its cases in 2009, Ghana had contained 94%, Mali 76%, and Ethiopia 96% (10).

The World Health Organization bears sole responsibility for certifying interruption of transmission of dracunculiasis. To do so, it requires adequate surveillance having detected no indigenous case of dracunculiasis in a recently endemic country for at least three consecutive years after the last known indigenous case. An International Commission for the Certification of Dracunculiasis Eradication reviews data submitted by countries and the reports of teams sent to verify the status of surveillance in selected countries, and makes recommendation to the director-general of WHO. As of September 2009, WHO had officially certified the absence of dracunculiasis from 180 countries, and 21 countries remain to be certified (9).

It is likely that only four endemic countries will remain as of January 2010, with the overwhelming majority of cases being in southern Sudan. The global Guinea Worm Eradication Program is thus poised to achieve its ultimate goal soon, despite many challenges described above, provided sporadic insecurity in the main currently endemic area, southern Sudan, is contained. The Southern Sudan Guinea Worm Eradication Program is quite able to contain the remaining Guinea worms, if the human insecurity is contained.

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