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Dracunculiasis eradication and the legacy of the smallpox campaign: What's new and innovative? What's old and principled?

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ABSTRACT

Coming on the heels the declaration of smallpox eradication in 1980 was the launch of the dracunculiasis (Guinea worm) eradication program, as a key outcome indicator of the success of the United Nations 1981–1990 International Drinking Water Supply and Sanitation Decade (IDWSSD). The dracunculiasis eradication campaign has carried on well beyond the close of the IDWSSD largely due to the efforts of President Jimmy Carter and The Carter Center, to assist the national Guinea Worm Eradication Programs in collaboration with partner organizations, including the Centers for Disease Control and Prevention (CDC), UNICEF, and the World Health Organization.

Dracunculiasis eradication efforts have as primary tools health education, filter distribution for drinking water filtration, and case containment, all guided by rigorous village based surveillance. Additional tools are treatment of selected water sources with ABATE^{R} (temephos) larvicide and provision of protected drinking water supplies. Village volunteers provide monthly reporting of cases (including reports of zero cases).

The global campaign has made remarkable progress through both innovation and adherence to eradication principles. Annual cases of dracunculiasis have decreased from 3.5 million in 1986 to less than 2000 in 2010. The challenge is to reach zero cases. The task, so often faced by eradication programs, is to finish the 'final inch' in some of the most difficult places on earth to work. In the case of dracunculiasis, that is the new Republic of South Sudan.

Dracunculiasis (Guinea worm disease) is an incapacitating disease of the poor that occurs in rural villages that have no access to safe drinking water [1,2]. Dracunculiasis is caused by the 2–3 ft (~1 m) long tissue parasite *Dracunculus medinensis*. Human infection with this worm is acquired only through ingestion of water contaminated with barely visible fresh water copepods (microcrustacea that are sometimes called 'water fleas') that act as intermediate hosts for the parasite (Fig. 1). Infectious third stage larvae, contained within these crustaceans, are released by the human digestive process and penetrate the human intestine. The parasites migrate to deep subcutaneous tissues where they grow and mate. After about a year the gravid females elicit burning blisters, usually in the lower extremities. The blisters break, and the worm is exposed at the base of the resulting ulcer. The afflicted person naturally desires to immerse the burning blister or ulcer in water, at which time the worm releases many thousands of immature larvae. These may be ingested by the copepods that act as intermediate hosts of *D. medinensis*, and where the larvae develop over a period of about two weeks to the infectious stage. The life cycle continues with the infection of the next person drinking water contaminated with infected copepods. Meanwhile, the afflicted person is left to slowly and painfully extract the meter long worm, often by winding the parasite on a small stick a few centimeters a day (Fig. 2). The patient may be disabled for an average of 8.5 weeks. Secondary bacterial infection often ensues, with the risk of long-lasting complications [3]. In endemic areas, dracunculiasis has considerable impact on agricultural productivity and school attendance [4].

Dracunculiasis transmission only occurs through drinking contaminated water. For that reason, and flowing from the enthusiasm stemming from the certification of the eradication of smallpox earlier in 1980, the Centers for Disease Control and Prevention (CDC) in October 1980 proposed the eradication of dracunculiasis as an ideal indicator of the success of the United Nations 1981–1990 International Drinking Water Supply and Sanitation Decade (IDWSSD).

1. Key considerations related to dracunculiasis eradication

Certain aspects of dracunculiasis make it a candidate for eradication. There is no animal reservoir for *D. medinensis*. The parasite has a one year life cycle: indigenous cases this year reflect the

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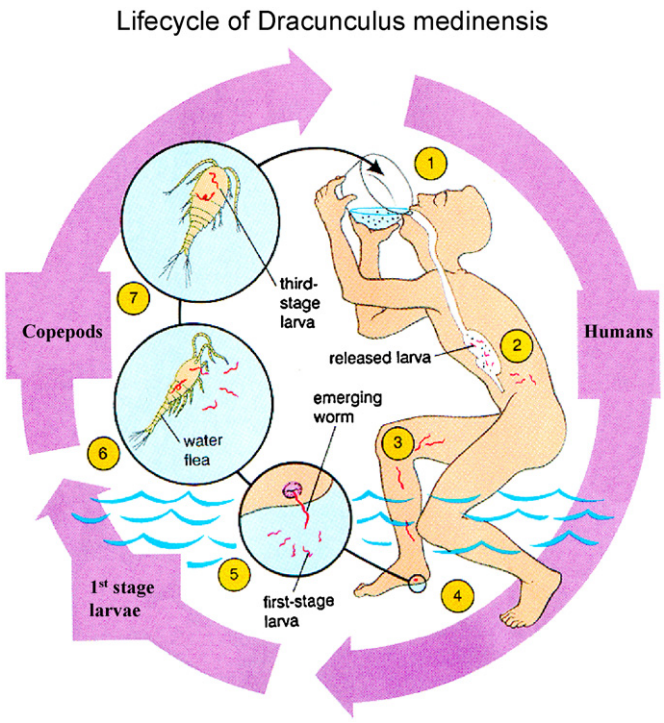

Fig. 1. Life cycle of *Dracunculus medinensis*.
By courtesy of Encyclopedia Britannica, Inc., © 1996, with permission.

Fig. 2. Emergence of *Dracunculus medinensis*.
Courtesy of Elizabeth Long, The Carter Center, with permission.

previous year's transmission. The clinical presentation is unique and easily recognized. The emergence of a worm from the skin is highly specific for dracunculiasis disease, and photographs of the condition can be used for active case surveillance. Guinea worm disease is often known by a specific name in the local language.

However, dracunculiasis poses several challenges to eradication, most importantly is that there is no 'silver bullet' intervention. There is no drug that can cure the infection, and no vaccine. Unlike smallpox, which confers lifelong immunity upon survivors (and vaccines have been available for centuries), there is no immunity to reinfection with dracunculiasis. There is also no diagnostic test to determine which persons might be incubating a Guinea worm. Therefore, only surveillance for cases, with forecasting for when and where cases are most likely to occur in the next year, can prompt and targeted preventive measures be taken to interrupt transmission. Unlike smallpox, where the incubation period is 2 weeks, that for dracunculiasis averages 1 year. The most highly technical intervention associated with the program, aside from water supply, is treatment of selected water sources with ABATE^{R} larvicide to kill the intermediate host copepods.

2. What's new and innovative about the dracunculiasis eradication campaign?

The early years of the program during the IDWSSD failed to muster the necessary resources to provide safe drinking water to all villages, or even to the number of dracunculiasis endemic villages. A key innovation was shifting the program's emphasis away from a focus on safe water supply to that of community health education and mobilization. Such mobilization includes education of residents about the origin of the disease (which usually means changing a traditional belief system), keeping persons with emergent worms from contaminating sources of drinking water ('case containment'), and having people filter their water to remove the water fleas that may contain the infectious form of the parasite. A big part of the innovation was to bridge the gap between the subdistrict level (where most primary health care stopped) and the village level. The dracunculiasis eradication campaign pioneered

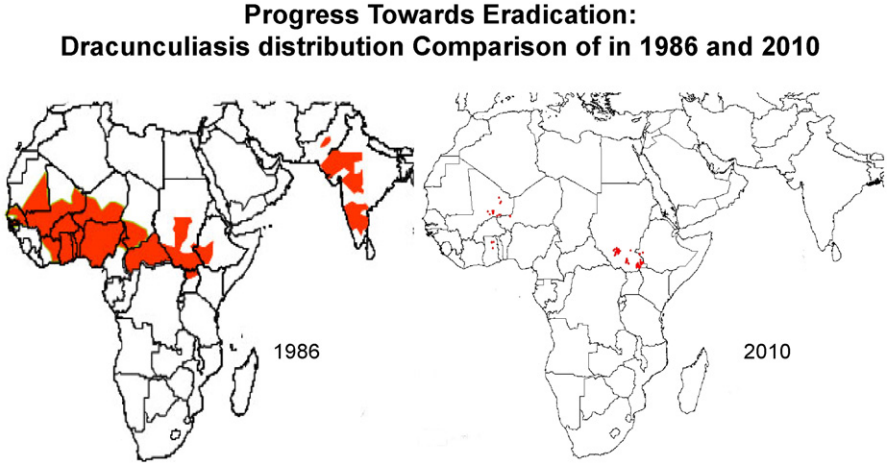

Fig. 3. Extent of areas in Africa affected by dracunculiasis in 1986 and in 2010.

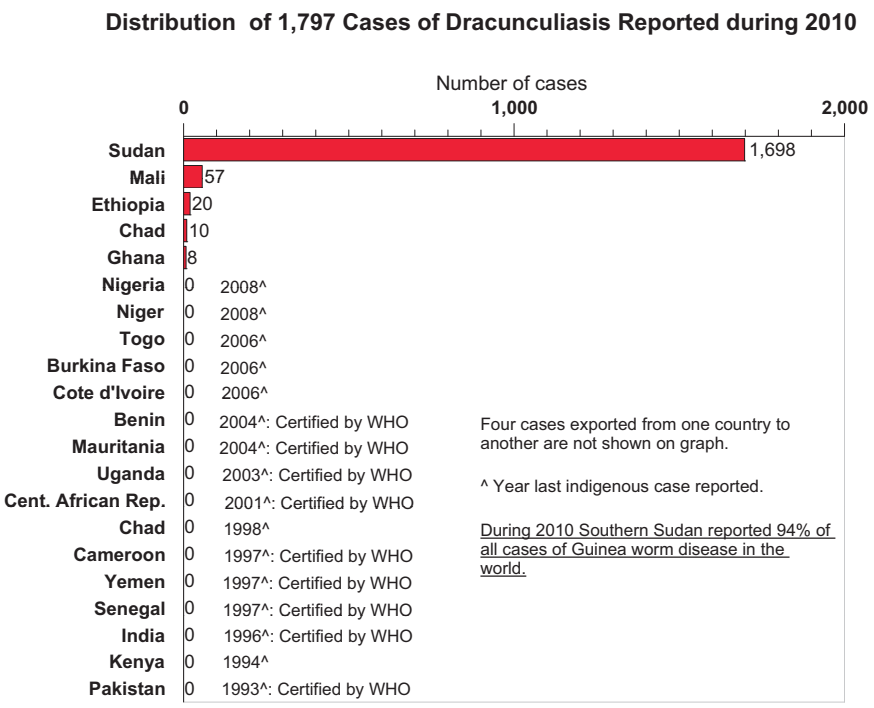

Fig. 4. Distribution of 2010 dracunculiasis cases.

Ref. [10]

the establishment of village volunteers (VVs) who provide health education, distribute filters, and immediately identify persons with emerging worms. VVs initiate case containment efforts to prevent those infected from contaminating local water sources. Another part of the VV innovation was to establish cadres of staff in charge of VV supervision, thus enabling the monthly reporting of cases and status of interventions to the sub district, district, regional and national levels. Hence, the dracunculiasis program in essence extended primary health care to all endemic villages (23,735 in 1993). Since transmission is highly seasonal, the major logistical challenge is to have all the programmatic assets in place and the personnel prepared and trained before each peak transmission season [7].

Another innovation is that the dracunculiasis campaign marks the first time a non-governmental organization has provided the lead technical and financial support to a global eradication program. The Carter Center has played that unique role since 1986, championing the elimination effort, with WHO playing a close supporting role. It was indeed The Carter Center that kept the momentum for dracunculiasis eradication alive beyond the close of the IDWSSD.

3. What's old and principled about the dracunculiasis eradication campaign?

As with smallpox, the dracunculiasis eradication program works under resolutions of the World Health Assembly (WHA) [6,7]. Surveillance is another key principle, being the foundation of dracunculiasis eradication from the initial stages [8]. The rapid identification of patients with emerging worms and their 'containment' to prevent them from spreading their infection follows the same principle as the surveillance and ring vaccination approach of the smallpox eradication program (SEP). The principle: Find the patient and then break the transmission chain through quick, local and focused action. Prompt local reporting with rapid local and programmatic response to cases was part and parcel of the success of the SEP. The dracunculiasis eradication program is based on case recognition through the village based surveillance system leading to case containment within 24 h of recognition by the VV, confirmed shortly thereafter by his or her supervisor [5]. At the programmatic level, line listings of villages indicating when during the previous year cases were reported and how many cases were not contained give guidance to when and where the program should intensify surveillance, provide health education, filters, and potentially ABATE^{R} larvicide treatment and which villages to prioritize for safe water provision. Establishing key and well defined surveillance and programmatic indices permits careful and evolving monitoring of the program. Surveillance 'feed-back loops' where the data collected by the VVs and the national programs are promptly returned in a 'value added' format (in this case monthly "Guinea Worm WrapUp" newsletters, and annual World Health Organization [WHO] *Weekly Epidemiological Record* reports) is another eradication principle adhered to religiously by the dracunculiasis program.

Another principle of eradication programs is the need to maintain constant and high level political support for the effort. The dracunculiasis eradication campaign takes that principle to a new level, representing the first time that an ex President of the United States (Jimmy Carter) has played a 'hands on' role in an eradication effort, including promoting support from industry for the campaign: DuPont, Precision Fabrics Inc (monofilament nylon and filter fabric); American Cyanamid and BASF (ABATE^{R}). President Carter negotiated what came to be know as 'the 2005 Guinea worm cease fire' in southern Sudan, which allowed for new health efforts in that war torn country directed not only against GW, but measles and onchocerciasis (river blindness) as well. President Carter also recruited two other former Heads of State, General Yokubu Gowon of Nigeria and General Amadou Toumani Toure of Mali, to act as dracunculiasis ambassadors in their countries, and beyond [5].

4. Progress toward eradication: the final 'inch'

When the dracunculiasis eradication program first began, an estimated 3.5 million cases still occurred annually in India, Pakistan

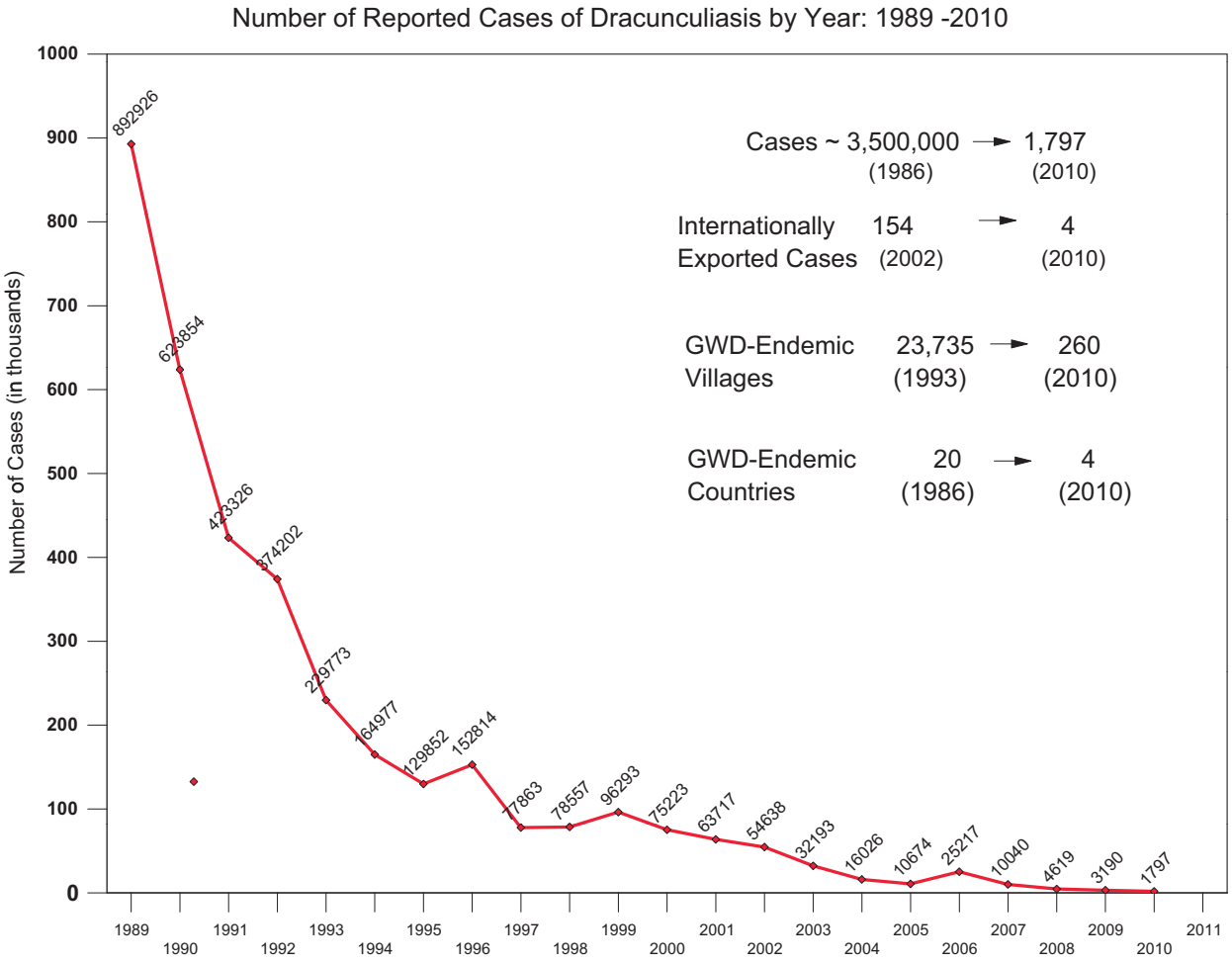

Fig. 5. Number of dracunculiasis cases reported 1989–2010.

Ref. [10]

and 16 African countries [9]. Since 1986 the number of dracunculiasis endemic countries has dropped from 20 to 5 in 2010: Sudan, Mali, Ethiopia, Chad and Ghana (Figs. 3 and 4) [10]. Asia became free of the disease in 1997. Dracunculiasis cases decreased by over 99%, from 892,926 to 1794, between 1989 (when endemic countries began reporting cases monthly from every endemic village) and 2010 (Fig. 5). Dracunculiasis endemic villages have decreased from over 23,000 in 1993 to 260 in 2010. Nine formerly endemic countries, including India and Pakistan, have been certified by WHO, and another seven are in precertification process by the WHO and the International Commission for Certification of Dracunculiasis Eradication (ICCDE) (Fig. 4). To date WHO has certified 187 countries as being Guinea worm free.

Fig. 4 also shows the distribution by country of 1794 indigenous cases of dracunculiasis reported in 2010. Ninety-four percent of cases were in Sudan (1698), followed by Mali (57 cases), Ethiopia (20 cases), Chad (10 cases) and Ghana (8 cases). Transmission was interrupted in 2009 in Niger [10] and Nigeria [11]. In 2010, 10 cases of dracunculiasis were detected Chad, which had been classified as non dracunculiasis endemic since 1998. In response to these cases, Chad's national dracunculiasis eradication program was revitalized and all appropriate interventions were implemented by late 2010. Chad's national dracunculiasis eradication program originally was launched in 1993 and concluded in 1998 when transmission of dracunculiasis was documented to have been interrupted. However, national surveillance shortcomings were noted during subsequent assessments by WHO teams, the latest being in 2008 in response to Chad's request to WHO to certify the country free of dracunculiasis. The surveillance shortcomings discovered during these external WHO assessments of the Chad program were not addressed, and for that reason Chad's request for certification was not granted by WHO. This is the only instance during the 30 year history of the eradication campaign that GWD has caused an outbreak in a formerly endemic country [12].

The challenge of 'the final inch' however, is clearly in the Republic of South Sudan, which became the newest country on the African continent on 9 July 2011. Some fear that there will be heightened insecurity within this new country in the coming years, either from internecine warfare or international conflict with Sudan. Insecurity is always an impediment to the effective program implementation needed to get to zero cases. Therefore, the final principle recognized in the SEP, yet again to be satisfied by the dracunculiasis effort, is that an eradication program must work and succeed everywhere, and that the last cases are by and large found in the most challenging countries to work.

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