Why is dracunculiasis eradication taking so long?

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The long time needed for global eradication of dracunculiasis (Guinea worm disease) was not anticipated at the outset. The successful eradication of smallpox in 10 years compares with the target date set in 1985 for dracunculiasis eradication – 1995. Seventeen years after that date, transmission continues. Why? Various factors are responsible, mainly lack of resources, or resources ineffectively used. The example of Ghana, where the programme stagnated for a decade, sheds light on this delay. When more resources were put into Ghana’s programme in 2007, transmission of the disease was interrupted in 3 years. The variable success of dracunculiasis eradication in different countries provides lessons for future disease eradication programmes.

Origins and a priori

Guinea worm disease (dracunculiasis), caused by the nematode Dracunculus medinensis, is acquired by drinking pond water containing infected cyclops, tiny aquatic crustaceans. The cyclops die in the stomach, but the worm larvae penetrate the gut wall and take up residence in the subcutaneous tissues. After mating, the female worm grows to 60 cm in length and moves to the legs, where 1 year after the initial infection she emerges gradually from a painful lesion, releasing thousands of larvae into the environment. Full emergence takes several weeks. Although rarely fatal, the disease has economic impact, as the highly seasonal pattern of painful and debilitating worm emergence tends to concentrate in the season of peak agricultural labour demand, preventing people from tending their crops.

The main preventive interventions are: (i) construction of safe water supplies; (ii) health education encouraging the avoidance of pond water, or where ponds are the only source of drinking water, filtering the water through a cloth to remove the cyclops; (iii) treatment of ponds with a cycocide such as temephos, which is harmless to people drinking it in the concentrations used.

The idea of targeting the disease for eradication was suggested by Muller [1], who noted its disappearance in 1930 from the Sind desert in Pakistan after a drought so severe that no ponds were seen for more than a year. The disease did not return to the area until the arrival of infected migrants after partition in 1947. In fact, the disease has disappeared from several countries with no deliberate human assistance; in addition to Central Asia and most of the Middle East, these include two African countries, Guinea and the Gambia, where indigenous cases have not been seen for the past half-century. If the disease could disappear from whole countries without anyone lifting a finger, it should be easy to eradicate it deliberately.

Moreover, a comparison of dracunculiasis with other diseases targeted for eradication, such as malaria, polio and smallpox, suggests that there are at least as many aspects of its natural history and epidemiology which favour the feasibility of eradicating it as with the others [2]. The parasite does not live beyond its 1-year reproductive cycle, so there are no long-term carriers. The disease is easily and unambiguously diagnosed, and cases are easily prevented from being passed on to others. Moreover, the intermediate host cannot fly, thus transmission is local.

The eradication of dracunculiasis was initially adopted as a goal of the International Drinking Water Supply and Sanitation Decade (1981–1990), with the implicit target date of 1990. After endorsement by the steering committee of the Decade, it was formally adopted as Resolution WHA 34.25 of the 34th World Health Assembly in May 1981; individual endemic countries were encouraged to set their own target dates for interrupting transmission of the disease in their territory.

Early developments and the cost of delay

From the start, resource constraints meant missed targets; in April 1983, India announced that it had rescheduled its target date from 1984 to December 1986, owing to the difficulty in obtaining the necessary funding [3]. India finally achieved zero cases in 1997.

Globally, the initial deadline of the end of the Water Decade (1990) was replaced by 1995, which is a more reasonable objective in view of the 10 years it took to eradicate smallpox [4]. However, the campaign has now been running for 30 years, and the eradication effort has been operational in most endemic countries for nearly 20 years. At the end of 2011, the disease was still endemic in three countries: Ethiopia, Mali and Sudan.¹ In a fourth country, Chad, the disease reappeared in 2010 after an apparent absence of 10 years [5], but the country is not officially considered endemic. A total of over 1000 cases occurred in those four countries during 2011. Moreover, it will take a few years more for the four countries to interrupt

¹Sudan and South Sudan were considered as a single country for most of the duration of the eradication campaign. We continue to do so here, for the sake of simplicity and not to express any political view.
disease transmission; it has been estimated that this will take until 2016 [6].

Why has progress been so slow? As the target date was repeatedly postponed and the campaign’s duration prolonged, it has added to the efforts and increased the cost, even putting in question one calculation of the cost/benefit ratio of the eradication campaign [7]. Delay will particularly affect a cost–benefit calculation with discounting.

Ideally, a disease eradication programme should be short [4], to avoid the waning of political will, which follows the initial reductions in cases [8]. Eradication of smallpox took 10 years. Eradication of rinderpest, a disease of cattle, took approximately 16 years (1994–2011). The campaigns for eradication of dracunculiasis and poliomyelitis have been running for more than 20 years with several target dates missed. The reasons for the failure to achieve rapid reductions in dracunculiasis cases year on year, and to understand why several countries suffered a long stagnation, point to lessons for the fight against other diseases.

**Why did some countries stagnate? Ghana as an example**

In several endemic countries, there were years when the annual number of dracunculiasis cases fluctuated with no consistent reduction. Ghana is a good example, as it stagnated for 13 years. Relatively reliable data are also available for Ghana, particularly from the two multidonor evaluations of the programme [9–11].

Ghana’s eradication programme followed a similar model to that used by most other endemic countries, with a volunteer in every endemic village submitting monthly surveillance reports, and also distributing filter cloths and health education messages to every household. Monthly supervision visits helped to keep the volunteer motivated and effective; surveillance reports were passed up from village volunteers through a zonal coordinator to the district level, whereas supplies of filter cloth were passed downwards. Although water supply was also part of this basic package, it was too costly and too complicated to be rolled out as rapidly to the thousands of endemic villages which had to be covered.

**Figure 1** shows the stagnation of the annual number of dracunculiasis cases in Ghana during a long period, from 1994 to 2007. The graph for Mali, which also stagnated in the latter part of that period, is also shown. The main reasons for stagnation in Ghana, which were listed in one report [10], are as follows:

(i) The ethnic conflict that broke out in the Northern Region (where most of the cases occurred) in 1994.

![Figure 1](image-url)
(ii) Cuts in funding from major programme partners, particularly the ending of the use of Public Law 480 revenue from sales of US food aid to support the costs of the programme, and the ending of donations of monofilament cloth by the manufacturers, which in previous years had served to make over a million cloth filters.

(iii) The change to the Sector-Wide Approach, under which preventive health programmes such as the Guinea Worm Eradication Programme did not receive the desired priority in the allocation of health sector funds. When, as often happens, there was a shortfall or delay in release of funds, health managers protected salary budgets by cutting field allowances, fuel budgets and other items associated with the operation of the programme. This tended to happen in the closing months of the financial year, which unfortunately coincided with the peak dracunculiasis transmission season in Ghana.

(iv) The pooling by health managers of vehicles for all health programmes (including those donated specifically for Guinea worm work) following the integration and decentralisation of the health sector.

(v) The transfer of environmental health staff, which included most district Guinea worm eradication coordinators, from the Ministry of Health to the district assemblies, where they were no longer accountable for contributing towards the national health goal of eradication, but under pressure to respond to various local priorities.

With the assistance of hindsight, some additional factors can be discerned. Most are related to the shortage of resources – human, financial and technical – in relation to the number of cases and endemic villages. These factors are considered in connection with major strands of the eradication strategy: (i) surveillance, (ii) filter distribution, (iii) case containment, (iv) vector control and (v) motivation of staff and volunteers to perform their tasks. A curious difficulty of adaptation of the programme to the ‘urban’ challenge of rural towns is described in Box 1.

Surveillance

In the case of smallpox eradication, surveillance was the yardstick of progress [4], and so it is also to the promoters of dracunculiasis eradication [12]. Because preventive interventions are not affordable for everyone, the programme depends on surveillance to focus its effort and resources. However, in practice, dracunculiasis surveillance in Ghana missed many cases. The field evaluation of the programme in 1997 [9] found that in a sample of 150 cases, only 112 (75%) had been recorded. The evaluation in 2005 [11], with a similar methodology, found a deterioration; out of 122 cases found, only 68 (56%) had been detected by surveillance.

Neither study found significant numbers of endemic villages unknown to the programme, but the oscillation of many villages between endemic and disease-free status (Table 1) is understandable in light of a surveillance system which misses a quarter to one-half of all cases. Surveillance is focussed on endemic villages rather than endemic areas, although more than one village may share a pond [13]. Moreover, villages reportedly free of the disease for a year were often dropped from the list of villages subject to surveillance and preventive measures, in order to save resources. Many of these villages would later reappear on the list, reporting cases again in the following or subsequent years [14].

Because of the inadequate surveillance, it was natural that the disease would spread uncontrolled from one village to another. For example, a new focus of transmission was detected in Volta Region in 1997, involving 47 endemic villages by 1999.

Box 1. Problems adapting a rural programme to ‘urban’ conditions

In 1997, the Northern Region accounted for 80% of all cases of Guinea worm disease in Ghana; half of those cases occurred in four towns. Many additional cases occurring in nearby villages had probably acquired their infection in those towns, when visiting the market. The population (some 10 000 to 30 000 in each town) lacking adequate water supplies, had frequent recourse to large dams. The rural model in which a volunteer villager visits her neighbours regularly for surveillance and filter distribution did not work so well in these larger settlements with their more transient populations and weaker community spirit [26].

One change did help in these quasi-urban conditions. As part of the initial case containment strategy, a modest cash reward (approx. US $1) was introduced in 1997 for early detection of cases. It was such a novelty for people to go to the clinic with a disease and to be given money that Guinea worm became the talk of the town, enabling preventive messages to spread as no village volunteer could.

In a random transect in Gusheigu, one of these towns, seven cases were found to have occurred in 1996, none of which had been reported; seven more cases occurred in 1997, when the reward scheme had been introduced, all of which had been detected and contained [8]. Within a few years, however, the reward scheme had been dropped. Its effectiveness never seems to have been systematically evaluated.

The use of one or two large dams in each of these settlements by large numbers of the population meant that vector control – killing of cyclops by the application of cyclopicide – was more cost-effective than in typically small and numerous village ponds. The problem was that the dams were larger than the maximum volume recommended for treatment by the Centers for Disease Control (CDC) manual [27] on cyclopicide application. The manual advised against treatment of ponds larger than 500 m³, but the dams in these large settlements held 2000 to 4000 m³. Encouraged by researchers from the Danish Bilharziasis Laboratory, health workers in the Northern Region experimented and developed methods to apply cyclopicide to such large ponds. Monitoring of Cyclops populations showed that these were effective, and their use in the four towns during 1997 reduced the incidence of dracunculiasis there by 92% [28]. In spite of being such an effective preventive health intervention, the practice had been abandoned by the time of the 2005 evaluation [11].

Table 1. Number of villages according to their infection status, Ghana 2002–2010*  

<table>
<thead>
<tr>
<th>Year</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Villages continuing to report cases</td>
<td>388</td>
<td>425</td>
<td>514</td>
<td>419</td>
<td>316</td>
<td>231</td>
<td>78</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>Villages reporting cases last year but zero cases this year</td>
<td>395</td>
<td>314</td>
<td>461</td>
<td>591</td>
<td>416</td>
<td>375</td>
<td>328</td>
<td>113</td>
<td>48</td>
</tr>
<tr>
<td>Villages newly reporting cases</td>
<td>351</td>
<td>550</td>
<td>503</td>
<td>315</td>
<td>290</td>
<td>175</td>
<td>53</td>
<td>32</td>
<td>0</td>
</tr>
</tbody>
</table>

*Sources: Country reports for Ghana Guinea Worm Eradication Programme.
villages. While the programme was struggling to interrupt disease transmission in the many villages where the disease continued (Table 1, first row), the number of villages freed from disease (second row) was counterbalanced or even exceeded by the number of newly infected villages (third row). Only in 2008, when the villages freed from dracunculiasis were six times more numerous than the newly endemic villages, was there a significant reduction in the number of affected villages.

**Distribution and use of filter cloths**

Most observers of dracunculiasis eradication have been content to extrapolate from the laboratory results showing the 100% efficacy of cloth filtration in removing cyclopoid from water, to deduce the field effectiveness of promoting the use of this technique. A rare epidemiological study [15] found in the two study villages with the greatest impact, that ownership of at least one cloth filter for every 10 members of the household reduced the risk of Guinea worm infection by roughly 30%. This effectiveness of 30% was much less than the efficacy of 100% from laboratory tests. Admittedly, this study was conducted in the 1980s when cotton cloth was used. Cotton is rapidly clogged by silt, making it much more frustrating to use than the fast-draining monofilament nylon cloth, which has been distributed to households in endemic villages since the early 1990s as the filter of choice. Conversely, the study households with filters had paid for them, at a price equivalent to US $0.45, and so might have been more likely to use them than those receiving the nylon filters in later years at no cost.

Cloth filters are not a panacea, but how high was the coverage of distribution? The 1997 programme evaluation [9] found that although 88% of households questioned in endemic villages knew that dracunculiasis could be prevented by filtering drinking water, only 48% had an intact filter for this purpose. By 2005, this shortcoming had been remedied; not one in 344 households lacked a filter, and these were being replaced every few months [11]. Moreover, 95% claimed by then that they brought safe water or a filter with them to ensure they had Guinea worm-free water to drink when working in the fields [10].

**The push to case containment**

Inspired by the strategy which successfully eradicated smallpox, this involved a shift from the protection of people from infection, by filter distribution and public education, to the protection of ponds from contamination, by early detection of cases, and the use of rewards and sanctions to prevent the cases from wading into ponds. This was estimated in 1996 to cost some US $100 per endemic village per year more than the cost of the basic package, nearly doubling the field costs of the programme [16] and imposing greater demands upon volunteer manpower. An analysis of national surveillance data for 1998–1999 showed no tendency for countries which implemented case containment more widely to achieve greater reductions in cases. In particular, Ghana, the first country in Africa to take containment of cases of dracunculiasis to a national scale, suffered the greatest increase in cases [17]. The data for Ghana and for the other endemic countries suggest that premature escalation to case containment diverted scarce resources from the basic priorities of surveillance, filter distribution and water supply.

In 2000, the eradication programmes in six countries including Ghana introduced Case Containment Centres, in which patients with emerging Guinea worms were encouraged to stay until they were no longer infectious, receiving free board and lodging while they were there. However, the proportion of known Guinea worm cases admitted to Case Containment Centres in Ghana was only 50% in the peak year, 2003, and fell to only 27% in 2004. The reasons given by those not admitted were various: 30% did not know about the Centres at the time, and 34% lacked the bus fare, or worried about the logistics of leaving their work or their family [18]. If everyone eligible had reported to a Case Containment Centre, there would not have been room to accommodate them all. Either way, the problem was one of resources: to help patients get to a Containment Centre, or to accommodate them if they got there. As case numbers came down, there would be more resources per case to invest in ensuring they were contained, and this is what occurred in later years.

**Vector control**

Like case containment, the treatment of ponds with cyclopicides was an intervention some national coordinators were initially reluctant to introduce, as it was so labour intensive, consuming resources such as staff and vehicles which might be used more effectively on surveillance and filter distribution. For instance, in 1994, the entire environmental health staff of Tillabéri Region, Niger, was required for treatment of one-third of the ponds in only one in five of the endemic villages in one of the six departments of that region (roughly 1% of the total number of ponds requiring treatment) [19]. Ponds need to be treated every few weeks in the rainy season, the time of year when many villages are inaccessible. Measuring the volume of a typical pond (necessary to calculate the dose) takes more than 4 h. Even in the semi-arid Sahel, and limiting the count to the small, man-made ponds, which are the main sources of infection, one village may have 10 such ponds [20]. In Benin, a highly experienced, skilled and motivated researcher interviewed villagers to determine which ponds to treat – and found when the following year’s crop of worms emerged that he had treated the wrong ponds [21]. In Ghana, the treatment of ponds was necessarily selective, but at least until the evaluation in 2005 there was no organised priority-setting to ensure that the ponds likely to cause most cases were treated first [11].

**Motivation**

When shortcomings appeared, particularly with the surveillance system, they were usually attributable to problems of motivation. When the cash reward scheme was operating in the late 1990s, those who detected a case received a portion. When that was stopped (presumably because of resource constraints), it had a demotivating effect. The zonal coordinators were the weakest link in the hierarchy of volunteers and staff making up the community-based surveillance system, unable to regularly visit the 10–20 villages for which each was responsible [11]. They were local people who worked on a voluntary basis and did not have adequate
logistical support to move and supervise a designated number of village volunteers, usually enough to amount to a substantial workload. By contrast, the village volunteers did not have to travel to perform their duties, and their work earned them the respect of their communities. Motivation was less problematic for the district staff, who were salaried.

**Improvements**

This scenario began to change in 2005, when the government allocated 1 billion cedis to the programme, increasing to 10 billion cedis (US $1 million) in 2007. Additional funds made it possible to create another supervisory cadre. ‘Area supervisors’ were hired by the programme and provided with motorcycles to do all tasks related to eradication. This included taking anybody infected with Guinea worm on their motorcycle to a Case Containment Centre for bandaging and full containment. They could bypass the hierarchy of health officials and report directly to the regional Guinea worm team in Tamale.

In 2007, a consultancy showed that the common problem of worms broken during emergence was largely associated with shortcomings in case management by volunteers or health service staff [22]. Remediying them would lead to improved case detection, because a broken worm has unpleasant consequences for the patient. The government and its partners also put extra resources into villages that were apparently freed from the disease, thus reinforcing the surveillance system. The new-found resources also allowed the treatment of ponds in an increased percentage of endemic villages, and the posting of watchmen (known as dam guards) to prevent their recontamination. Even the provision of safe water supply in endemic communities, long blocked by the insistence of the Water Department on 5% cash contributions from the villagers, started to move slowly forward after 2007, thanks to the more relaxed policy of a United Nations Children’s Fund (UNICEF)-assisted project funded by the EU.

Table 2 shows that during most of the period of stagnation in Ghana, a low percentage of cases were contained and a low percentage of ponds treated. In 2006, the case containment rate increased to 75%; it continued to increase in subsequent years, reaching 100% in 2010. A high case containment rate is the result of robust surveillance. Coverage with cyclopicide treatment of ponds was also low (less than 50% of eligible villages) before 2005, but then increased to reach 66% in 2006 and ultimately 86% in 2009.

The effects of the funding breakthrough on the disease were soon apparent. The annual number of cases dropped from over 3000 in 2007 to only eight in 2010 (Figure 1), with the yearly reductions averaging more than 75%, and far beyond the pessimistic maximum 50% that was predicted [6].

**Box 2. Fragmentation of resources and weak partnership**

From its inception, the Global Guinea Worm Eradication Programme was based on the enthusiasm of a few individuals, who in the mid-1980s convinced former US President Jimmy Carter to lead the campaign [29]. The World Health Organization (WHO) and the United Nations Children’s Fund (UNICEF) joined later, forming a weak partnership in which each has provided varying inputs during the 25 years of the campaign. The support from donors was most of the time insufficient for a global eradication programme. It has been estimated that until 1997, US $90 million had been spent on Guinea worm eradication [7]. More recently, the eradication programme in Nigeria (1988–2009) is estimated to have cost US $37.5 million, not counting government salaries [30]. On the one hand, raising such amounts can be seen as a remarkable success. On the other hand, it was thin sustenance for a global campaign which by then had been operational for a decade. With limited financial resources, it was difficult to cover a score of endemic countries with adequate surveillance and preventive interventions at the same time. Only when several countries had successfully interrupted transmission could the programme concentrate its resources on the few remaining endemic countries.

Funding for the eradication activities of the WHO was less than US $1 million a year before 2009 and was operated mostly by only one official in Geneva and one in its regional office in Africa. The work of the WHO was mainly surveillance in areas freed from the disease and in countries in the pre-certification stage. The former was largely neglected, as an estimated US $7 to $10 million per year would have been needed for the WHO to undertake its activities properly.

The contribution of UNICEF was considerable in the early stages of the programme, with two dedicated officials in the New York office and one based in Ouagadougou to provide technical support. In 1992, the New York staff obtained funding of US $70 million, redeployed because of a mid-year underspend by the Delhi country office, and distributed it to endemic countries, some of it for Guinea worm surveillance, filter distribution etc. but mostly for rural water supply in endemic areas. UNICEF support for the eradication effort declined gradually after the early 1990s, and soon it had no official responsibility for the disease globally.

In the case of polio eradication, the Rotary Foundation, UNICEF and WHO approached the donors together to obtain funding on the basis of a joint programme, and distributed it between them. This degree of coordination was not achieved for Guinea worm eradication until 2008 when The Carter Center and WHO made joint approaches to the Bill & Melinda Gates Foundation and the UK Department for International Development (DFID). This led to funding pledges by The Bill Melinda Gates Foundation which, with matching funds, will amount to US $72 million. DFID promised a challenge fund of up to £20 million (US $31 million), and other donors are expected to provide double that to support the final stages of eradication.

**Political will**

If strengthening surveillance and increasing the coverage of interventions have led to this sharp decline in cases, why were these measures not taken before? The weak partnership at the heart of the campaign is partly responsible (Box 2), but so is a lack of political will and the resources which express it.

The recent surge of funding is welcome to finish the job quickly, but there is also the risk that it will arouse the
jealousy and frustrations of many health officials who will wonder why this non-fatal, transient condition gets so much funding compared to trachoma, African trypanosomiasis, leishmaniasis, cholera, leprosy and other neglected diseases. The short answer is that the final push to eradication is essential to consolidate and safeguard the investment in the campaign to date. The continuing outbreak in Chad [5], the reports of imported cases reaching Algeria [23] and accounts of recent indigenous cases in Rajasthan [24] all speak in favour of that argument.

A further argument, much discussed in the 1990s, was the hope that the community-based surveillance systems set up for dracunculiasis could serve a broader purpose in community health [25]. However, with the decline in the number of endemic villages, most of the surveillance systems seem to have contracted also; a shorter-term perspective has prevailed. There is an ironic symmetry in 1991, on the one hand, when the global total of cases was more than 400 000 (excluding Sudan and Uganda, which had many thousands more), and the programme set the target date for eradication as 1995, 5 years ahead; on the other hand, in 2011, with only about 1000 cases worldwide, the target date was increased to 2015 to allow a similar period of time to spend the funding.

Concluding remarks and lessons learnt
To summarise, the resources available to the global dracunculiasis eradication programme during its first 25 years were inadequate in relation to its goal. They were spread thinly between 20 endemic countries and pre-certification countries, leaving gaps and shortages. This forced some national programmes to depend upon volunteers above the village level, such as Ghana’s zonal coordinators. These individuals gradually lost interest and commitment. It could be argued that, if more had been available to spend in the early years, eradication could have been achieved in less time and at a lower total cost.

Although eradication of dracunculiasis is technically feasible, the lack of adequate resources led to shortcomings in the implementation of surveillance and preventive interventions. Political support was present, thanks largely to the advocacy of The Carter Center, but is hard to retain continuously, year after year. Where it has been strong, the programme has benefited enormously. However, resource constraints meant that most national programmes had to drop support for villages that reported zero cases in a year. The World Health Organization (WHO) could not continue surveillance to prevent reinfestation of those villages, nor was the UNICEF able to provide them with safe water supply. Thus, the disease returned to many of them. Dracunculiasis could have been eradicated a decade ago if enough resources had been available, if all interventions were effectively conducted and surveillance maintained in villages freed from the disease.

Acknowledgements
Dr Andrew Seidu Korkor is the national coordinator of Ghana’s Guinea Worm Eradication Programme. The views expressed in this article are those of the authors, and not necessarily of their organisations.

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