SANTÉ PUBLIQUE

Dracunculiasis eradication.

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Résumé : **Éradication de la dracunculose.**

La dracunculose est une maladie parasitaire transmise par l'eau de boisson infectée. La Décennie internationale de l'eau potable et de l'assainissement (1981–1990) a offert une chance pour éradiquer cette maladie.

La campagne d'éradication était basée sur la provision d'eau de boisson saine, l'isolement des cas cliniques et l'éducation pour la santé. Un système de surveillance épidémiologique approprié a été mis en place pour guider et évaluer les activités d'éradication. Au début de la campagne, on estimait que 3,2 millions de personnes étaient atteintes par la maladie. À la fin de 2005, le nombre de cas rapportés n'était plus que de 10674. La transmission de la maladie continue dans seulement 9 pays de l'Afrique sub-Saharienne et 7 autres pays sont dans la période de pré-certification. À ce jour, 168 pays et territoires ont été certifiés indemnes de transmission.

L'éradication de la maladie requiert que l'absence de transmission soit certifiée dans tous les pays. Avec le soutien de la communauté internationale et le travail accompli par les programmes nationaux d'éradication de la dracunculose, cette maladie pourrait bien être la première parasitose à être éradiquée.

dracunculose
campagne d'éradication
Afrique intertropicale

Summary:

Dracunculiasis is a disease caused by a parasite transmitted through infected drinking water. The International Drinking Water Supply and Sanitation Decade (1981–1990), provided a unique opportunity to eliminate the disease.

The strategy of the eradication campaign was based on provision of safe drinking water supply, intensified case containment and health education. An appropriate epidemiological surveillance system was established to guide and evaluate the eradication effort. From an estimated 3.2 million people affected by the disease at the beginning of the campaign, the number of cases dropped to 10,674 by the end of year 2005. Currently, the transmission of the disease takes place in 9 sub-Saharan countries only and another 7 countries are in the pre-certification stage. So far, 168 countries and territories have been certified free of transmission. However, eradication of the disease requires that all countries be certified free of transmission.

With the support of the international community and the work of national dracunculiasis eradication programmes of affected countries, dracunculiasis may well be the first parasitic disease to be eradicated.

dracunculiasis
eradication campaign
Sub Saharan Africa

Introduction

The success in eradicating smallpox inspired many individuals and organizations in the early 1980s to advocate elimination of dracunculiasis or Guinea worm disease (15). The proposal was seen as feasible since it is the only disease which is transmitted exclusively through drinking water. The International Drinking Water Supply and Sanitation Decade (1981-1990) provided an opportunity to eliminate Guinea worm disease which was considered as an indicator of the success of the Decade. Member states of the World Health Organization embraced the goal of eliminating dracunculiasis formally by adopting in 1986 resolution 39.21 of the World Health Assembly (46), which set out a combined strategy of provision of safe drinking water sources, active surveillance, health education, vector control, and personal prophylaxis. In that year, the disease caused an estimated 3.2 million cases (42). In 1991, the World Health Assembly adopted a resolution calling for the global eradication* of dracunculiasis by 1995 (47). A process of country-by-country certification of interruption of transmission was initiated as the foundation for eventually declaring the attainment of global eradication. However, achieving this goal by 1995 proved impossible. In May 2004, the ministers of health of the 12 countries still endemic met in Geneva at the time of the World Health Assembly and signed a Declaration committing to eradicate the disease by 2009 (58). In 2004, the World Health Assembly adopted a resolution strengthening the Declaration and calling on all endemic countries and partners to eradicate the disease by 2009 (59).

Historical aspects

Guinea worm or *Dracunculus medinensis* was recognized and mentioned by various Greek authors from antiquity. Although the disease probably did not occur in Greece, it was

*In contrast with elimination, eradication requires that the 'roots of the disease are removed', in other words that the parasite is no longer present worldwide mentioned by the great Greek/Roman philosophers and physicians such as GALAN, AGATHARCHDIS and PLUTARCH. It is believed that the 'fiery serpent' which afflicted the Israelites during their exodus around the Red Sea was *Dracunculus medinensis*. The disease probably existed in Egypt and the eastern Mediterranean as indicated in several texts from Pharaonic Egypt and Assyrian Mesopotamia (36).

The first detailed description of the worm and the disease was given by the Persian/Arab physicians IBN SINA (AVICENNA) and AR-RAZI during the medieval period in the tenth century as it was prevalent in the Arabian Peninsula where it was called 'Medina vein' (36).

In the early seventeenth century, several European travellers wrote about the disease which they saw during their travel in Asia and the western coast of Africa. The first accurate account of the anatomy of dracunculiasis was made by BASTIAN (3). The milestone in the history of parasitology was the finding by FEDCHENKO (13) that the cyclops is the intermediate host in dracunculiasis. In the early twentieth century, LEIPER (22) and TURKHUD (41) produced experimental infections in animals and humans, which confirmed FEDCHENKO's finding and demonstrated the complete life-cycle of the disease.

Life cycle and transmission

Dracunculiasis is a disease caused by *Dracunculus medinensis* or Guinea worm. It is the largest of the tissue nematode parasites affecting humans. The female worm emerging from the human body releases larvae by contractions of the uterus. At each contraction, larvae are released but their number decreases gradually day after day. The larvae remain viable in the water for up to 7 days but their infectivity to the copepod is maximal during the first 2-3 days after they are released. Larvae ingested by the copepods migrate through the gut wall to the haematocele where they remain for about 2 weeks during which they evolve after 2 moults in a stage 3 larvae. The copepods usually harbour one or two larvae and do not survive multiple infections (5, 26).

Man gets infected by drinking water containing infected copepods. The vector gets dissolved by the gastric fluids and releases the infective larvae which enter the abdominal or thoracic cavity and then migrate into the connective tissues of the host where they evolve into the stage of mature worm, approximately three months after infecting the host. Mating occurs at this stage, male worms die shortly after and females continue their development and migrate towards their point of emergence, generally in the lower part of the body. The mature female, measuring 550-800 cm long by 1.7-2.00 mm in diameter, tries to emerge 10-14 months after infection (26). At this stage, the female body is mostly occupied by a distended uterus containing millions of stage 1 larvae. A blister forms in the skin of the host around the anterior extremity of the female worm. When in contact with water, the blister ruptures, the worm protrudes and discharges hundreds of thousands of stage 1 larvae into the water. The 1 larvae are then ingested by the cyclops, thus completing the life cycle of the parasite.

Clinical features

The penetration of the larvae of *D. medinensis* in tissues is not associated with any particular manifestation. The development of the larvae into adult parasite in deep somatic tissues remains also asymptomatic. The migration of the gravid worm to the subcutaneous tissues generates host reactions to the by-products of the worm which may be local or systemic. The development of a cutaneous blister at the point of emergence is associated with an intense sensation of burning locally. Most common sites of emergence are located at the lower part of the leg, around the ankles. However, the worm can emerge at any place of the body, including the trunk, the arms and hands, the buttocks, the thigh, the knee joint, the calf and the genital sphere. A few hours before the development of the local cutaneous lesion, the symptoms are exacerbated and may include erythema, urticarial rash, intense pruritus, nausea and vomiting, diarrhoea, dyspnoea, giddiness and syncope (26). The lesion develops within a few hours in the form of a papule centred by a vesicle and surrounded by a local induration. On contact with water, the blister bursts and the anterior part of the worm emerges and discharges larvae and internal fluids. At this stage, the pain and the burning sensation are reduced and the other symptoms also tend to decrease.

Some worms do not emerge and calcify in tissues. Most of the calcified worms remain asymptomatic and are discovered by chance on the occasion of an X-ray or during a surgical intervention (26). However, the calcification of worms in tissues may induce local manifestations: pulmonary, cardio-vascular, abdominal, uro-genital or gyn-obstetrical (26).

Additional symptoms are generally linked with the rupture of the worm during attempts to extract it. Typically, the rupture generates an inflammatory reaction with intense pain along the trail of the worm.

Secondary bacterial super infection at the point of emergence of the worm is rather common when nursing is not available, and may lead to an aggravation of the condition and complications such as septicaemia and tetanus. Severe arthritis and ankylose may be due to either the release of *D. medinensis* embryos inside the joint (aseptic arthritis) or the bacterial infection of the tunnel of the worm (septic arthritis). Such complications may lead to physical deformity and limitation of mobility.

Treatment

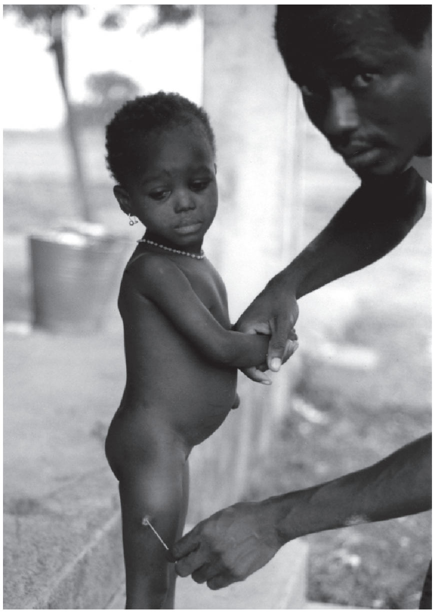
Treatment of dracunculiasis itself is in fact limited to the extraction of the worm by cautious winding around a stick and extirpation of a few centimetres every day until the complete worm is extracted (photo 1). Treatment of the lesion using topical antibiotic prevents secondary bacterial infection and complications.

The use of niridazole (25 mg per kg body weight daily for 10 days), thiabendazole (50 mg per kg body weight daily for three days), or metronidazle (400 mg for an adult daily for 10 to 20 days) can help in lessening the intense tissue reaction, making extraction easier, and can relieve the pain (27). However, it has been suggested by CHIPPAUX (7) that treatment with a high dose of mebendazole could result in emergence of worms from unusual sites thus endangering the life of the infected person. Ivermectin has no effect on the pre-emerging worm and it does not affect its migration route (18).

Surgical extraction prior to eruption of the worm was practiced in India (32) and can remove the worm painlessly using aseptic techniques and local anaesthesia. Although this technique may be useful for treatment of individual cases, it is not recommended as an intervention for public health purposes. Surgery should be considered only exceptionally and should be undertaken in a hospital environment as it requires post

Photo 1.

A Guinea worm emerged from a child's leg is pulled out by a health worker.
Un ver de Guinée émergeant sur la jambe d'un enfant est extrait par un travailleur sanitaire



operative care and follow up to avoid complications. With the prevalence of HIV in countries also affected by dracunculiasis, the use of surgery where no quality conditions exist in the field to practice this technique would add to the risk of HIV transmission and should raise ethical concerns (5).

Social impact of the disease

The social and economic effect of the disease is mainly attributed to the temporary disability endured by the infected persons. SMITH *et al.*, (35) show that 25% of the patients with dracunculiasis are incapacitated for 30 days on average. As the disease occurrence is maximal during the peak season of agricultural activities when labour is required, the loss in manpower leads to a deficit in income. CHIPPAUX *et al.* (9) report a loss of 15% of the revenue of each active villager. As a result, malnutrition prevails among children of households whose able members are affected by dracunculiasis (37). It is not surprising that the disease is called "the disease of the empty granary" by people in Mali. The community tends to compensate for the economic loss through different mechanisms: in Africa, when the agricultural activity is run as a family undertaking, there is a reorganization of the distribution of tasks within the family or within the community to compensate for the loss in manpower due to dracunculiasis (45). When the activity is a small business enterprise, the loss is compensated through the recruitment of temporary manpower (8). Children also miss school, either because they have the disease or when they replace sick household members in agricultural activities (4).

Epidemiology

Transmission

Infection with Guinea worm is mainly attributed to drinking from surface untreated still water such as ponds, hafirs and dams (6), and step wells in India (34). Rivers and streams are not suitable for transmission of the disease since they have a continuous flowing pattern. However, when they form small stagnant pond, such ponds may be the source of transmission (1). People become infected by drinking water from such sources containing infected copepods. The water source gets infected when humans immerse their lesion with an emerging worm into the water source to alleviate the pain allowing the worm to release thousands of stage 1 larvae into the water.

Transmission of *D. medinensis* is seasonal and two patterns of transmission are described. Based on data received from countries the transmission period varies according to the bioclimatic environment. In Asia, the transmission used to take place mostly during the dry season when the level of water in the step wells was low and the concentration of copepods was maximal (34). Table I shows a likely pattern of seasonal transmission for several African countries.

In Sahelian semi arid areas, the peak transmission period coincides with the rainy season when drinking water is taken from surface sources. In Guinea savannah areas, where water sources are available throughout the year but where there is a distinct dry and rainy season, transmission of dracunculiasis takes place during the dry season. In some countries, such as Nigeria, there may be two peak transmission periods, one typical of the north (dry savannah) and the other typical of the south (wet savannah). Knowledge of the peak transmission period is an important element for the planning of timely interventions for preventing transmission. Indeed, preventive measures should be applied and intensified during the time when transmission occurs to ensure greater effectiveness of eradication programmes.

Reservoir of parasite

Man is the only known reservoir of *D. medinensis* and it seems that there is a host-parasite specificity as the occurrence of dracunculiasis in domestic or in wild animals in endemic areas is very rare. However, in Japan and in Korea, two countries where dracunculiasis is not known to have ever been endemic, two cases were reported in people who had never left the country; these infections may have originated, exceptionally, from an animal species of *Dracunculus* (14, 21). In the Americas, where *D. insignis* and *D. fuellebornus* are endemic, there are no documented cases of locally contracted human cases.

Geographical distribution of the disease

At the start of the initiative, nineteen countries were endemic: India, Pakistan and Yemen in Asia; all other countries were in Africa with the majority of them being in West Africa: Benin, Burkina Faso, Côte d'Ivoire, Ghana, Niger, Nigeria, Mali, Mauritania, Togo. In central Africa, Cameroon, Central African Republic and Chad. In East Africa, Ethiopia, Kenya,

Tableau I.

Usual peak infection periods of several African countries.
Pic moyen de l'infection dans plusieurs pays d'Afrique.

country	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Mauritania							X	X	X	X		
Chad						X	X	X	X	X		
Mali						X	X	X	X	X		
Niger						X	X	X	X	X		
Burkina Faso					X	X	X	X	X	X		
Cameroon					X	X	X	X	X	X		
Sudan					X	X	X	X	X	X		
Uganda				X	X	X	X	X				
Ethiopia				X	X	X	X	X				
Côte d'Ivoire	X	X	X	X	X	X	X					
Ghana	X	X	X	X	X						X	X
Benin	X	X	X							X	X	X
Togo	X								X	X	X	X
Nigeria	X	X			X	X	X	X			X	X

Tableau II.

Monthly number of Guinea worm cases reported in 2005.
Nombres de cas de dracunculose notifiés mensuellement en 2005.

country	No. of cases in 2004	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
		number of Guinea worm cases reported in 2005												
endemic countries														
Burkina Faso	60	0	0	0	1	0	3	5	15	0	1	4	1	30
Côte d'Ivoire	21	0	0	1	0	0	3	4	1	0	1	0	0	10
Ethiopia	17	2	0	0	3	7	20	2	3	0	0	0		37
Ghana	7,275	553	483	395	397	458	383	162	60	56	224	355	455	3,981
Mali	357	4	1	1	1	25	25	86	132	203	116	52	13	659
Niger	240	2	4	1	4	3	3	7	23	19	43	59	15	183
Nigeria	495	36	17	13	29	9	6	5	1	0	0	2	2	120
Sudan	7,266	66	102	169	146	1,606	1,442	542	499	324	410	262	1	5,569
Togo	278	11	4	2	3	19	8	6	4	1	2	4	9	73
countries in the pre-certification period (imported cases only)														
Benin	3	0	0	1	0	0	0	0	0	0	0	0	0	1
Cameroon	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Central African Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chad	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kenya	7	0	0	0	0	0	2	0	0	0	0	0	0	2
Mauritania	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Uganda	4	0	0	0	0	0	4	1	2	2	0	0	0	9
total	**16,026**	**674**	**611**	**584**	**583**	**2,127**	**1,899**	**820**	**740**	**605**	**797**	**738**	**496**	**10,674**

Sudan and Uganda. Currently, transmission occurs in only ten countries, all in sub-Saharan Africa: Benin, Burkina Faso, Côte d'Ivoire, Ethiopia, Ghana, Niger, Nigeria, Mali, Mauritania and Togo. The other countries were either certified free of transmission (India, Pakistan, Senegal, Yemen) or are presently in the pre-certification period (Cameroon, Central African Republic, Chad, Kenya and Uganda) (table II).

Dracunculiasis is essentially a disease affecting rural communities. Whilst the occurrence of cases is possible in an urban environment, such cases have usually been "imported" and were contracted elsewhere (42). Given the long incubation period, infected people do not make the relationship between disease and infected drinking water.

Age and sex distribution

Dracunculiasis rarely occurs in children below the age of three as the babies are generally breast fed, and the long period of incubation delays the first emergence of the worm to one year after the weaning (19). The incidence of the disease increases significantly after five (25, 29). EDUNGBOLA & WATTS (10, 11) observe an increased incidence after the age of 10. Generally, the incidence of the disease is maximal between 15 and 45, and decreases after the age of 45 or 50 (11). The decrease in incidence in older people is due to the fact that their water consumption from contaminated sources is less frequent (unless the source of infection is close to the village). The incidence is high in active adults who, because of their farming activities, drink larger quantities of water and use water from unsafe sources such as non-treated ponds far from the village and close to the farming field. CAIRNCOSS and TAYEH (6) showed that when the source of contamination is close to the village, most of the population is affected by the disease, irrespective of age and sex.

The disease affects both sexes and there is usually no significant difference of prevalence of infection related to gender. However, in some communities, such as in northern Nigeria, the rate of infection appears to be higher in males. This is observed in populations in which women do not participate in farming activities, and thus are less exposed to the use of drinking water from unsafe sources. However, when the data are controlled for risk factors, this difference disappears.

Eradication strategy

Provision of safe drinking water supply

Provision of safe water supply is an important intervention for the successful interruption of disease transmission. The impact of provision of safe water supply on reducing the number of cases or on the elimination of the disease from an area has been documented in several studies (12, 16, 17). Piped water is suitable for large populated areas. For small villages, and where feasible, drilled boreholes equipped with hand pumps can be an appropriate solution although they require continuous monitoring and maintenance with cost implications for populations living in lesser developed areas. Improving the existing water system such as protecting open wells, using concrete or stone masonry parapets, is a sustainable intervention. Small dams and ponds can be equipped with infiltration galleries to prevent people from wading into the water and therefore prevent their infestation by the parasite larvae.

Filtering of drinking water

In remote villages in endemic countries when safe drinking water is not available, transmission can be interrupted using filters made from fine mesh 100 microns. Ordinary cloth filter can be used at household level but it has short life as it becomes dirty with the high turbidity of water and strong sun when it is put to dry. Monofilament nylon cloth filter is more robust and has the ability to remove the vector of the disease from drinking water. Distributing such material to households to filter their drinking water can be an effective way of preventing the disease from infecting its members and visitors. Although filtering of drinking water is theoretically easy, it implies a change in the behaviour of poor and illiterate rural populations scattered in many remote villages and speaking different languages with strong beliefs that contradict modern theories of infection. In addition, collection of water in most endemic countries is the exclusive responsibility of women who are overburdened by other heavy daily duties. In the rural areas of Northern Region of Ghana, the ownership of a filter by households during one year did not have a significant impact on the reduction of the number of cases the following year (38, 39, 40).

Chemical treatment of pond water

The application of abate (temephos) to surface drinking water sources, mainly ponds, is an effective measure to prevent transmission through the killing of the vector. However, treatment of the drinking water sources should be conducted monthly throughout the transmission season.

Intensified case containment

Early detection of cases (within 24 hours after emergence of the worm) by the village health worker is an essential step in the implementation of case containment. This task is generally carried out by the health worker who cleans the ulcer, tries to gradually pull out the worm or part of it, disinfects the lesion and bandages the ulcer to facilitate the expulsion of the worm and avoid bacterial super infection. At this stage, it is essential that people with an emerging worm be advised to stay home and not to wade into drinking water sources.

Health education

Health education is one of the important components of the eradication strategy. In many countries, the beliefs about the mode of transmission of the disease are far from reality. Nevertheless, villagers relate the disease to drinking water from ponds. This relationship was based on observations by the villagers that the disease had decreased or disappeared after the establishment of a safe source of drinking water such as bore holes or protected wells. The knowledge about the cycle of the parasite and the real mode of transmission through health education sessions has enabled the infected communities to better understand the proposed methods of prevention. Health education has certainly had a synergistic effect on the interventions. Wherever health education sessions were repeatedly organized, the number of cases in the community declined faster.

Surveillance

The evaluation of interventions for eradication programmes cannot be done without strong surveillance of the disease. Dracunculiasis being a rural disease affecting isolated communities in remote areas affected by dracunculiasis, the national health surveillance system of many endemic countries did not cover the needs and requirements of the eradication programmes. Therefore a Guinea-worm specific, active surveillance system was established at the inception of the National Guinea Worm Eradication Programme. The surveillance system is vertical and designed in a pyramidal architecture comprising, from bottom to top, villages, districts, regions and national programme headquarters.

The active surveillance is carried out by a village health worker, usually a volunteer or a person designated by the community. Every month he/she visits each household and records cases of dracunculiasis together with other requested information on the patients. All the information is recorded in a specific surveillance book. This information is collected by the district nurse on a monthly basis and compiled for transmission to the regional health structure, which also reports monthly to the National Programme headquarters for analysis. The results of the analysis are used to plan or adjust subsequent interventions. Therefore, monthly data by village are available. Annual surveillance data from each NGWEP are provided to WHO. A yearly update of the epidemiological situation and the status of dracunculiasis eradication in the world is published in the *Weekly Epidemiological Record of WHO*.

The surveillance system for dracunculiasis eradication also requires that monthly reporting continues during the three years following the occurrence of the last case. This phase is the pre-certification period during which the monthly reporting of zero case is essential for the certification process. As the interest of health workers may dwindle, it was suggested, where possible, to integrate, at village level, the surveillance of other diseases such as leprosy. This approach enabled the surveillance to be sustainable when its integration into the national health system was not possible.

The maintenance of a rumour register is mandatory during the pre-certification period. All rumours are recorded and verified within 24 hours as far as possible. If a case is confirmed, it must be established whether it is indigenous (resulting from local transmission) or imported. In the latter, the case must be fully documented and the origin of infection clearly established.

When the number of cases becomes low in a country, the establishment of a reward system brings an increased sensitivity to dracunculiasis surveillance. If a rumour proves to be a case, a cash reward is granted. The organization of the reward system and the amount granted vary considerably from one country to another. In some countries, the reporting person receives the reward; in others instances, the patient also receives a reward. Sometimes, the reward goes to the whole community and may be used for an activity that is beneficial to the entire village such as the digging of a new well.

In addition, compulsory notification of cases is requested from all units of the national passive disease-surveillance system including primary health care posts, health centres district and referral hospitals.

Following the certification of transmission - free status, countries must continue the surveillance of dracunculiasis until all the countries of the world have been certified. This post-certification surveillance is particularly important for countries neighbouring endemic countries. Indeed, an imported case may at any time generate a local focus if it is not detected and immediately contained.

Establishment of national eradication programmes in endemic countries

Soon after the adoption of Resolution WHA 39.R21 by the World Health Assembly in 1986 on the elimination of Guinea worm, the endemic countries, with the assistance of WHO and partners, including UNICEF and The Carter Center, established a National Guinea Worm Eradication Programme (NGWEP). Burkina Faso, Ghana and Nigeria started their effective surveillance system in 1989. Benin, Cote-d'Ivoire, Mali, Niger and Senegal started their programmes in 1991. Chad, Mauritania and Togo followed in 1993. Kenya, Uganda and Yemen reported significant number of cases in 1994. And finally Sudan reported about 120,000 cases in 1996 when its programme was established.

National Programmes aimed first at evaluating the numerical importance of the disease, as well as its geographical distribution within the country and the identification of all endemic villages. The next steps for Programmes were to implement the interventions needed in each and every affected village and to set up a surveillance system at the village level. For this purpose, a village health worker was identified by the villagers and subsequently trained to collect basic epidemiological data on the disease for surveillance purposes and apply measures for the prevention of transmission. He also distributed filters and checked the condition of the filters previously provided and devoted time to giving basic care to patients with an emerging worm.

Results of the eradication campaign to date

Until the nineteen eighties and nineties, transmission was still occurring in Asia (India, Pakistan and Yemen) and in sub-Saharan Africa (Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Mali, Mauritania, Niger, Nigeria, Senegal, Togo, Uganda, and Sudan). In the early eighties, the global number of cases was estimated to be in the magnitude of

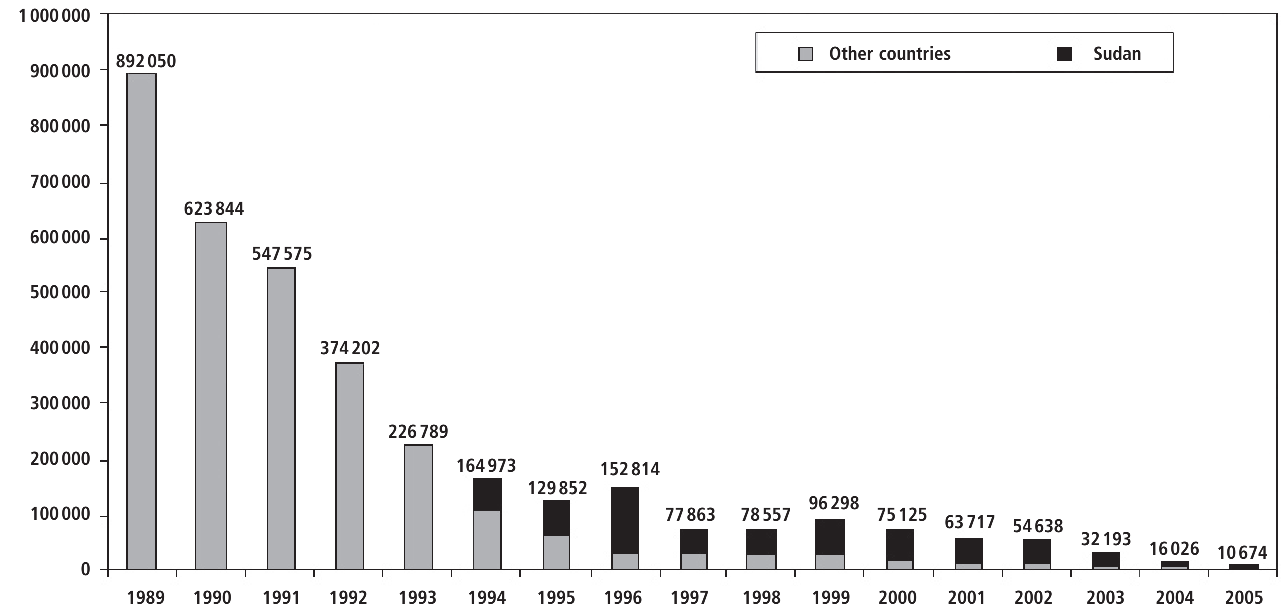
3.2 million (42). In 1989, the total number of cases reported to WHO amounted to 892,050. As a result of the interventions implemented by national programmes, this figure dropped regularly reaching 32,193 in 2003 (figure 1), (57).
Sudan alone reported 20,299 cases, i.e. 63% of the cases worldwide. Ghana and Nigeria were the second and the third most endemic countries in 2003, reporting 8,290 cases and 1,459 cases respectively. Other countries reported each less than 1,000 cases in 2003 (Mali: 829 cases, Togo: 669 cases, Niger: 293 cases and Burkina Faso: 203 cases). The remaining countries each reported less than 100 cases. For 2004, the total number of cases was 16,026 and in 2005, this figure dropped to 10,674 confirming the good progress made by most countries (table II).
Currently, the transmission has been interrupted in Asia and the Arabian Peninsula after an active eradication campaign in India, Pakistan and more recently in Yemen. The disease is now confined to sub-Saharan Africa where good progress has been achieved since the beginning of the eradiation effort. Indeed, the epidemiological situation of each country as of December 2005 shows that indigenous transmission has been interrupted in Benin, Cameroon, Central African Republic, Chad, Kenya, Mauritania, and Uganda. All these countries are currently in the pre-certification period despite the fact that Benin reported one imported case from Ghana and Kenya and Uganda reported respectively 2 and 9 cases imported from neighbouring Sudan (table II). Senegal has even taken the lead among countries which were recently endemic and was the first sub-Saharan country to be certified free of transmission.

Certification of Interruption of transmission of *D. medinensis*

For eradication to be completed, all countries of the world need to be certified free of parasite transmission. In 1995, WHO established an International Commission for the Certification of Dracunculiasis Eradication (ICCDE) composed of 12 public health experts from the six WHO regions. The first task of the Commission was to establish criteria for the certification of interruption of transmission and criteria for eligibility of countries applying for certification. WHO also established a panel of experts from which are drawn those who will form an International Certification Team (ICT).
All countries applying for certification must complete a questionnaire on the status of dracunculiasis in their country, on the surveillance system of the country and its ability to detect, isolate and report a possible case. The questionnaire also provides information on the coverage of safe drinking water, particularly in rural areas. In addition, countries must complete a declaration stating that dracunculiasis has not occurred in the country during at least the previous 3 years.
For countries which have been recently endemic or for which there has been published information in the recent past (generally during the past 25 years), the ICCDE requires a detailed report from the ministry of health and a visit by an International Certification Team. The ICT visit is mandatory for all countries which were endemic at the start of the eradication campaign. The ICT visit to the country takes place after the country has completed the three years transmission-free pre-certification period. The ICT carries out an in-depth review of the dracunculiasis situation in the country to ascertain that transmission has been interrupted and that the requirements for certification are fulfilled. Particular emphasis is placed on the strength or weakness of the surveillance system, its ability to detect and isolate a case should it occur, on provision of safe drinking water and on the knowledge about Guinea worm and its transmission resulting from health education. The findings of the ICT are reported to the ICCDE. On the basis of the documentation provided by the country and by the ICT, the Commission recommends to WHO whether or not to certify the country as free of *D. medinensis* transmission.
The most recent meeting of the ICCDE was held in March 2004, at which time, 17 additional countries were certified free of transmission (56). This brought the total number of countries and territories certified to 168. Map 1 shows the status of countries as of January 2005: countries that have been certified, those in the pre-certification stage and countries where transmission is ongoing.

Figure 1.

Annual number of Dracunculiasis cases worldwide 1989-2005.
Courbe de l'incidence annuelle de la dracunculose dans le monde, 1989-2005.



Certification of countries that were endemic before 1980

Certification of Egypt

Although no indigenous cases of dracunculiasis had been detected in Egypt, at least in the last 150 years (43, 44), the *International Commission for Certification of Dracunculiasis Eradication* recommended that an *International Certification Team* (ICT) visit Egypt to make sure that local transmission does not take place in the country and that there is no possibility of introduction of the disease from other countries. This is because Sudan, which neighbours Egypt on its southern border, was reporting the highest number of cases. The team visited Egypt in November 1997 and concluded that the disease cannot establish itself in the country. Nowhere in the country are conditions suitable for transmission (51, 52).

Certification of Iran

In early last century, dracunculiasis was prevalent in the area stretching from Bushehr, Bandar Lengeh, Bandar Abbas on the coastal area and encircled by Lar Town returning to Bushehr as reported by LINDBERG (23, 24). The last identified cases were in the early 1970s, mainly in the Province Fars, along the Persian Gulf with the peak transmission occurring in spring and summer (2). Water was scarce in that area and people depended upon very large and deep cisterns called *berkeh* which were used to collect rain water during the rainy season. SAHBA *et. al.* (33) gave a detailed description of the epidemiology of the disease including the high rate of infection in males. The age group 6-20 was the most affected. The number of cases had significantly decreased and the endemic areas cleared in the mid 1970s (31).

In November and December 1996, an International certification team visited six provinces in Iran (49). The ICT concluded that the disease disappeared from the country for about two decades. The main reasons for disappearance of the disease were chlorination of drinking water sources (*berkehs*), the increased coverage in the supply of piped water, the increased awareness about the disease and an acquired habit of filtering drinking water. The possibility to purchase water through water tankers and make modification to the *berkehs* to prevent their contamination with the parasite were also contributing factors for the interruption of transmission.

Certification of countries that were endemic after 1980

Certification of Libya

Although imported cases from Sudan were reported in Libya during late 19th century, (28), Libya has not been endemic with dracunculiasis according to medical literature. In mid-1993, a few indigenous cases were recorded in an extended family in Ruhaibat area (in Nafusah Highland). This was an accidental local transmission that did not spread to other neighbouring families and occurred in only one season. From June to August 1993, seven cases of Guinea worm were reported to the local health authority in Ruhaibat, four of them were confirmed at that time.

In March 1999, an International Certification Team visited the Libyan Arab Jamahiriya upon request from the International Commission for Certification of Dracunculiasis Eradication. Three areas were visited; Ruhaibat area in the West, Sabha and Marzuq in the south and Al Kofrah in the southeast of the country (53). The ICT focused its investigation in Ruhaibat where indigenous transmission was reported. The affected family indicated that in 1992 a shepherd, presumably from Chad, who was their temporary employee, had a swollen leg. He was taken to the hospital in Ruhaibat but Guinea worm was not diagnosed at that time as there was no sign of an emerging worm and the disease was not known in the area. It is believed that the shepherd had infected an open water source, *majen*, in 1992 on the family farm. During that year, there was a shortage of water in the family's *fiskiya*, a cylindrical-shaped cistern dug in the family compound usually used for collection of rainwater from the roof. So the family transported the contaminated water from the *majen* and refilled the empty *fiskiya* in the household.

The ICT concluded that the local transmission of *Dracunculiasis medinensis* in Ruhaibat was accidental. Reintroduction of the disease to Libya is unlikely due to the existence of a good health surveillance system as well as the availability of safe water supply in almost all inhabited areas.

Certification of Pakistan

The Pakistan National Guinea Worm Eradication Programme was established in November 1986. The following year a country wide survey was conducted and an estimated 2,400 cases in 408 villages were identified clustered in remote areas of Punjab, Sind and North West Frontier Provinces. The number of reported cases declined gradually from 1,110 in 1988 to 534 in 1989, 160 in 1990, 106 in 1991, 23 in 1992 and 2 in 1993.

The Internationalcertification team visited Pakistan in September-October 1996. The team covered the whole formerly endemic areas. No cases were detected during the visit and no evidence of cases during the three previous years could be found by the ICT. People interviewed in villages showed a high level of knowledge about the disease and its prevention and the reward for reporting on cases. A rumour registry covering the preceding five years showed that all the rumours had been investigated properly and none was a case of dracunculiasis. For that reason, the team recommended that the country be certified as disease free, although the routine reporting system of communicable disease was neither complete nor very reliable (50). The team recommended that the rumour registry, reward system, and active surveillance in formerly endemic villages continue.

Certification of India

Dracunculiasis was known in India from ancient times. In 1983-1984, the Ministry of Health was the first country to launch a Guinea Worm Eradication Programme. In 1984, 39,792 cases were detected in 12,840 villages. They were mostly in Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra and Rajasthan. The number of cases fell in 1991 by 95% to only 2,185 cases and the disease disappeared from three states (Gujarat, Maharashtra and Rajasthan) as reported by WHO (48). In 1996, only 9 cases were reported and the following year the country was disease-free (51).

The last case of dracunculiasis reported by the Indian Government occurred in July 1996. Thus, the ICT visited the country in November 1999 to confirm that the country was disease free. The five previously endemic states were visited. All villages previously endemic had safe drinking water supplies. Knowledge of the disease and its mode of transmission by the population was good and the rate of filter usage by households was quite high. The surveillance was well established and functional at all levels. Rumours were registered correctly and thoroughly investigated during the three years in all districts prior to the ICT visit. On the basis of these findings, the ICT recommended certifying the country as free from Guinea worm disease (54).

Certification of Senegal

Dracunculiasis had been reported to be prevalent in Senegal during the 18th century (30). Transmission of *D. medinensis* was still ongoing until 1996, resulting in the last 4 cases reported in 1997. The disease has never been highly prevalent in Senegal. Some of the historic foci located in the North-West and the Centre of the country have disappeared as a result of the provision of piped water.

The NGWEP undertook its first national survey on dracunculiasis in 1991 and reported 1,341 cases distributed in 69 villages, all located in the South-East of the country. In 1994, another survey took place identifying 181 cases in 51 other villages. The implementation of the eradication interventions enabled Senegal to interrupt transmission in less than 10 years. An International Certification Team visited Senegal in October 2003. Historical foci as well as recently endemic ones were investigated by the ICT. The team confirmed the absence of transmission since the last case was reported in 1997. They also concluded that the surveillance system is still able to detect a case should it occur. Senegal was certified free of dracunculiasis transmission in March 2004 (56, 57).

Certification of Yemen

Dracunculiasis was widespread in Yemen during the first half of the last century and probably earlier (24). Water cisterns built some 500 years ago were the source of infection. Several dracunculiasis cases were reported among Yemeni Jews migrating to Israel (20, 60) during the 1950s and migrant labour to Saudi Arabia. The disease was not reported for many years after that period.

Yemen officially reported the first active case in 1994 at Mukaibuna Al Hawaz village in Dhamar Governorate in a young woman harbouring several worms. Through a countrywide search, 94 cases were found in the Governorates of Amran and Ibb in 1994. The number of cases declined from about 94 cases to zero case during the period 1994 to 1998.

In December 2003, the International Certification Team (ICT) was requested to visit Yemen to prepare a report for the certification of eradication. The ICT had meetings with various officials in charge of the implementation of the Guinea worm eradication programme. It checked the monthly surveillance reports, studied the country report and undertook a survey. None of the people interviewed throughout the survey had seen a case of dracunculiasis during the three years prior to the date of interview. About 50% of informants had seen a case of dracunculiasis 10 to 30 years previously. About 54% of informants were aware of the reward for reporting a case; half of them recalled the exact amount of the reward. More than half of the villages visited had open well water. Upon recommendation of the ICT, Yemen was certified free of dracunculiasis transmission in March 2004 (56, 57).

Conclusion

Tremendous progress has been achieved towards eradication of dracunculiasis since the inception of the initiative in l986. Although the original target date of l995 could not be met, the epidemiological situation has dramatically improved since then and at the end of 2005 there was only 9 countries where the disease was still endemic, 3 of them reporting less than 60 cases.

National eradication Programmes must remain vigilant and persistent in their efforts as in many countries, although the transmission has ceased, the ecological condition remains favourable for the re-establishment of indigenous transmission if the parasite is accidentally reintroduced from endemic countries.

Thanks to national and international cooperation, eradication is coming closer and dracunculiasis may well be the first parasitic disease to be eradicated.

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