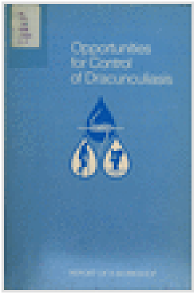

Opportunities for Control of Dracunculiasis: Report of a Workshop (1983)

Pages
76

Size
5 x 8

ISBN
030932646X

Board on Science and Technology for International Development; Office of International Affairs; National Research Council; World Health Organization

National Academy Press

The National Academy Press was created by the National Academy of Sciences to publish the reports issued by the Academy and by the National Academy of Engineering, the Institute of Medicine, and the National Research Council, all o [redacted] **d to the National Academy of Scienc** [redacted] **States.**

Opportunities for Control of Dracunculiasis

REPORT OF A WORKSHOP

Washington, D.C.
June 16-19, 1982

Sponsored by

Board on Science and Technology
for International Development
Office of International Affairs
National Research Council
United States of America

In collaboration with

World Health Organization
Geneva, Switzerland

NATIONAL ACADEMY PRESS
Washington, D.C. 1983

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This report has been prepared by the Board on Science and Technology for International Development, Office of International Affairs, National Research Council, for the Office of the Science Advisor, U.S. Agency for International Development, Washington, D.C., under Grant No. DAN-5538-G-SS-1023-00.

Copies available from:

Board on Science and Technology
for International Development
National Research Council
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Washington, D.C. 20418 USA

Order from
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Information Service,
Springfield, Va.
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Preface

Dracunculiasis, or guinea worm disease, is one of the oldest parasitic diseases known to man. It was described in the Old Testament (Numbers 21:6) as the fiery serpent that afflicted the Israelites in their wanderings around the Red Sea. From biblical times to the present day, dracunculiasis has been the cause of human suffering and an impediment to economic development in parts of Africa, India, and the Middle East. Until recently the disease has not been the subject of sustained research or control efforts. It has been neglected because it does not kill, but temporarily disables people in remote, rural areas. Dracunculiasis, like many other tropical diseases, is one of the "forgotten problems of forgotten people."

This report marks a change in that posture. It is the report of the first international meeting on dracunculiasis--a workshop sponsored by the National Research Council in collaboration with the World Health Organization (WHO). It contains the findings and recommendations of a distinguished group of scientists who were brought together to discuss dracunculiasis as an international health problem. Financial support from the Office of the Science Advisor, U.S. Agency for International Development, made the meeting possible.

Members of the steering committee and workshop participants hope that this material will stimulate government agencies in endemic countries to include dracunculiasis control in their national health agendas, primary health care efforts, and water supply and sanitation programs. International agencies also may wish to direct a portion of their health services, biomedical research, or water and sanitation resources toward the application of control technologies that are already known and toward the development of new scientific tools and methodologic approaches for attacking this disease.

All of the workshop participants and the chairman, in particular, are indebted to Karen N. Bell, professional associate, Board on Science and Technology for International Development, National Research Council, who coordinated the workshop and whose sustained effort, erudition, and organizational skills made this meeting possible.

Myron Schultz
Chairman

Introduction

International awareness of dracunculiasis has increased in the last few years as a result of the initiation of an eradication program in India (Rao et al. 1981) and the advent of the International Drinking Water Supply and Sanitation Decade (IDWSSD), whose steering committee endorsed the idea of using dracunculiasis control as an indicator of the Decade's impact on health in endemic regions. In May 1981, the World Health Assembly (WHA) adopted a resolution on the IDWSSD that mentioned dracunculiasis in the following context (WHA Resolution 34.25, May 22, 1981):

> The Decade presents an opportunity to eliminate dracunculiasis . . . as a public health problem in affected areas, where the prevalence of the disease could serve as a uniquely visible and measurable indicator of progress for the Decade.

In response to expressions of interest from international and domestic agencies, the National Research Council's Board on Science and Technology for International Development (BOSTID) decided to convene an international workshop on dracunculiasis. A new BOSTID advisory committee on health, biomedical research, and development organized a 4-day workshop on "Opportunities for Control of Dracunculiasis." This workshop was held June 16-19, 1982, in Washington, D.C.

Approximately 30 experts in parasitic diseases, vector biology, epidemiology, communicable disease control, health education, and sanitary engineering participated in the workshop. Participants included two WHO staff members from Geneva and one from the WHO regional office in Brazzaville, Congo Republic, a representative from the Organisation Centrale Contre les Grandes Endemies (OCCGE) based in the Ivory Coast, and nationals from Ghana, India, Nigeria, France, Togo, Great Britain, and the United States. Participants were asked to do the following:

- Review current knowledge of dracunculiasis—its epidemiology, surveillance, control, and economic impact

- Assess the economic, social, and administrative feasibility of mounting dracunculiasis control efforts in conjunction with primary health care and water and sanitation projects

- Review alternative methods of control, with special emphasis on their cost-effectiveness

- Identify basic, field, and operational research needed to develop, implement, and evaluate control activities.

The first day and a half of the workshop were devoted to presentations of original papers prepared by workshop participants on the clinical aspects and etiology of dracunculiasis, its global epidemiology, and possible strategies for control. These issues are discussed here in Overview of Dracunculiasis. The papers will be published separately (a list of the papers appears in the appendix).

Participants then divided into three working groups that focused on (1) problem assessment, (2) selection and implementation of surveillance and control strategies, and (3) monitoring and evaluation of control programs. Working papers were drafted by the groups and were presented for discussion in a plenary session. Recommendations were considered by all workshop participants. The workshop report was prepared by the staff under the guidance of the steering committee, drawing on the working papers (see Chapters 1-3) and the papers contributed by workshop participants. The reports of the working groups have been edited to eliminate duplication, but they accurately reflect the discussions of the three groups.

This report is intended for use by international agencies, government leaders, administrators, scientists, engineers, physicians, educators, and other health professionals who are responsible for projects and programs in countries where dracunculiasis is endemic. It suggests ways of gathering information about this disease, planning control efforts, and monitoring program effectiveness.

Overview of Dracunculiasis

Dracunculiasis is a parasitic infection caused by a long, stringlike, female worm--the nematode Dracunculus medinensis. Its larval form infects an intermediate crustacean host (Cyclops, a water flea) that commonly infests shallow ponds or step wells used as sources of human drinking water. Known to cause human suffering since ancient times, the infection was referred to by physicians as early as the Graeco-Roman era and by Arab physicians in medieval times. Common names include guinea worm and Medina worm. The worm was classified by Linnaeus in the eighteenth century. Fedchenko, a Russian naturalist, described the life cycle in 1869--the first time an invertebrate (arthropod) intermediate host was described for any parasitic disease of man.

Dracunculiasis belongs to a group of water-based diseases that includes malaria, onchocerciasis, and schistosomiasis. All of these diseases depend in some way on water as the natural habitat of an intermediate host. Unlike the others, however, dracunculiasis is transmitted only through drinking contaminated water and does not have any alternate pathways for infection. Thus, it is the only water-based disease that can be entirely prevented by protecting supplies of drinking water.

Dracunculiasis still represents a serious health risk for several millions of rural villagers in parts of Africa, the Middle East, and India. It affects only the rural poor who lack safe sources of drinking water for their households and places of work (agricultural plots). These people also often suffer from other parasites, trachoma, infant diarrheas, severe respiratory infections, and malnutrition, all of which are major health problems associated with poverty.

Unlike most communicable diseases in developing countries, the greatest morbidity from dracunculiasis occurs in adults. This may be the reason it has received less attention than those illnesses resulting in high morbidity and mortality in children. Because peak case rates often coincide with such agricultural activities as clearing land, planting, and harvesting, the disease is a major cause of agricultural work loss in many areas. Infected individuals are often crippled or disabled for many weeks each year from painful ulcers produced by the worms' emergence and complications resulting from secondary bacterial infections.

Public health authorities in endemic countries may be unaware of the annual incidence of dracunculiasis, because most patients do not attend clinics and therefore are not reported. The true burden of illness is seldom recognized, since almost no deaths occur as a result of the parasitic infection. However, reported numbers of cases and special epidemiologic studies have yielded rough estimates of the number of people at risk for acquiring dracunculiasis that range from 10-48 million throughout the world.

ETIOLOGY AND LIFE CYCLE

Guinea worms enter the human body when water containing cyclops infected with the third-stage *D. medinensis* larvae is swallowed. Cyclops are killed by gastric juices in the stomach, and the larvae are released. The larvae migrate quickly to the duodenal wall and proceed to the abdominal and thoracic cavities where they begin maturing in connective tissue. Male and female worms mate about 3 months after ingestion. The male worms die at 6 months of age and then become encysted, calcified, or are absorbed. The adult female worm, which measures about 70 cm long by 2 mm, lives in the connective tissues. At about 8 months female worms usually move down to the lower limbs, where the uterus containing first-stage larvae develops to fill nearly the entire adult worm.

Approximately 1 year after initial host infection, the worm is ready to emerge and to emit larvae. It migrates to the subcutaneous tissues and secretes a toxic substance that produces a painful blister. Infected people frequently try to relieve the burning sensation by immersing the affected part in water. Contact with water causes the worm's uterus to rupture and stimulates the worm to expel larvae into the water. The process is repeated intermittently over several weeks (see Figure 1).

Each female worm releases about a million microscopic first-stage larvae into the water. The larvae remain active for about 5 days in pond water or step wells, where they may be ingested by cyclops exceeding a certain minimum size. When water temperature is above 21°C, the larvae inside a cyclops undergo second-stage molting and develop into the infective third stage in about 14 days. First-stage larvae swallowed directly by humans do not undergo further development and are probably killed immediately by gastric juices. *Dracunculus* larvae do not reach the third stage unless they enter cyclops.

Cyclops containing third-stage larvae tend to sink to the bottom of a pond or step well, where they are more likely to be scooped up during the dry season, when water levels are low. People drawing drinking water from stagnant surface-water sources during the height of the transmission season are exposed to higher rates of infected cyclops (approximately 5 in 100 cyclops may be infected).

Although *Dracunculus* species are known to infect animals, the role of animal reservoir hosts in the transmission of *D. medinensis* to humans has not been clearly established. For example, raccoons and other wild carnivores in North America often harbor a parasite named

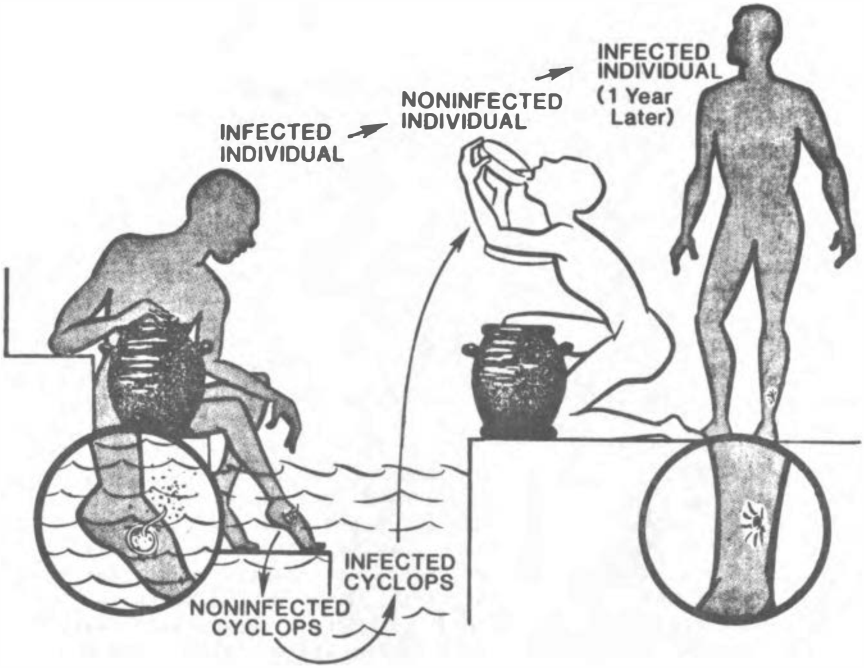

FIGURE 1 Life cycle of Dracunculus medinensis. (Source: Centers for Disease Control 1981)

D. insignis, which is not easily distinguished from D. medinensis. D. medinensis has also been used experimentally to infect monkeys and dogs. Even though there is no evidence to suggest that dracunculiasis is a zoonotic infection, and while the possibility of reintroduction of the parasite into unprotected human drinking water sources by possible reservoir hosts is very remote, it should not be entirely discounted.

CLINICAL SYMPTOMS AND TREATMENT

Infected people exhibit no signs or symptoms until the female worm matures and is ready to emerge. The first manifestation of dracunculiasis is localized swelling at the spot where the mature worm will emerge. In over 90 percent of cases, it emerges somewhere on the legs or feet, although worms may emerge from any part of the body. Intense burning or itching accompanies the swelling, which develops into a blister within 1 or 2 days. This blister ruptures several days later and becomes a superficial ulcer. Infected people often immerse the lesion in water in an effort to relieve discomfort. The worm's uterus expels larvae when the affected part is exposed to water, a process that may continue for several days to 3 weeks. Occasionally worms die before reaching the skin's surface and are absorbed, form aseptic abscesses, or become calcified, leaving cordlike masses.

Generalized nonspecific symptoms may accompany the appearance of Dracunculus at the skin, but they are usually not severe. Such symptoms may include diarrhea, vomiting, skin rashes, or asthma.

The tissues near the blister become swollen, red, and very tender, probably as part of a largely allergic reaction. There is usually a secondary infection, which commonly spreads from the initial skin lesion to deeper tissues and may be accompanied by severe or fatal septicemia. Infected ankle and knee joints can become contracted, leading to permanent crippling. Even in cases uncomplicated by secondary infection of the ulcer, the affected person may find it very difficult to walk and thus must give up his usual labors. On average, about 4-6 weeks elapse before an uncomplicated infection heals completely.

Less frequent are other severe conditions or death resulting from Dracunculus infection. These conditions include septic arthritis, tetanus, gangrene, pulmonary scarring, and ophthalmic disease.

A person may be infected by several guinea worms at the same time. Although each infection lasts a year, no effective immunity develops, and people at risk may be repeatedly infected year after year.

Because of its unusual manifestation, guinea worm disease is easily diagnosed once the worm is ready to emerge. Diagnostic tests to detect the presence of Dracunculus at earlier stages have not been developed for routine use. However, laboratory investigators have reported positive fluorescent antibody tests 6 months or more before emergence of the worm (Belcher 1981). Another nonspecific aid to diagnosis may be eosinophilia of 10-15 percent. In general, however, very little biomedical research on dracunculiasis has been carried out, thus making interpretation of findings reported in the literature quite difficult.

No drugs have proved effective in killing the adult worm prior to emergence, although some have shown experimental promise in reducing inflammation and facilitating extraction of the worm. Niridazole, metronidazole, thiabendazole, levamisole, bitoscanate, and mebendazole have been tested in humans within the last 7 years. Of these compounds, only thiabendazole is given as a short (2-day) course of treatment, which would make patient compliance more likely. One study reported that mebendazole (7-day course) resulted in significant symptomatic improvement. The action of niridazole appears to be largely one of reducing inflammation. For the most part, however, these drugs are expensive and may not be available locally. Large-scale controlled clinical trials have not been conducted, and the results of the smaller studies are difficult to interpret because of different patient selection methods, wide variation in criteria of efficacy, lack of control groups, and high drop-out rates.

FIGURE 2 Traditional method of extracting the worm by rolling it around a stick a few centimeters each day. (R. Muller)

The majority of infected people neither seek nor receive medical care from qualified physicians or nurses. Patients often consult healers or resort to the traditional technique of extracting the worm by rolling it a few centimeters each day around a stick or gauze (Figure 2). Infection often results if the worm breaks. Some physicians prescribe chemotherapy and make multiple incisions under local anesthesia to extract the emerging worm. Antibiotics may be given to treat secondary bacterial infections, and tetanus prophylaxis is strongly advocated.

EPIDEMIOLOGY

Adults between the ages of about 16 and 45 years are usually most heavily infected, although a considerable proportion of children over

5 years of age may also be affected. Young children and very old people are much less likely to acquire the disease, possibly because they do not drink as much from contaminated shallow ponds and wells near agricultural fields (Figure 3).

Because of its life cycle and the year-long incubation period, the transmission and clinical manifestations of dracunculiasis are highly seasonal. Transmission occurs only under certain climatic conditions and varies according to the local rainfall pattern. In very dry areas such as the Sahel of West Africa, transmission generally is limited to the few months during the rainy season when surface sources of drinking water become available and are used, with consequent infections becoming clinically apparent during the same period a year later. In other areas such as southern Nigeria, where rainfall is much more substantial and prolonged, the disease is most evident and is transmitted during the dry season, when surface water sources are much more scarce and

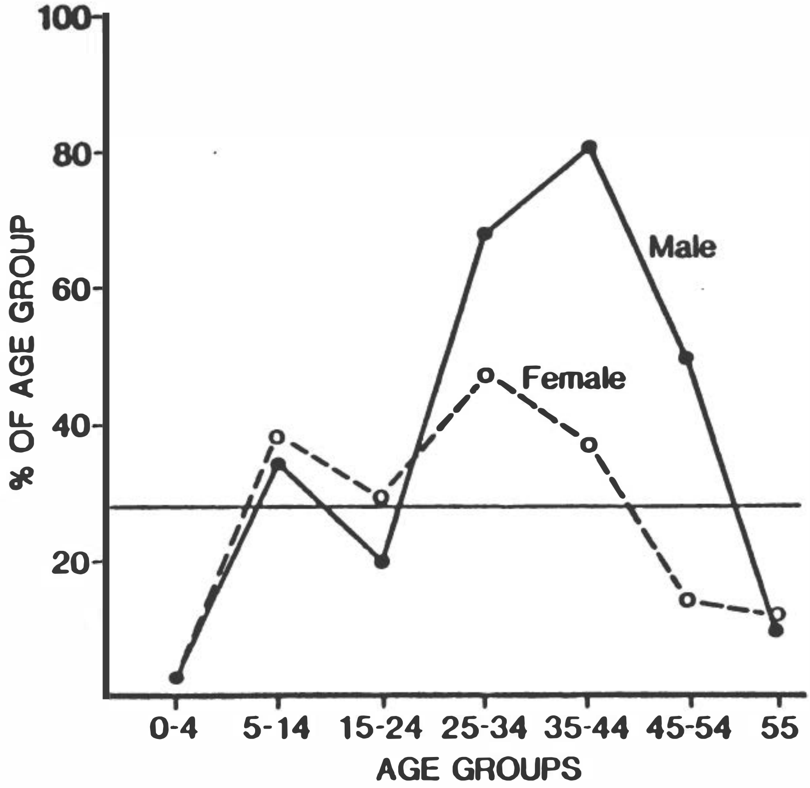

FIGURE 3 Age distribution of people affected by dracunculiasis. (Source: Belcher et al. 1975)

contain higher concentrations of cyclops (Figure 4). Severe droughts have been known to interrupt transmission for periods suffi- cient to cause the disease to decline or even disappear naturally. In areas where step wells and open cisterns are used, transmission periods tend to be longer due to the persistence of cyclops in larger numbers. Because of variable transmission seasonality, local case data is important in planning control activities.

Geographically, dracunculiasis occurs only in the Old World, mainly India and West Africa (Figure 5). In India the disease is limited to six states in the western part of the country; about half of the cases are reported from Rajasthan State (Figure 6). Transmission in Tamil Nadu State appears to have been interrupted recently by long-standing control measures (World Health Organization 1983). India is the only country that has actively searched for cases of dracunculiasis, and the numbers of cases reported from India are the most complete and reliable data available on the incidence of the disease (Table 1). The reported surveillance data from other countries give only an approximate indication of the most highly affected areas.

In West Africa, where probably less than 10 percent of cases are reported, the zone of highest endemicity includes Ivory Coast, Ghana, Togo, Benin, Nigeria, Mali, Niger, and Upper Volta. Questionnaire surveys are under way or have recently been conducted in Ghana, Nigeria, and Benin. Preliminary indications are that Oyo, Ondo, and Anambra may be the most severely affected of the 16 endemic states in Nigeria, while Cross River, Rivers, and Lagos states are apparently free from the disease. According to another preliminary report, an estimated 600,000 people are affected by dracunculiasis in Benin. Niamey, Niger, appears to include the only significant urban focus of the disease (over 3,000 cases reported in 1979). Migration of infected Moshi tribesmen and women to the forest zone in Ivory Coast is thought to have spread the disease in the latter area. The most highly affected areas of Upper Volta are Banfora, Dori, Koudougou, Ouagadougou, Ouahigouya, Yako, and Tenkodogo. In Ivory Coast, most cases were reported from Bouaké, Boufile, Dimbokro, Tiassalé, Bondoukou, and Séguéla. Tsévié, Notse, and Bassari appear to be the most highly affected administrative areas in Togo.

Provision of safe water supplies by drilling wells in the rural health sector of Dimbokro, Ivory Coast, is said to have recently reduced the prevalence of dracunculiasis there from 30 percent to approximately 1 percent. A similar reduction is reported from an area of Bendel State in Nigeria. In Mali it is reported that dracunculiasis disappeared from the village of Guirel (in northern Nara) after a drought dried up the local pond for 2 consecutive years.

Although the disease is known to be endemic in southern Sudan, that country is the only major affected area where no recent surveillance information is yet available. With the probable exception of southern Sudan, the infection appears to be limited to small parts of only a few countries in East Africa and the Middle East. In Pakistan in 1969, dracunculiasis reportedly was limited to two areas involving five districts in the north-central and extreme southeast regions of the country. In 1983 Iran informed the World Health

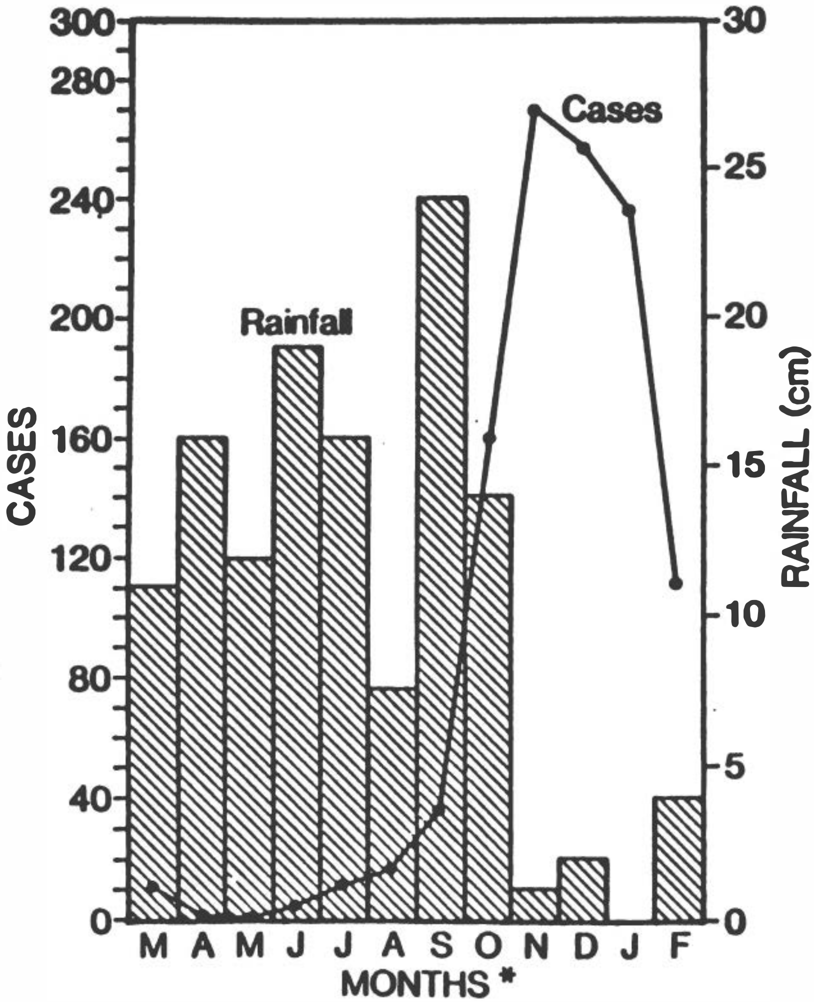

FIGURE 4 The impact of dracunculiasis on a community in southern Nigeria. Transmission is greatest during the dry season when surface water sources are scarce and contain higher concentrations of cyclops. (Source: Kale 1977)

FIGURE 5 Areas in which dracunculiasis is reported or probably exists. (Source: World Health Organization 1982)

Organization that there had been no dracunculiasis in the country for the past 5 years, despite continued surveillance.

Although the disease is easily diagnosed, and thus recognition of the problem is relatively simple, surveillance of dracunculiasis, paradoxically, is exceptionally poor. The lack of ongoing case information is due in part to the remote rural nature of affected populations, their limited attendance at government clinics, and the low government priority accorded to dracunculiasis. This situation could continue since the absence of a specific curative or preventive drug or vaccine removes a treatment incentive for villagers to visit health centers where their infection might be diagnosed and officially reported. In most endemic zones, less than 5 percent of cases are reported. Millions of cases are thought to occur annually

FIGURE 6 Dracunculiasis endemicity in India (June 1982). About half of the cases are reported from Rajasthan State. (Source: World Health Organization 1983)

TABLE 1 Reported Cases of Dracunculiasis in India (up to June 1982)

State	Number of Cases
Rajasthan	14,905
Karnataka	4,211
Maharashtra	3,776*
Madhya Pradesh	3,542*
Andhra Pradesh	3,049
Gujarat	423
Tamil Nadu	0
Goa	n.a.
Total	29,906

NOTE: These figures represent an estimated 10-50 percent of cases detected by field visits, except for complete coverage in Tamil Nadu.

*Provisional figures from Dr. C.K. Rao, National Institute of Communicable Diseases, 22-Sham Nath Marg, Delhi 110054, India.

SOURCE: World Health Organization 1983.

worldwide, but systematic epidemiologic surveillance is needed to produce a reliable estimate of the annual global incidence.

SOCIAL AND ECONOMIC EFFECTS

Dracunculiasis primarily affects families of subsistence farmers, with peak transmission often coinciding with heavy demands for agricultural labor. Because the worm's incubation period is approximately 1 year, farmers and their families tend to suffer the greatest number of cases during the same season each year.

Data from village studies in West Africa and India show dracunculiasis attack rates ranging from 10-40 percent or more in a single season. Some families are affected more heavily than others, with virtually all the victims incapacitated at the same time, each with one or more emerging worms. Approximately 40 percent of dracunculiasis victims are completely disabled for periods lasting 1-3 months. Villages affected by the disease experience significant losses in agricultural productivity. Families with high rates of infection may suffer during the remainder of the year from lost agricultural earnings, inadequate food supplies for home consumption, and many missed days of school. Responsibilities for working in the fields may have to be given to other members of the family, often to the detriment of adequate child care. The psychological stress of worms emerging from the leg, chest, or even genitals can also be considerable.

The adverse impact of this disease on school attendance was recently documented in Anambra State of Nigeria. In a 1979 study, Nwosu and colleagues (1982) found that the mean percentage of absenteeism attributed to dracunculiasis in 13 schools increased from an average of 13.2 ± 4.6 percent to a peak of 60 percent at the height of the guinea worm season. Two schools were virtually closed for 2 weeks (Figure 7).

Unlike many other infectious diseases in developing countries that carry high mortality rates, the impact of dracunculiasis on public health is a function of length of disability, severity of illness, village attack rates, and its seasonality (Belcher et al. 1975, Kale 1977). These indicators can be related to days of work lost among the most productive age groups within the population, along with nutritional or income deficits suffered by affected families.

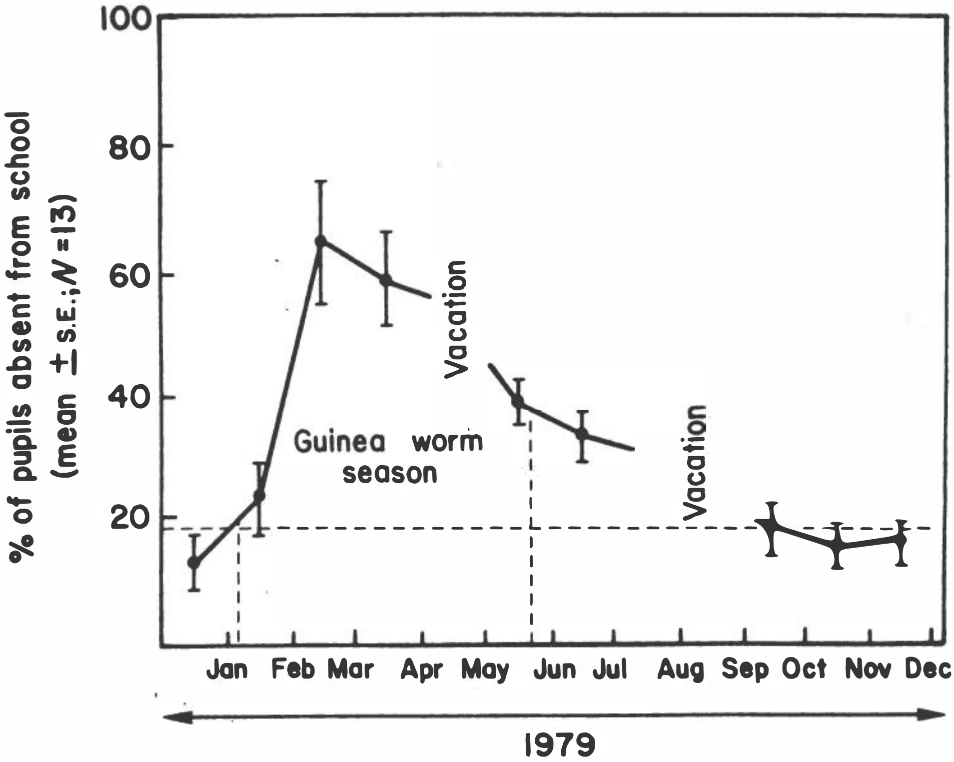

FIGURE 7 Impact of dracunculiasis on school attendance in Anambra State, Nigeria. (Source: Nwosu et al. 1982, Liverpool School of Tropical Medicine)

CONTROL MEASURES

Dracunculiasis transmission is considered to be "water-based," that is, dependent on direct contact with water. The cycle of transmission requires that (1) infected individuals immerse the mature emerging worm in water used for drinking, (2) suitable cyclops species are present in that water source under optimal conditions, and (3) someone drinks water containing cyclops infected with mature Dracunculus larvae. Any break in this chain of events will interrupt transmission of dracunculiasis.

Effective personal protective or prophylactic measures that may be used include boiling the drinking water or straining it through a cloth to remove cyclops. The utility of these measures for a large-scale attack on the problem is somewhat diminished by their dependence on intensive educational efforts and by their inconvenience or cost (e.g., farmers quenching thirst in fields, firewood needed for boiling water). Health education, including community organization, might also be employed to encourage residents of affected villages to prevent people suffering from the disease from entering, and thereby contaminating, sources of drinking water.

Effective control measures include the periodic chemical treatment of water used for drinking in affected villages to kill cyclops. Temephos (Abate) is the insecticide most commonly used for this purpose. At concentrations of 1 part per million in stagnant surface sources of drinking water, temephos kills cyclops; is harmless to vegetation and fish; is tasteless, colorless, and odorless in drinking water; and has a wide margin of safety for ingestion by humans. Moreover, the compound has been used extensively in West Africa to control the blackfly vector of onchocerciasis.

Thus far, however, the most effective means of preventing dracunculiasis has been to provide safe water supplies. Such protected water sources prevent contamination of the drinking water by larvae from infected people, thereby breaking the chain of transmission. Provision of safe water via piped sources and protected bore and tube wells, along with the destruction or conversion of contaminated step wells, successfully eliminated dracunculiasis from large areas in the southern part of the Soviet Union in the 1920s and 1930s. In Nigeria, construction of piped water for a town of 30,000 people in the 1960s reduced the incidence of dracunculiasis from over 60 percent to zero within 2 years. In several other instances, dracunculiasis has been eliminated or drastically reduced as a side benefit of efforts to bring safe drinking water to rural populations who happen to suffer from the disease.

The current International Drinking Water Supply and Sanitation Decade offers a unique opportunity for an attack on dracunculiasis. In the context of the Decade, the provision of safe drinking water is intended for all by 1990. Hence, there is no need to justify providing safe drinking water solely as a means of eliminating dracunculiasis, only to encourage endemic countries to consider this disease when assigning relative priorities to areas where elimination of the disease would occur in addition to other benefits. Indeed, the number of villages in which dracunculiasis is endemic is estimated to be less than 10 percent of all villages targeted to receive safe drinking water during the Decade.

Recommendations

Workshop participants discussed various methods for assessing the problem, possible intervention strategies, several options for monitoring and evaluation of programs, and suggested priority areas for research related to dracunculiasis. The results of these discussions are included in this report to help authorities in countries where dracunculiasis is endemic to determine which control measures may be most appropriate.

Many other water-related diseases affect large numbers of people in countries where dracunculiasis is endemic, and program efforts targeted solely on this one problem may appear difficult to justify. However, taking humane and practical considerations into account, dracunculiasis is exceedingly painful, is easily diagnosed, and effective methods for controlling it are already known. Moreover, the International Drinking Water Supply and Sanitation Decade (1981-1990) presents an unprecedented, transient opportunity to reduce the incidence of this disease everywhere it occurs. The obvious next step is for endemic countries to start implementing control activities suited to their needs and resources immediately, and for international and bilateral agencies to assist them, if requested.

Many of the recommendations that follow are intended to apply to those situations in which water supply improvements are not imminent, thereby warranting initiation of control efforts targeted solely on dracunculiasis. The additional costs of such efforts are easily justified in these special circumstances, given the high likelihood of eliminating the infection from a given area within 2-4 years, and the possibility of assigning control activities to existing national and state programs. By comparison, maternal and child health care services, water supply and sanitation systems, and many communicable disease control programs will have recurring costs for many years to come.

Workshop participants were reluctant to make estimates of costs for each type of control activity because there is so little experience from which to generalize. They agreed that it would be important for national authorities and assistance organizations to design and carry out pilot projects so that costs can be carefully monitored. Control activities should be integrated into existing programs (e.g., immunization, agricultural extension services) whenever possible to reduce fuel, salary, and transportation costs.

FOR GOVERNMENT AUTHORITIES IN ENDEMIC COUNTRIES

- It is recommended that public health authorities in all countries with any reported (or suspected) cases of dracunculiasis assess the extent of the dracunculiasis problem at the national level. Such an assessment can be based on analysis of reported cases and/or responses to a questionnaire sent to district or provincial health officers and to other appropriate officials in the country.

- In each endemic country, appropriate steps should be taken to facilitate the reporting of cases of dracunculiasis.

- Each endemic country should select strategies for controlling dracunculiasis and should prepare a written plan of action that includes a pilot-project phase and a training component. The plan of action should specify the collaborative roles of health, water, education, administrative, agriculture, and finance sectors, where appropriate, in implementing the program. The ministry of health should probably be responsible for identifying endemic regions and villages within regions and for making that information known to water works authorities and other relevant agencies. Water works authorities should give priority to dracunculiasis-affected areas wherever feasible.

- Endemic countries should take maximum advantage of resources mobilized for the International Drinking Water Supply and Sanitation Decade to provide dracunculiasis-endemic villages with protected water sources on a priority basis. When all endemic villages have been identified, the proportion of those that can be provided safe drinking water as a part of already planned activities should be determined, after which other national or international resources should be sought to support provision of safe water to the remaining endemic villages and to support other program activities designed to reduce the incidence of dracunculiasis. Relevant donor activities should be coordinated systematically within a countrywide plan.

- Control efforts should include health education of people living in endemic areas. The goal of these efforts is to mobilize members of affected communities to act against dracunculiasis, including local efforts for improving and maintaining water supplies, preventing people with patent dracunculiasis from contaminating water sources, adopting personal protective measures, reporting cases, and cooperating with other aspects of the program.

- A standardized treatment protocol should be developed for health clinic personnel, specifying the appropriate care for patent dracunculiasis cases and emphasizing that preventive measures should receive first priority. Because of its rural distribution, dracunculiasis patients are likely to make initial contact with the primary health care system.

- The school system of affected countries should help extend the program throughout the country by reporting cases and disseminating information about personal protective measures. Some endemic countries may wish to encourage university researchers to address applied research issues identified during the national control program.

- Endemic countries may wish to designate the elimination of dracunculiasis as a national goal. Progress can be monitored and achieved through effective control efforts in affected villages, leading to elimination of the disease at the village, provincial, and district, and then national, levels.

- It is recommended that priority be given to applied research in the following areas:

  -- Development and evaluation of prototype health education materials for use in affected communities
  -- Development and standardization of field methods for species identification and quantification of cyclops vectors and D. medinensis larvae
  -- Comparison of the efficacy and cost of different intervention methods
  -- Evaluation of techniques for analysis of patterns of community water use.

- It is recommended that priority be given to biomedical research in the following areas:

  -- Development of therapeutic (e.g., chemotherapy) or preventive (e.g., chemoprophylaxis) measures that either are capable of destroying or sterilizing female D. medinensis worms to prevent subsequent patency and/or release of viable larvae or are capable of destroying early stages of the worms soon after infection. Controlled clinical trials of antihelminthic drugs to find one that will kill D. medinensis larvae before the worms mature and emerge, with no harm to the human host, should be strongly encouraged.
  -- Ecologic studies of conditions in surface waters favorable or unfavorable to infestation of cyclops, should be conducted.

FOR INTERNATIONAL OR BILATERAL ASSISTANCE AGENCIES

- It is recommended that international and bilateral assistance agencies encourage endemic countries to give priority support to villages with dracunculiasis as part of national and regional potable water plans.

- International and bilateral agencies should review rural development projects under way or planned in countries with endemic dracunculiasis for opportunities to incorporate or initiate specific activities designed to control the infection, especially in those instances where agriculture, health, and education programs would not reduce the incidence of dracunculiasis.

- International agencies should undertake themselves, or should coordinate programs and funding, to:

  -- Make consultants available to countries that wish to assess their national dracunculiasis problem, establish surveillance systems, or carry out control activities. Such consultants might include specialists in epidemiology, vector biology, health education, parasitology, or rural water supplies and sanitation.
  -- Fund research and operational studies pertinent to control of dracunculiasis, especially in association with water development projects.
  -- Help document the impact on the disease of projects that already provide safe drinking water to populations in dracunculiasis-endemic areas and obtain reliable estimates of program costs associated with various types of control strategies.
  -- Publish and publicize training manuals and guides for dracunculiasis control programs in languages appropriate for major endemic regions of the world.
  -- Monitor progress in eliminating dracunculiasis from endemic areas.
  -- Promote and assess technical or scientific breakthroughs pertinent to control of dracunculiasis.
  -- Supply temephos or other recommended pesticides to national control programs at reasonable cost.
  -- Sponsor demonstration projects in several endemic regions with different climatic and cultural conditions.
  -- Sponsor annual or biannual meetings of a small group of international experts to review the status of global anti-dracunculiasis efforts and to make further recommendations for future efforts. The site for such meetings might rotate among the major endemic areas of India and West Africa, and perhaps WHO headquarters in Geneva.

WORKING PAPERS

1
Problem Assessment and Data Collection

Baseline epidemiologic and water use information is required to plan control programs, to determine the time of the year when educational activities and water treatment will be most effective, and to assist in selecting sites for installation of protected water supplies. Although data collection and surveillance are discussed here solely in terms of dracunculiasis, the methods outlined could certainly be incorporated into existing disease control or surveillance activities or could be used to assess the extent of other water-related health problems.

Public health authorities in countries where dracunculiasis occurs will want to assess the extent of the problem at the national level before initiating control activities or surveillance. This section is intended to (1) establish guidelines and definitions for data collection and analysis relevant to dracunculiasis, (2) to suggest practical approaches for conducting an initial assessment of the dracunculiasis problem at the national level, and (3) for those districts or villages where dracunculiasis is occurring, to describe various methods of collecting epidemiologic information about cases and organizing these activities into a surveillance system.

DEFINITIONS

Despite the relative simplicity of the life cycle and epidemiology of *Dracunculus medinensis*, some traditional terms need to be defined more precisely to promote communication and enhance the comparability of data over time and among different areas. The definitions that follow are based on current parasitologic and epidemiologic knowledge of the disease. As future research and experience adds to the understanding of dracunculiasis, these definitions may need revision. (Names and parts of the definitions in brackets indicate synonyms or optional inclusions.)

Active case A person in whom an investigator, health worker, or other trained person sees the *Dracunculus medinensis* worm beneath or extending from the skin. Also, a person with an acute skin lesion from which the larvae of *D. medinensis* have been identified by a trained person using microscopy or other means.

Presumptive case [Retrospective or historical case] A person who reports having experienced the emergence of one or more *D. medinensis* worms within the past 2 years.

Prepatent case A person who has been infected with dracunculiasis or who has ingested infective larvae but who has not yet manifested clinical symptoms or signs of the disease such as blistering, ulceration, and worm emergence. There is no specific diagnostic test to identify such cases at present.

Affected community A local administrative or social unit (e.g., village, hamlet, town, city) in which indigenous active or presumptive cases of dracunculiasis, or both, have been reported during the previous 2 years.

Incubation period The period of time between ingestion of infective *D. medinensis* larvae by a person and the onset of clinical symptoms.

Peak patency period [French: périod de mise en évidence communitaire] Period of the year during which more than 50 percent of all cases (in a community or defined geographic area) are reported. This definition applies to areas where incidence is seasonal.

Individual patency period [French: périod de mise en évidence individuel] The interval in an individual case between the time of first parasitologic evidence of the worm beneath or extending from the skin (or onset of typical skin blister from which a worm will soon emerge) and the time of complete expulsion or extraction of the worm from the body.

Unprotected water source Source of drinking water that contains *Cyclops* and that either allows partial or total immersion of an infected person in the water source or permits water runoff to enter. Such sources are also likely to contain unacceptable levels of microbiological contaminants.

Protected water source Source of drinking water that prohibits the partial or total immersion of an active guinea worm case and contamination from ground runoff. Such sources are usually constructed so as to remain free from fecal pollution.

Infested water source Source of drinking water containing *Cyclops* species capable of ingesting first-stage larvae (L_1) of *D. medinensis*.

Infective water source Source of drinking water containing *Cyclops* infected with third-stage larvae (L_3) of *D. medinensis*.

Surveillance The continuing collection, analysis, and feedback of epidemiologic data based on reporting or detection of cases of disease.

Passive case reporting Recording of cases that voluntarily come to the attention of public health authorities. Passive reporting or surveillance is achieved through the establishment of routine reporting mechanisms and is useful for obtaining initial data on the distribution of dracunculiasis in an area.

Active case detection Search for cases by representatives of the health system through a village-to-village or house-to-house survey or a sample of the population thought to be at risk. This method usually reveals more cases than does passive reporting.

Incidence The rate of appearance of new cases in a defined population within a specified period of time, usually 1 year.

Prevalence The proportion of a given population showing patent dracunculiasis infection at a given point in time. Prevalence data may be of little use with regard to dracunculiasis because the period of patency is usually short and seasonal. Therefore, information collected during low transmission periods can be misleading. Prevalence should be measured at the period of peak patency.

Control Reduction of disease incidence in a defined area over a period of 24 months through planned activities.

Elimination Complete absence of new indigenous cases of patent dracunculiasis infection in a previously defined endemic area for a period of at least 24 months given the presence of an active surveillance system, including at least two annual village-to-village checks.

Eradication Global elimination of human dracunculiasis infection.

INITIAL ASSESSMENT

Public health authorities in countries with reported cases of dracunculiasis should be able to identify endemic regions, provinces, and some affected communities using existing information. Although data from secondary sources may reflect less than 10 percent of actual cases, they indicate the approximate areas of endemicity, geographic distribution, and peak transmission seasons for dracunculiasis. Possible sources of information regarding incidence and distribution of dracunculiasis within a given country include:

- Communicable disease surveillance records for preceding 20 years
- National communicable disease specialists
- National medical and scientific literature
- International medical literature (write to International Health Program Office, U.S. Centers for Disease Control, Atlanta, Georgia, 30333, USA)

- Meteorologic records for preceding 20 years
- Water and sanitation records from communities with protected or potentially infective water sources
- Mass media (print)
- Hospital and outpatient clinic records.

Information from secondary sources can be supplemented by responses to questionnaires prepared by national public health authorities responsible for communicable disease control and sent to state and district health officials (World Health Organization 1983). Information that can be derived from questionnaire responses might include:

- Number, name, and location of villages with new cases of dracunculiasis within the preceding 24-month period
- Peak transmission season for dracunculiasis
- Estimated annual incidence of dracunculiasis (i.e., new cases in an estimated residential population)
- Names of health workers or physicians in affected villages.

Relevant portions of the questionnaire should be filled out by or in consultation with the official in charge of water and sanitation for that state or district. Better response rates will be obtained if the questionnaire is announced and discussed at a health officers' meeting or is followed up shortly with telephone calls or personal visits. The questionnaire might best be distributed in the month following the suspected peak transmission season. A sample questionnaire and cover letter used by the National Institute of Communicable Diseases in India appear in Figure 8.

This initial assessment will allow national health authorities to determine if and where dracunculiasis is endemic, to identify geographic areas requiring more aggressive data collection, and to determine an appropriate course of action (see Table 2).

SURVEILLANCE

Countries in which a dracunculiasis control program is being planned or has already been started at the regional or national level should establish a surveillance system. The main objectives of a dracunculiasis surveillance system should be to identify affected villages and to determine the number of people affected by the disease. A surveillance system can be either passive or active. The type of system selected should depend on (1) available resources, (2) estimated extent of the disease, and (3) existing mechanisms for case reporting.

Passive surveillance uses existing reports of disease from health authorities, published and unpublished studies, and other data already available from local, national, and international sources. Medical authorities may be queried by questionnaire. The major disadvantage of a passive surveillance system is that an overwhelming majority of the cases will not be reported. In a study conducted in Togo in 1977, less

TABLE 2 Possible Courses of Action Based on National Problem Assessment

Information from National Problem Assessment	Suggested Action
Dracunculiasis reported to have occurred in only several areas more than 2 years ago	Continue to review passive case reports and search actively for cases in small sample of villages within suspected areas.
Dracunculiasis reported in several contiguous provinces	Initiate regional surveillance and control activities.
Dracunculiasis reported from provinces representing 50 percent or more of national territory	Initiate national surveillance and begin control activities in known affected areas.

than 4 percent of dracunculiasis cases had been reported. Another study in Rajasthan, India, in 1978-1979, found that none of the 985 patients identified as active cases in the study had visited a health center (Johnson and Joshi 1982). Careful study of passive surveillance data can provide a basis for tentative judgments about which regions in a country are affected and which of those are likely to be most heavily affected. If a serious effort to control or eliminate the disease is planned or contemplated, however, some form of active surveillance will be required.

Active surveillance methods are employed to seek information about affected individuals and villages that is not reported. Aggressively applied, such a system can detect virtually every affected village and patent case. It does, however, require mobilization of numerous health and other workers and volunteers, rigorous supervision to ensure reliable results, and high investments of time and money. Techniques include stimulation of the routine reporting system by means of an information campaign to increase reporting of the disease by medical authorities and by the public; use of "sentinel" sites such as schools, markets, and selected outpatient departments of clinics to inquire about cases in their catchment areas; and an active village-to-village or house-to-house search for cases.

Recognition cards or color photographs of patients with typical signs of dracunculiasis infection might be used to enhance diagnostic accuracy in areas where the disease is newly introduced or occurs infrequently. This technique was used in the successful smallpox eradication program. Dracunculiasis, however, is more distinct than smallpox and is well recognized by most villagers in highly endemic areas, so the value of such recognition cards--as indicators of an "official" inquiry or as true aids to diagnosis where the disease is not well known--remains to be determined.

State____________________ District____________________

1. Is the disease reported from any part of the district? If yes*:

(a)

Name of affected block	Population of affected block	Number of villages affected	Population of affected villages	Cases in: 1978	1977

(b) Year of first report of the disease in the district and the source of information:

(c) Nature of source of drinking water in the affected blocks or villages: tanks/step wells/draw wells

2. Organized control measures undertaken against guinea worm disease (if no organized measures taken, please say so)

Name of affected blocks	Year of commencement	Nature of measures

*If information is not available, please leave the column blank.

Date____________ Name of the District Medical and Health Officer/Chief Medical Officer

____

Send to: Dr. C. K. Rao
Deputy Director
National Institute of Communicable Diseases
22-Sham Nath Marg, Delhi, 110054, India.

Copy to: Director of Health Services of the States

FIGURE 8 Sample questionnaire and cover letter to be prepared by national public health authorities and sent to state and district health officials.

SAMPLE COVER LETTER

No. 10-32/79-NICD (PRC)
Government of India
Directorate General of Health Services,
Nirman Bhawan, New Delhi
Dated the 24th October, 1979

To: Directors of Medical and
Health Services of all States and
Union Territories

Subject: Guinea Worm Disease: Delimitation of Endemic Areas in the Country

Sir:

It is proposed to define the extent of the present problem of guinea worm disease in different states of the country in order to consider control measures at the national level. Requisite number of the questionnaire prepared for the purpose are enclosed herewith. It is requested that one copy be sent to the Senior Medical Officers in charge of each district with a request to transmit the duly completed questionnaire to Dr. C. K. Rao, Deputy Director, National Institute of Communicable Diseases, 22-Sham Nath Marg, Delhi-110054 who has been asked to prepare a report for the country. They may please be directed to send NIL reports also.

Kindly acknowledge the receipt of this letter.

Yours faithfully,

(B. Sankaran)
Director General of
Health Services

FIGURE 8 Continued.

To ensure comparable and consistent reporting, investigators should distinguish between an active dracunculiasis case (one in which the investigator or other trained inquirer actually sees the adult guinea worm beneath or extending from the skin), and a presumptive case (in which the past emergence of a worm is reported, with compatible scar(s) or ulcer(s)).

Active searches for cases have recently been employed quite effectively in the Indian Guinea Worm Eradication Program. A questionnaire circulated to responsible health officers in that country in October 1979 (see Figure 8) yielded reports of 1.8 million people in 728 villages at risk of the disease; however, active searches conducted in January-February 1981, and in September-October 1981, revealed 5.9 million persons in 7,533 villages, and 12.2 million persons in 10,582 villages to be at risk, respectively. Thus it is likely that an apparent increase in cases will follow an active search for cases.

The surveillance system should collect no more detailed information than the control efforts require at each stage in the program. In some situations it may be sufficient simply to identify the villages where dracunculiasis occurs, without regard to the number of cases. In other situations, and especially as incidence of the disease reaches "low" levels, it will be necessary to enumerate all affected patients and eventually to identify every case by name.

COLLECTION OF BASELINE INFORMATION

Household Surveys

Before initiation of control activities, responsible public health authorities should collect baseline information from households in a small representative sample of villages during the peak transmission season. These data are essential for subsequent evaluation of a control program. A household sample survey might include the following categories of data:

- Basic epidemiologic indicators (e.g., incidence rates, geographic distribution, size of population, and age groups affected) must be established for endemic districts and communities through active inquiries.

- The location, type, and use of infective water sources must be determined through visits to affected communities and inspection of suspected sites.

- Health beliefs, knowledge, and practices regarding dracunculiasis and water used for drinking must be ascertained for each identifiable ethnic or cultural group affected, including village leaders and women and children.

A sample household survey questionnaire that incorporates some aspects of each of these information categories is shown in Figure 9. At a minimum, a reasonably reliable estimate of the annual incidence of dracunculiasis and the size of the population at risk or number of affected villages, or both, should be obtained before control measures are undertaken, to provide a basis for comparison later.

Recommended and optional data that should be collected as part of surveillance and control activities are outlined in Table 3.

Special Studies

More detailed baseline data can be obtained by conducting special studies in affected communities. University students might be enlisted to conduct observational studies, collect water samples, and prepare maps and charts of sources of drinking water. These special studies should be planned and coordinated with other data-gathering activities. Possible topics for such studies are shown in Table 4.

Other activities that may be initiated as part of surveillance include:

- Development of a practical field manual(s) for programs of surveillance, control, and elimination of D. medinensis, for example, the India program manual (National Institute of Communicable Diseases 1982)

- Development and evaluation of training materials and methods for carrying out control programs.

TABLE 3 Recommended and Optional Data Collection for *D. medinensis* Surveillance and Control

Origin of Inquiry	Recommended [R] and Optional [O] Data	Suggested Methods
Capital city, regional center	Presence or absence of *D. medinensis* [R] Location of *D. medinensis*, by region or district [R] Patency period [O]	Review published medical and scientific literature Review national surveillance data, if any Canvass health professionals, administrators, teachers (mailed questionnaires, interviews) Review health facility registers and patient records
	Inventory of protected water source [O]	Review of water supply installation records, including operational status
	Rainfall/climatic information, by region [O]	Review meteorologic records
Small administrative subdivision (district, town, health center)	Presence or absence of *D. medinensis* [R] Location of affected and infected communities [R] Community patency periods [O] Number of active and presumptive cases, by community [O] Inventory of drinking water sources, by community [O]	Review local surveillance data, if any Canvass health workers, teachers, administrators, political leaders, respected elders (mailed questionnaires, interviews) Review health facility registers and patient records Village interview search (all villages or representative sample)
	Population data, by community [O]	Use census data from national or regional level

TABLE 3 Continued.

Origin of Inquiry	Recommended [R] and Optional [O] Data	Suggested Methods
Community	Number of active and presumptive cases, and non-cases, by household [R] Age and sex of cases and non-cases, by household [R] Inventory and mapping of drinking water sources [O] Water sources used by cases and households [O]	Household interview survey of all or a representative sample of households in a community Other surveys of schools, places of work
	Vector studies [O]	Sampling of water sources for identification and quantification of cyclops population and *D. medinensis* larvae
	Water-related practices [O]	Observations of water collection, bathing, swimming, wading, etc.
	Disability of cases [O] Impact on economic productivity [O]	Household interview survey of all or a representative sample of households in a community Surveys of agriculture, employment, or production

NOTE: Sets of recommended and optional data are arranged in approximate rank order of usefulness. For each group of data items, a series of methods that may be used to collect that information is suggested. These methods are arranged in approximate order of increasing complexity and resource requirements.

Instructions: Use this questionnaire for one adult member of the household. Ask the respondent to answer first for him/herself, then for each of the other members of the household.

________District ____________State/Province Village__________

Name of head of household ____________________ Date ___/___/___

1. How many people are there in your household? __________

2. How long has your household lived in this village? (years) __________

3. Where do you obtain water for drinking during the rainy season? __________

   During the dry season? __________

4. Have you heard of a disease called (use local term) dracunculiasis?
   1-yes 2-no 3-uncertain __________

   If no or uncertain, show recognition pictures and describe. Then ask: Do you know about this disease?"
   1-yes 2-no 3-uncertain __________

5. Have you or anyone in your household had it during this past year?
   1-yes 2-no 3-uncertain __________

   IF ANSWER TO QUESTION 5 IS NO, STOP INTERVIEW HERE AND THANK RESPONDENT:

   IF ANSWER TO QUESTION 5 IS YES, ASK:

6. Please tell me the following information about anyone ill with (use local term) dracunculiasis:

	NAME	SEX/AGE (years)	Month when disease began?
a)		/	
b)		/	
c)		/	
d)		/	
e)		/	

CLOSE INTERVIEW AND THANK RESPONDENT FOR HIS/HER HELP!

FIGURE 9 Sample questionnaire for household survey.

TABLE 4 Topics and Methodology for Conduct of Special Studies

Topic	Method
Vector studies	Sampling of water sources for identification and quantification of cyclops populations and *D. medinensis* larvae
Water-use practices related to dracunculiasis	Observations of water collection, bathing, laundering, swimming, wading, etc.
Knowledge of disability, prevention, and treatment of dracunculiasis and attitudes toward the disease	Household interview survey of all households--or a representative sample of households--in a community
Impact on economic production	Surveys of agriculture, employment, cooperatives, or production
Impact on school attendance	Review of attendance records at local school(s)

2
Control Strategies

Control of dracunculiasis is clearly desirable even though the disease is rarely fatal. Control efforts must be considered in terms of the societal burden of illness and disability attributable to the infection, length of time control efforts would be required, their likelihood of success, and the net additional investment needed to carry them out.

This chapter discusses alternative approaches for reducing dracunculiasis incidence in endemic villages. Much of the text is devoted to activities other than provision and improvement of water supply systems, because workshop participants recognized that numerous reports and manuals dealing with general issues of rural water supply are being produced elsewhere. Activities directed solely at dracunculiasis can easily be justified in areas where protected water supplies will not be available or adequately supplied to populations at risk for some time. Comparisons of costs estimated for each type of control activity proved exceedingly difficult to make, because in most cases these efforts should be organized (albeit with centralized coordination) as temporary missions assigned to agencies already responsible for multipurpose programs.

Careful studies of the costs to society of the disease have not been prepared, but available literature suggests a global loss of marketable goods of between $300 million and $1 billion a year. The values attached to suffering, loss of household production, and reduced educational opportunities have not been assessed at all but probably approach those attributed to marketable goods. If these rough calculations are correct, the benefits of disease control would be at least U.S. $500 million a year. According to estimates prepared by Fredrick Golladay, a workshop participant, at present interest rates, a successful program to eradicate the disease globally would justify an investment of at least $6 billion or, alternatively, about $150 per person at risk.[1]

Public health authorities in countries or regions where dracunculiasis is endemic will be able to plan continuing surveillance and control strategies once data gathered during the problem assessment phase have been analyzed. The surveillance system and control activities adopted will depend on available resources and willingness of other public agencies to share costs and personnel. The scope of such activities could include conducting periodic surveys, giving priority for safe water supply to endemic villages, and establishing an ongoing case reporting system and mounting a multi-approach elimination program.

A dracunculiasis control strategy might consist of any one or a combination of the following approaches: (1) provision of protected sources of drinking water, (2) health education of the population at risk, (3) vector control of cyclops, and (4) treatment of victims of the disease. Training of control workers would be needed for any strategy. Figure 10 illustrates the points of intervention in the *Dracunculus* life cycle that correspond to control approaches. A surveillance system provides the epidemiologic feedback needed to direct program resources toward areas most in need and to measure progress in achieving program objectives. Manpower and supplies may come from many different sources, but they should be coordinated by one central office.

Quantifiable national program objectives should be established and tailored to specific conditions in local endemic areas. These objectives should be set by an interministerial policy group, including representatives of health, water, education, agriculture, planning, and finance sectors. Such quantifiable objectives should include measures for *process* (changes in levels of training, educational activities, distribution of pesticide, rates or priorities in providing safe water, etc.), *impact* (changes in levels of knowledge, beliefs, practices, and cyclops populations), and *outcome* (changes in disease incidence, prevalence or disability rates), and should specify the time period in which change is expected to occur.

Workshop participants believe that the goal of elimination of dracunculiasis is feasible at the national level. Sustained control activities applied to specified endemic areas, together with surveillance, should result in the documented disappearance of the disease within several years.

The remainder of this section discusses the advantages and disadvantages of each potential intervention and suggests ways of organizing each.

PROVISION OF SOURCES OF SAFE DRINKING WATER

The most effective means of eliminating dracunculiasis is to provide sources of safe drinking water, i.e., sources that are free of infected cyclops. The presence of dracunculiasis indicates that a community is using unprotected surface water supplies or step wells as primary sources of drinking water--sources that are probably also used for washing and bathing. The burden of other water-related diseases is hence likely to be high, although it may be masked by the dramatic presentation of dracunculiasis.

Safe sources of drinking water can be provided in several ways. In selecting an appropriate method, the following factors should be considered: availability of raw water sources in adequate supply to meet demand; socioeconomic factors; and political, legal, and institutional constraints. Protected sources of drinking water must be

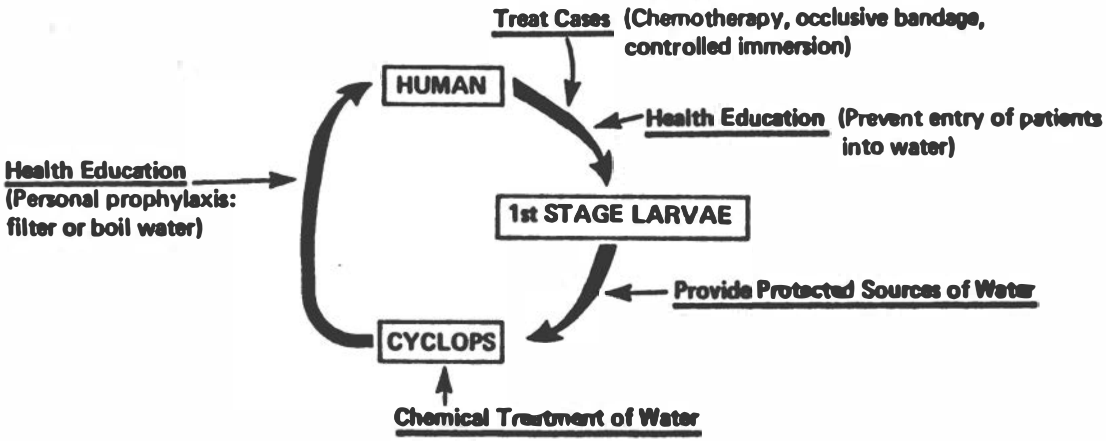

FIGURE 10 Control measures against dracunculiasis at various points of intervention. (Source: Donald Hopkins, Centers for Disease Control, 1982)

located in accord with wishes of villagers or they will not be used and maintained.

Options for providing sources of safe drinking water range from relatively simple and inexpensive modification of existing sources for personal or family water supplies, to sophisticated piped systems engineered for collection, treatment, and distribution of water. The latter systems require a commitment of capital for construction and adequate resources for maintenance and operation to ensure reliable performance on a continuing basis and are therefore not appropriate in all situations.

Some households may have unedged wells that permit runoff to drain back into the drinking water. This type of well may be protected from dracunculiasis infection at relatively low cost by adding a concrete rim that slopes outward. A dramatic reduction in dracunculiasis incidence was reported in northern Nigeria in 1948 after concrete-lined wells with sloping aprons were installed (White et al. 1972:75).

One currently underexploited source of safe water is rainwater that is collected and stored during the rainy season by households or communities for use during dry periods. However, in regions with extended dry seasons this method may not be feasible. Selected villages might receive potable water in tanker trucks at the height of the dry season.

Groundwater may be considered safe for drinking if it comes from a protected dug well or spring. Examples of protected wells include dug wells that are lined and covered, with or without pumping equipment, and tube wells.

Options for Improving Unprotected Sources of Drinking Water

Some degree of protection from dracunculiasis may be obtained through physical or environmental alteration of unprotected surface water sources used for drinking. Possibilities include (1) dredging or silt removal to permit shoreline access to deeper water, and (2) construction of fingerdikes extending from shore to deep water. Both of these efforts should be accompanied by erection of a barrier such as a retaining wall that prevents water users from entering the source. Surface contamination can be reduced by installation of a pumping mechanism and by use of infiltration galleries or equipment for conventional treatment (e.g., slow sand filters).

Alternatively, individuals can treat the water using one or a combination of the following methods:

- Filtration through cloth, sand, nylon bolting silk, or other locally available filtration media
- Clarification--use of a coagulating agent such as aluminum sulfate followed by filtration
- Boiling/disinfection (because of cost, in time and materials, generally not a viable option)

Table 5 outlines the various control options for protected and unprotected water sources and compares them on a qualitative basis.

HEALTH EDUCATION

A well-planned health education program is an essential component of any effort to control or eliminate dracunculiasis. The Indian Guinea Worm Eradication Program, for example, has developed some prototype health education and training materials for use in that country (National Institute of Communicable Diseases 1982). The potential efficacy of health education efforts against dracunculiasis was documented in a recent study by Akpovi and his colleagues (1981) in Nigeria.

Rural villagers are not likely to change their behavior unless they believe the benefits to be gained from adopting new practices outweigh the physical and psychological costs of abandoning traditional ones. Their belief in the efficacy of a new approach for preventing dracunculiasis may need to be strengthened through a successful demonstration in the first year of control activities. Health education of populations affected by dracunculiasis must be integrated into all aspects of control efforts. Villagers' involvement in decision making relevant to control operations must be secured from the outset in order to improve their chances of succeeding.

Health Education Strategies

Three major educational strategies or techniques can be used in conjunction with dracunculiasis control efforts:

1. Mass communication
2. Community (popular) organization
3. Instruction or training of individuals and small groups

These strategies vary in degree of effectiveness and resource requirements, depending on which control effort is being implemented. The message delivered by each strategy will also vary with the desired objective and the anticipated audience. For example, television programs or news articles about dracunculiasis may create a favorable political climate for a national elimination campaign among wealthier urban dwellers but would probably not be seen by people in affected villages. Radio programs and cassette tapes would be more likely to reach the population at risk, but even these techniques would be more effective when used as an integral part of control efforts. They would increase awareness of the problem but would probably not increase understanding of the disease to any appreciable extent.

The primary objective of health education efforts is to secure the active participation of the populations at risk in every phase of control activities. Health education objectives specific to each control option are shown in Table 6. The appropriateness of the various education strategies to each of the control options is discussed below:

TABLE 5 Comparison of Water Supply Protection Options for Preventing Dracunculiasis Transmission

		Option	Type of Treatment	Risk of Dracunculiasis Transmission	Cost	Infrastructure Needed	Reliability	Advantages	Disadvantages
SURFACE SOURCES (supplied by surface runoff)	UNPROTECTED	Personal treatment	Filtration	Low	Low	Low	Low	A,B,D	1
			Clarification	Unknown	Moderate	Low	Low	B	2
			Disinfection/boiling	Low	Moderate/high	Low	Low	A,B,C	4
		Community action	Preventing infected people from entering water source	Low	None	None	Low	A,D	1,4,6
			Chemical treatment	Low	Moderate	Low	Moderate	A,F	1,4,5,6
	PROTECTED	Passive structure/surface withdrawal	Preventing user-water contact	Moderate/low	Moderate	Low	Moderate	E	2,3,6
			Infiltration gallery	Low	Moderate/high	Low	High	C,E	3
		Conventional	Clarification, filtration, disinfection	None	High	High	High with appropriate maintenance	C,E,F	3,5

TABLE 5 Continued.

		Option	Type of Treatment	Risk of Dracunculiasis Transmission	Cost	Infra-structure Needed	Reliability	Advantages	Disadvantages
GROUNDWATER SUPPLY (springs; dug, bored, and drilled wells)	UNPROTECTED	Step well*	Chemical treatment	Moderate/ low	Moderate/ low	Low	Low	A	6
		Lined or unlined dug well	Chemical treatment	Low	Moderate	Low	High	E	6
		Covered, lined, dug well**	Initial disinfection after construction	None	Moderate/ high	Moderate	High	C,E	3
	PROTECTED	Covered, lined, dug, with pump	Initial disinfection after construction	None	High	High	Low	C,E	3
		Tube well with pump	Initial disinfection after construction	None	High	High, recurrent capital costs	Operation & maintenance dependent	C,E	3
		Tube well or spring with piped distribution	Disinfection	None	Very high	High, recurrent capital costs	Operation and maintenance dependent	C,E,F	3,5

TABLE 5 Continued.

NOTE: The cost of rural groundwater supplies varies widely depending primarily on the depth to a reliable source of water, the ease of identifying water-bearing strata, the status of transportation and communications, the level of industrial development, and the density of population to be served. Capital expenditures to develop a well with handpump in order to provide approximately $10m^3$/day (e.g., 30 liters per capita per day for about 300 people) range from as little as $600 for a shallow well with a low-lift pump to more than $43,000 for a deep well bored through difficult formations and equipped with a deep-well pump. Annual operation and maintenance costs also depend on the reliability required, local capacity for carrying out maintenance, and extent of vandalism and abuse. Reports of annual costs per well range from $150 to over $1,000. Total costs (capital and recurring) for supplying water from wells using handpumps thus range from about $2-$31 per capita annually.

*Actually characteristic of unprotected surface supplies
**Including springs

KEY

A Immediate short-term measure	1 Temporary solution
B User-controlled	2 Questionable effectiveness
C Protection against other water-related diseases	3 Resource intensive (includes operation and maintenance)
D No outside resources required	4 Problems with social and cultural acceptance
E Long-term control measure	5 Infrastructure dependent
F Quality control from central agency	6 No protection against other water-related diseases

SOURCE: World Bank staff, March 1983.

TABLE 6 Health Education Objectives Associated with Control Options

Control Option		Health Education Objectives
Physical protection of water sources	* 1.	Participate in the planning and installation of new or improved supplies.
	* 2.	Care for and maintain installations and their surroundings.
	* 3.	Keep an adequate supply of spare parts.
	** 4.	Use only the new or improved source of water.
	+ 5.	Report new cases.
Personal preventive measures	+ 1.	Filter and/or boil water.
	++ 2.	Avoid contact with ponds when blisters appear and throughout patency period.
	+ 3.	Avoid drinking from contaminated surface sources.
	+ 4.	Drink water only from protected sources.
	+ 5.	Report new cases.
Vector control	* 1.	Use only treated water.
	* 2.	Treat surface sources regularly and properly.
	* 3.	Keep chemicals in stock.
	+ 4.	Participate in surveillance.
	+ 5.	Report new cases.
Prevention and treatment	++ 1.	Seek and obtain treatment.
	++ 2.	Persist with treatment.
	+ 3.	Report new cases.

* Community
** Water carriers
+ Individual residents
++ Patent case

Physical Protection of Water Sources Mass communication is useful in spreading information about the need to protect wells and springs and the need to use such safe sources exclusively once they are available. Ways of protecting those wells and springs can be taught in small group sessions.

Community organization is essential for participation in planning, installation, and maintenance of water supplies; site selection; selection of trainees for maintenance; collection of funds for installation, materials, and maintenance; and the organization of work teams.

Personal Preventive Measures Mass communication can be used to inform the public about correct methods of boiling and filtering water and about using protected water sources and avoiding contaminated sources, and to urge people with patent infections not to enter sources of drinking water. Such measures may find easier acceptance if alternative laundry, bathing, and sanitary facilities are provided, maintained, or repaired. In some cultures people enter surface waters to defecate.

Community organization is useful in providing social support for filtering and/or boiling of drinking water, for preventing contamination of ponds, for facilitating cooperative purchase of filters, and constructing alternative sources of water for personal and household needs.

Instruction is needed for people in affected villages in the proper type and use of filters, boiling (a few minutes is sufficient), and sanitary handling of clean drinking water.

Prevention and Treatment Mass communication can be used to inform the public of the risk of dracunculiasis and the possibility of prevention. Individual and small group discussions can emphasize the location of treatment centers and encourage individuals to seek early treatment, so as to avoid complications and prolonged disability. The same communication methods are available as indicated above.

Community organization can help to identify individuals needing treatment, establish new treatment centers, provide supplies to dispensaries for care of dracunculiasis cases, and facilitate access to care for those disabled by the disease.

Vector Control Mass communication efforts can be used to bring about awareness of the extent and severity of dracunculiasis and the relationship of the disease to contaminated water, and to urge consumers to carry out the measures suggested in Table 6. Efforts might include radio or television in some areas, poster campaigns, study groups, folk media (drama, festivals, folklore), and pop culture (comics, photonovellas).

Community organization is useful in collecting baseline epidemiologic data, in providing social support for behavioral change in use of water for drinking, in selecting individuals for training in application of chemicals, in collecting funds for materials, and in support of trainees.

VECTOR CONTROL OF CYCLOPS

Transmission of dracunculiasis occurs only if a surface water supply supports a population of cyclops, a proportion of which are infected by D. medinensis larvae. The disease may be prevented by ensuring that people drink only water that is free of infected cyclops. A variety of technical options is available for either eliminating cyclops from water used for drinking or ensuring that the cyclops are not infected by the dracunculiasis larvae. The effectiveness of these options requires cooperation from the people at risk. The level of water treatment and/or protection needed to control dracunculiasis is less than that required to halt transmission of waterborne viral and bacterial diseases, although measures taken to render drinking water safe from Dracunculus medinensis may improve the quality of drinking water with respect to other pathogens as well.

Chemical Treatment

Chemical measures to control or eliminate cyclops may be used when existing contaminated drinking water sources either cannot be made safe immediately or cannot be eliminated from use. When an unsafe source is converted to a safe source (e.g., when a physical barrier is constructed), chemicals should be used in conjunction with such measures in order to eliminate any still-infected cyclops. They should also be used when an existing safe source becomes a hazard naturally or because of mechanical breakdown. If chemical treatment is carried out effectively, it may not be necessary to continue it for a period longer than 2 years.

Available Chemical Compounds

At present, a few chemical compounds are considered potentially effective against cyclops in controlling dracunculiasis: temephos (Abate), Hightest Hypochlorite, and niclosamide. Temephos is by far the preferred available compound for this purpose. Further research and testing are needed before the use of niclosamide in cyclops control can be recommended.

Temephos (Abate)

Advantages:

- Effective at low dose (1 mg/liter), as shown in field tests conducted in India
- Low mammalian toxicity[2]

- Residual effect (4-6 weeks)
- Easy to apply
- Various Abate formulations can be purchased and shipped from American Cyanamid in Italy (Cyanamid Italia, S.p.A., Casella Postale A. 95100, Catania, Italy, tel. 591-555). A 1% sand granule formulation is the formulation of choice because of ease of application.
- Low cost[3]
- Has uses for control of other vectors such as _Aedes_ and _Culex_ mosquitoes, _Simulium_ larvae
- Can be held in stock in tropical climates for as long as 3 years without deterioration.

Disadvantages:

- Technical-grade temephos is no longer available for resale. (The current policy of American Cyanamid is to sell the formulated product only.)
- Health or sanitation infrastructure is necessary to make the required visits to villages. Alternatively, a literate, respected person in each affected village (e.g., the school-teacher) could be taught application and safety procedures.

Hightest Hypochlorite

Advantages:

- Low mammalian toxicity
- Effective against other disease-causing organisms

Disadvantages:

- Expensive
- Unstable
- Free chlorine residual required to kill cyclops (2 mg/liter). Villagers may refuse to use it if they perceive a bad taste or smell from excess chlorine.
- Applications may have to be frequent, depending on the reappearance of cyclops.

Application of Chemical Compounds to Water Sources

The text that follows relates only to temephos, which is the preferred available compound.

Frequency and Timing of Applications

1 Ascertain seasonal frequency of case distribution.

2 Treat all surface drinking water sources at least 1 month before peak incidence and repeat every 6 weeks until incidence is at minimum (i.e., 3 or more applications may be required to suppress the cyclops population).

How to Apply Chemical

1 Collaborate with community (inform and consult with community leaders).
2 Measure the average length, width, and depth of each water source used for drinking and calculate the volume of water to be treated.
3 Calculate correct quantity of chemical to be applied at a concentration of 1 gram of active ingredient per cubic meter of water (1 mg/liter).
4 Distribute uniformly over water body either manually or mechanically.

Monitoring of Safety

1 In the case of a massive overdose of temephos, any obvious adverse side effects in the population (e.g., nausea, vomiting, bronchospasm, abdominal pain, diarrhea, weakness) should be reported promptly.
2 Be prepared to deal with apprehension of community if there is a coincidental, unrelated outbreak of illness.

Quality Control

1 Keep a record of nature, number, dimensions, and water use patterns of all sources of drinking water.
2 Keep a record of applications to water bodies. For each application record the dimensions, and volume of water, quantity of chemical, and date of application.
3 Keep a record of presence of cyclops before and after treatment; record date of check.
4 Conduct an independent cross-check of sample of treated sources.

Management of Chemical Treatment at the Village Level

1 Temephos can be stocked at village level (or in each health unit, where appropriate).
2 Local health worker, schoolteacher, or other person can be trained to apply temephos and keep records. In certain endemic areas of West Africa, however, school holidays coincide with the peak transmission period and teachers may not be available.
3 Long interval (4-6 weeks) between applications requires that only one individual from each village be responsible for treatments.

NOTE: Breakdown of supplies or application for a brief period (e.g., 1 month) during the program will not greatly affect control efforts.

Institutional Support

1 Management of inventory, procurement, and distribution is necessary at central, regional, and local government levels to ensure the availability of temephos during transmission season.
2 Transportation must be made available to deliver temephos to affected villages.
3 Evaluation of applications should be monitored by ministry of health personnel by periodic checks of records and through participation in control activities.

Biological Agents

Documented experience with biological agents for cyclops control has involved only the use of predator fish. However, there have been no recent studies with fish species used previously--*Gambusia*, *Barbus*, and *Rosbora*. In general, many surface water sources are seasonal, have small volumes of water, and are scattered over wide areas. Biological control will probably be much less feasible than chemical treatment under these conditions. The requirements, advantages, and disadvantages of using fish to control cyclops are outlined in Table 7.

TABLE 7 Use of Fish to Control Cyclops

1. Requirements
   a. Bottom, column, and surface feeders are required.
   b. Hatcheries at different locations are required for replacement.
   c. Placement of fish in drinking water has to be culturally acceptable.
   d. Fish selected should be unsuitable for human consumption and of no commercial value to village.

2. Advantages
   a. Cheap on short-term basis.
   b. Compatible with environment.
   c. Long lasting.

3. Disadvantages
   a. Replacement at intervals is required.
   b. Maintenance of hatcheries involves cost.
   c. Incomplete clearance of cyclops.
   d. Not practical in small, temporary ponds.

TREATMENT OF CASES

Chemotherapy

The role of chemotherapy in the control of dracunculiasis is indirect and complementary to the main measures indicated above. Chemotherapy provides symptomatic relief and by doing so enhances community participation. Because it speeds up expulsion of the worm, chemotherapy may reduce transmission marginally and may shorten the period of disability.

Available drugs (thiabendazole, metronidazole, mebendazole, and niridazole) are not very effective against D. medinensis worms, and they are rather expensive. Because treatment requires more than one dose, they are difficult to administer to a rural population. Medical supervision is a prerequisite for chemotherapy with the available drugs, some of which have toxic effects. Moreover, none of the available drugs prevents dracunculiasis reinfection, nor has any drug been shown to be effective against early stages of the parasite in humans.

Prevention and Treatment of Secondary Bacterial Infection

Victims of dracunculiasis should be taught and encouraged to keep the wounds as clean as possible by washing periodically with soap and water and applying a clean dressing, if possible. Systemic or topical antibiotics can be used to treat secondary bacterial infection. Most important is to ensure adequate immunization against tetanus. Analgesics such as aspirin may provide temporary relief from the pain caused by the emerging worm.

Patients with soft tissue infections (e.g., open ulcers, adjacent cellulitis) can be managed in outpatient facilities by paramedical workers, who can give instructions about use of cleansing compresses, dressings, and bedrest. Oral penicillin (400,000 units 3 times daily for adults) for 5-7 days is generally adequate. Patients with more complicated dracunculiasis (e.g., sepsis, tetanus, limb contractures) will require hospitalization for appropriate treatment and rehabilitation. Contact between a paramedical worker and someone suffering from the disease also affords an opportunity to explain why the affected limb should not be immersed in a source of drinking water.

TRAINING

Each of the approaches for controlling dracunculiasis (e.g., filtering water prior to drinking, killing cyclops with temephos, installing a piped water system) requires training of people involved in control efforts (control workers) and in education programs. Decision makers should be made aware of the need for a systematic approach to training workers for dracunculiasis control (for example, through national workshops). Fortunately, personnel are often available who have acquired similar training and experiences while working in other disease control programs (e.g., tuberculosis, leprosy, malaria). Such individuals might be retrained to meet dracunculiasis control needs and then serve as instructors for training activities at the district level.

Training Goals for Control Workers

The goals stated below are relevant to all approaches aimed at preventing dracunculiasis, with some variations. Although each goal is elaborated specifically for dracunculiasis control efforts, it should be noted that the underlined general statements could serve equally well as goals for most disease control and primary health care programs. It is assumed that most staff assigned on a temporary or part-time basis to dracunculiasis control efforts will be drawn from public health or water and sanitation agencies. Such control workers (administrators, planners, and other employees) should be able to:

- Acquire appropriate technical skills. This may include, for example, the ability to store, measure, and apply pesticides properly; to determine cyclops density in contaminated water; and to maintain a spare parts inventory.
- Establish rapport with target populations. Technical agency staff should establish a basis for continuing collaboration with the target population so as to assure lasting results from the program.
- Actively involve the population in all stages of the program. Collection of accurate baseline data requires participation by target populations. Likewise, community participation in program planning, implementation, and evaluation will enhance program effectiveness and measurability of outcomes.
- Transfer appropriate technical skills. Unless basic technical skills are acquired by local people, there is no assurance of continued operation, maintenance, and repair of recommended improvements and additions to water sources. Without those skills villagers will remain dependent on outside resources, which are at best difficult to guarantee.
- Use appropriate communication techniques. Choice of appropriate communication techniques requires knowing how new information is incorporated and diffused within the target population.
- Adapt the program to local situations. Field staff must be able and allowed to modify activities to suit local practices, so as to assure their acceptance, use, and maintenance.
- Form linkages with existing services. To prevent unnecessary competition and wasted resources through overlap, the agents of the various organizations (agricultural and rural development, education, health, public works) working with local populations need to develop ways of mutually supporting each other.

OPERATIONAL RESEARCH ISSUES

Research pertaining to control of dracunculiasis is being pursued in a few universities in India and Nigeria. The Organisation Centrale Contre les Grandes Endemies (OCCGE) is also sponsoring applied research on different control methods in climatically different zones of French-speaking West Africa. National authorities in endemic countries should consider carefully the different options for control, selecting those that seem most appropriate and practical. Where different approaches are used in different areas, operational research issues associated with each approach should be identified and studied early in the control program. Study results can then assist in modifying control efforts as they are expanded to cover the entire affected population. Topics that may need to be investigated in some countries include:

- Efficacy of filtering devices and materials for drinking water and their acceptance by the target population
- Cost and efficacy of cyclops control using temephos in different (representative) ecological situations
- Evaluation of effect of different health education techniques (i.e., mass communication, community participation, or individual and small group instruction) on knowledge, attitudes, and practices regarding dracunculiasis
- Efficacy and cost of different combinations of control approaches, as tested in several dissimilar villages
- Relative efficiency of alternative surveillance systems (e.g., passive reporting to health clinic versus active case searching by community member)
- Comparison of different training and supervision methods for control workers (e.g., workshop versus individual instruction)
- Evaluation or monitoring of national dracunculiasis control activities in West Africa.

NOTES

[1]According to Golladay, calculation of the economic loss attributable to dracunculiasis is constrained by the absence of data on the number of cases and the characteristics of victims. If one accepts that 10-48 million people are at risk (see Overview of Dracunculiasis, above), that 10-30 percent of these people become infected annually, and that 40 percent of the victims are disabled for 1-3 months, then the annual loss of work time ranges from 400,000 to 17,280,000 person-months. While a few of the victims are children, the overwhelming majority are of working age. Per capita incomes in the affected areas range from about $200 a year in India to over $1,000 in Ivory Coast. However, production per working adult is about three times these amounts since only about half the population is of working age and approximately one-third of this number is working in the home or is bearing children. Moreover, the disease strikes during the peak

period of agricultural labor requirements, so that most of a crop is lost rather than only the average production of 1-3 months. The foregoing implies that the loss in production due to dracunculiasis ranges between $210 million and $3 billion a year; a range of $300 million to $1 billion appears likely to represent the true loss.

If for purposes of analysis one assumes that the annual loss is $500 million and that the present value of benefits is discounted at 8 percent, then global elimination would justify an expenditure of at least $6 billion. Even with the extreme assumption that 40 million people are presently at risk, this analysis suggests that on narrowly economic grounds an expenditure to eliminate the disease of up to $150 per person at risk would be justified.

[2]Extensive data on Abate toxicity has been collected during more than 10 years of its use in the West African Onchocerciasis Programme. See WHO Doc. OCP/EAC/80.1, Onchocerciasis Control Programme in the Volta River Basin Area. Report of the first meeting of the Expert Advisory Committee, September 1980, pp. 8-9.

[3]In February 1983, American Cyanamid supplied the following list prices:

- 1% sand granule formulation packed in 25-kg drums = US $1.90 fob per kg
- Abate 500 E.C. formulation in 20-liter drums = US $15.69 per liter
- Abate 200 E.C. formulation (used in Onchocerciasis Control Programme in West Africa) in 60-liter drums = US $9.95 per liter.

3 Program Monitoring and Evaluation

The contents of this section necessarily overlap with those of the previous two on problem assessment and surveillance and control strategies. On the one hand, monitoring efforts should be compatible with data gathered as a part of problem assessment--to document changes in incidence, disability, and case severity. On the other hand, there is a need to demonstrate the relationship between control efforts and these changes. Workshop participants therefore attempted to establish a minimally acceptable level of monitoring and evaluation and suggested additional steps that could be taken to increase confidence in findings.

The existence of only a few reports showing significant reduction of dracunculiasis as a result of interventions other than provision of safe water supplies points to the need to emphasize evaluation. Evaluation is needed to compare the effectiveness of different strategies and programs. Monitoring is understood to refer to frequent, routine, ongoing analysis of program activities; evaluation here refers to relatively infrequent, periodic, comprehensive reviews of progress toward program goals in training, education, surveillance, collection of baseline information, improvement of water source, and, ultimately, a reduction in dracunculiasis incidence.

PROCESS INDICATORS TO MONITOR PROGRAM COVERAGE

Each operational component of the anti-dracunculiasis strategy should be monitored regularly as an interim measure of the program's effectiveness in order to permit corrective action to be taken promptly, when necessary. Such operational or process indices are important in this disease since the long incubation period limits the use of disease outcome (i.e., reduced incidence) as an indicator of program effectiveness on a weekly or even monthly basis. Process indicators are expressed as a comparison of the number of selected activities actually carried out to the number of similar activities scheduled as a part of program operations.

The director of control activities and other members of the national steering committee or task force should agree early in the program on key control activities that will serve as process indicators. Agreement should also be reached about which activities should receive priority, so that monitoring efforts can continue throughout the life of a program, despite unforeseen cutbacks in resources. By relating these activities to an estimated operational timetable, attention can be directed to unexpected delays and alternative approaches can be considered. Process measures should be calculated by program management staff on a regular basis, either as part of routine activity reports or as a brief sample survey conducted in villages targeted for control activities. A periodic comprehensive program review, or evaluation, should be undertaken every 2-3 years to include:

- A thorough review of program operations
- Extent to which program objectives have been achieved
- Identification of problems
- Recommendations for improvement of strategies.

Based on the principle of technical cooperation among developing countries (TCDC), workers from programs in other countries should be invited to participate in these reviews.

The extent to which program goals are achieved can be determined by calculating the percentage of planned activities that are actually carried out. A list of these activities, and criteria for determining completion of each, follow:

1. Provision of protected water sources, determined by presence of properly constructed wells or other sources of protected water, evidence of properly functioning equipment, and evidence of maintenance.
2. Health education. Process measures can be based on reports from individuals responsible for health education, validated where possible through documentation of occurrence of health education activities in a sample of villages. Such documentation might include the type of activity (e.g., community organization efforts, small group discussion, contact with affected individuals, audiovisual programs, and placement of posters), the date held, and approximate attendance. The success of the program will be influenced by the extent to which educational activities are related to desired changes in dracunculiasis-related behavior.
3. Chemical disinfection of water sources, evidenced by signature in book kept by village chief, schoolteacher, etc., signifying when chemicals were added, amount, and by whom. Availability of supply of chemical in village could also be a criterion, but only if feasibility study indicates someone in the village is capable of administering the chemical.
4. Treatment of patients. Treatment of patent cases is part of patient care under the primary health care plan and should not be the major priority in a control program. Where treatment of cases is used to help enlist community participation, coordination with local health personnel will be important. The following proportions of all active dracunculiasis cases

might be measured: those with bandaged active dracunculiasis lesions and those reporting controlled prophylactic expulsion of larvae from ulcers.

5. Training. The program should include specific objectives relevant to the training of different types of health workers. A time frame and a means for assessing the extent to which training objectives are being met should be established. The extent to which needed training materials are produced, available, distributed, and used should be monitored.

OUTCOME INDICATORS TO MEASURE PROGRAM EFFECTIVENESS

The effectiveness of dracunculiasis control activities can be assessed in two ways: (1) through program impact measures--by determining if the activities carried out had the desired effect (e.g., changed human behavior with regard to use of water for drinking); and (2) through epidemiologic measures--by determining whether the activities carried out reduced the incidence of dracunculiasis. Both categories of information are desirable for measuring the relative value of approaches to control. For example, persistence of dracunculiasis in villages where control efforts are judged to have been successful might indicate recent immigration of infected individuals to the area. (See questionnaire, Figure 9, regarding length of residence. Infected respondents with less than 1 year of residence could be imported cases.)

Program Impact Measures

Program impact measures indicate whether program activities led to their intended result or objective. They are often very useful in analyzing a pilot program, to provide information about which activities are more effective and therefore should be included as part of a wider program. In monitoring a regional or national program, impact measures might be calculated every 2 years in a sample of villages to determine the extent of:

1. Prevention of infected individuals from contaminating unsafe water sources
2. Use of a protected water source, if available
3. Use of unprotected water sources
4. Physical or chemical protection of all unsafe water sources
5. Household measures to filter (or possibly boil) drinking water
6. Appropriate measures to keep dracunculiasis ulcer(s) clean.

Where resources are limited, the above information should be collected by giving highest priority to item 1 and lowest to item 6.

Epidemiologic Measures

The most important epidemiologic measures are the number of cases, reported through existing reporting systems or detected by active surveillance, and the number of affected villages, obtained through active case detection (e.g., counting cases by village once the size of the population has been established or estimated). Where resources to provide comprehensive coverage are not possible at the outset, a sample of representative villages should be identified and followed over time. Eventually, however, information derived from comprehensive coverage will be necessary. The 1-year lag in appearance of patent infections makes more difficult the determination of effectiveness of interventions on outcome. Programs should consider classifying affected villages according to level of annual incidence (less preferably, according to prevalence or incidence during the peak transmission season): hyperendemicity = 20% or more; mesoendemicity = 5-19%; hypoendemicity = less than 5%. Because school-aged children (6-14 years old) and adults (15+ years) appear to have greater exposure to dracunculiasis than preschool children, they might be appropriate population subgroups for classification (see Figure 3).

EVALUATION OF SOCIOECONOMIC BENEFITS AND PROGRAM COSTS

Socioeconomic effects of this disease are substantial and may be direct or indirect. For example, a decrease in average school attendance may result directly from disabilities suffered by school children or from the need for children to replace disabled parents in the field.

Although the evaluation of the social and economic benefits and costs of dracunculiasis control programs is optional, such evaluation can provide a sound basis for determining which intervention(s) can be implemented most effectively within a limited budget, and can provide useful information for justifying previous expenditures and future requests for resources. Rural development and water supply agencies should be willing to assist in such data collection and interpretation, especially where control efforts are added to existing multipurpose programs.

Measuring Socioeconomic Change

Baseline data should be collected in endemic villages prior to the start of control activities. If possible, baseline data should also be collected in endemic villages not targeted for immediate program activities, so they may serve as controls. Alternatively, one could measure selected socioeconomic indicators in comparable affected and unaffected villages before and after control activities. The following indicators are suggested as measures of socioeconomic benefit resulting from reduction or elimination of dracunculiasis:

1. Differences in labor, as manifested by number of days worked (time), productivity per day or week (output: area harvested or planted, or amount of crop harvested or planted), or wages earned (pay). In addition to these individual measures, entire villages may be compared by their per capita production. Alternatively, in rural areas where seasonal agricultural work is the norm and "cash" for services or "output" terms may be less applicable, one might inquire about the number of days workers were restricted or disabled during a specified period.

2. Differences in school attendance, as manifested by either total number of days missed or days missed because of dracunculiasis only; or average daily attendance during the dracunculiasis season as compared to other times of the year, before and after control programs.

3. Possible differences in nutrition. Where the disease is highly prevalent in a precariously balanced subsistence economy, the presence or absence of dracunculiasis and its attendant secondary effects on the capacity of affected villagers to undertake farmwork may be manifested in demonstrable tertiary effects on the nutritional status of affected villages, especially in young children. Compare weight-for-height profiles to assess recent nutritional/caloric deficiency.

Programs in the Bendel State of Nigeria and the Dimbokro District of Ivory Coast have already afforded opportunities to measure changes in dracunculiasis incidence where safe drinking water sources are being provided. Such changes should be documented as carefully as resources permit and should be publicized when and where significant program efforts are being made. Important items that may be measured include changes (preferably compared with control villages) in:

1. Incidence of dracunculiasis
2. Productivity and labor
3. School attendance
4. Preschool nutrition
5. Direct costs of health care for dracunculiasis patients.

Costs of Control Programs

Information on costs will be extremely valuable to program administrators. Certain costs such as those for provision of wells and water systems, since they address a broad variety of health and socioeconomic issues, should be allocated among multiple programs. Similarly, health personnel already employed by state or national agencies might be used to conduct dracunculiasis control activities on a temporary or part-time basis. Thus the additional costs attributed to these workers may be less than proportional to the additional effort. Other costs that need to be calculated by control program administrators include:

1. Transportation
2. Special supplies, including pesticides, training materials, medical supplies, educational or promotional materials
3. Research costs, including operational studies to develop methodologies for measuring costs of dracunculiasis control programs
4. Training costs, including instructor compensation, trainee wages, materials, travel reimbursement, etc.

DETERMINATION OF DISEASE ELIMINATION

There is limited experience concerning the measures needed to ensure that dracunculiasis has been eliminated from an area. However, at least two consecutive annual active case searches in recently affected villages during the peak transmission season are desirable. Although house-to-house searches are more costly, they should result in a higher degree of certitude. These active searches may be combined with other rural surveys.

Disease may be considered eliminated in a village if no new indigenous cases are discovered during two consecutive annual searches. Before a district or endemic area can be considered entirely free of dracunculiasis, however, one search must be made of all villages in the district or area, regardless of whether they have been known previously to harbor the infection. A case imported into an area that was previously disease-free should provoke a follow-up of that village for two consecutive years.

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APPENDIX
Papers Prepared for Workshop

A. H. ABDOU	WHO/AFRO Programme Proposal for Control of Dracunculiasis in the African Region
JOSHUA D. ADENIYI	Health Education Strategies for the Control of Dracunculiasis
DONALD BELCHER	Opportunities for Control of Dracunculiasis: Transmission and Epidemiology
HERBERT M. GILLES	Dracunculiasis
H. DOUGLAS HUDGINS	Protection of Water Supplies for the Control and Prevention of Guinea Worm Disease
OLADELE O. KALE	Epidemiology of Dracunculiasis in Nigeria
FO-KODJOVI KLOUTSE	Village Waterworks and the Fight Against Dracunculiasis in Togo
S. K. LITVINOV and A. YA. LYSENKO	Dracunculiasis: History of the Discovery of the Intermediate Host and the Eradication of Foci of Invasion in the USSR
FERGUS McCULLOUGH	Cyclopoid Copepods: Their Role in the Transmission and Control of Dracunculiasis
RALPH MULLER	The Life Cycle of Dracunculus medinensis
ROBERT A. MYERS	Social and Cultural Aspects of Guinea Worm Eradication
J. PROD'HON and M. DESFONTAINE	Epidemio-geographic Data on Dracunculiasis in French-speaking West Africa
E. F. QUASHIE	Water Supply and Other Environmental Aspects of Guinea Worm Control, Including Observations on the Opportunities for Implementation of Control Activities in Ghana

C. K. RAO	Epidemiology of Dracunculiasis in India
MATTHEW H. SHULMAN	On Correlations between Dracunculiasis and Malnutrition: The Use of Nutritional Indicators in the Evaluation of Dracunculiasis Abatement Programs
WILLIAM WARD	The Impact of Dracunculiasis on the Household: The Challenge of Measurement