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COST - EFFECTIVE APPROACHES TO THE CONTROL OF DRACUNCULIASIS

WASH TECHNICAL REPORT NO. 38

SEPTEMBER 1986

Prepared for
the Office of Health,
Bureau for Science and Technology,
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Prepared for the Office of Health, Bureau for Science and Technology,
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under WASH Activity No. 140

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ABSTRACT

A recurring problem in planning programs to control dracunculiasis (guinea worm disease) has been how to mount effective measures within the context of existing primary health care, water supply and sanitation, or vector control programs.

This paper proposes activities, develops cost estimates, and carries out a cost-benefit analysis for modular strategies for the control of dracunculiasis. It is intended that existing country projects and programs could select modules, or parts of modules, that could serve as cost-effective guinea worm control adjuncts to existing programs.

Four modules relating to activities necessary for the control of guinea worm disease are developed in this paper, with costs estimated for each: (1) an epidemiologic surveillance module; (2) a community participation/community health education/personal prevention module; (3) a community water supply module; and (4) a chemical control module. Cost estimates were developed for a hypothetical two year program to benefit an estimated 50,000 persons in 100 villages. Country data utilized are largely from Burkina Faso.

Estimated total costs related to guinea worm control vary from US $1.73 per person for chemical control interventions to US $5.91 per person for community water supply interventions. Each of these interventions was costed in combination with epidemiologic surveillance and community participation/community health education components. Overall costs varied from US $2.43 for chemical control to US $13.87 per person for community water supplies. Benefit-to-cost ratios were favorable, ranging from 1.05 to 5.79 under a variety of assumptions.

Chapter 1

INTRODUCTION

1.1 Background

Dracunculiasis (guinea worm disease) has received attention as a disease which almost exclusively affects rural populations and which has significant seasonal morbidity with substantial human and economic costs, impacting directly on health, agriculture, and education. It also is a disease highly amenable to control and even eradication when affected populations alter water usage habits, receive and use improved water supplies, or treat existing water supplies. As such, the condition has been recognized by the World Health Assembly as a target for control during the International Drinking Water Supply and Sanitation Decade (Hopkins, 1984). Activities are underway under the auspices of both the World Health Organization (WHO) and the United States Centers for Disease Control (CDC) to identify endemic areas in Africa and Asia and specific affected communities, and to determine the disease incidence and prevalence rates in these communities (Isely, 1984). The epidemiologic data which will result from these efforts should help governments and other agencies target water supply improvements, health education programs, and other preventive measures to areas most affected by the disease.

A workshop held June 16-19, 1982[1] provided the first international forum for exchange of information on the control of dracunculiasis, and has stimulated an ongoing dialogue regarding research and control activities. A variety of subsequent efforts has maintained information transfer and momentum for the study of means to control the disease.

1.2 Purpose of Paper

A recurrent problem in planning programs to control dracunculiasis is how to integrate guinea worm control efforts with planned or ongoing primary health care, water supply and sanitation, vector control, or agriculture programs. While the largely vertically-organized (categorical) dracunculiasis control program in India has served to organize surveillance efforts at the state level, it has not been effective in bringing about dracunculiasis eradication, and is probably not the model for countries in West Africa which must depend to a large extent upon donor aid in implementing programs. Guinea worm-related health education efforts or a national guinea worm secretariat to coordinate information exchange among other ministries or implementing agencies may be all that many countries can afford on their own.

The goal of this paper, therefore, is to define cost-effective modular strategies for the control of dracunculiasis in which existing projects and programs can select modules or parats of modules that can serve as potential add-ons to existing programs to provide efficient means to control

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[1] "Opportunities for the Control of Dracunculiasis," sponsored by the National Research Council of the United States under a grant from the United States Agency for International Development (USAID) and conducted in collaboration with WHO. Proceedings have been published by the National Academy Press (1983).

dracunculiasis. In addition to health education and personal hygiene (filtering) measures, two somewhat exclusive technological strategies exist for controlling dracunculiasis--providing improved or protected water supplies, or treating existing water supplies through chemical application. These different approaches, therefore, are considered as separate modules.

An initial effort by the WASH Project to describe possible cost-effective approaches to dracunculiasis control resulted in a working paper presenting a model program for an endemic area of a typical affected country, the People's Republic of Benin (Isely and Jordan, 1984). Isely and Jordan's paper costed out four possible types of programs in the context of Benin: (1) community water supply and health education; (2) community water supply, health education, and chemical treatment; (3) chemical treatment and health education; and (4) health education alone. The general approach of that paper met with approval, and it was decided to proceed with a more elaborate effort to develop the methodology. This paper represents the result of that effort, and includes as Chapter 2 an overview of dracunculiasis and its effects; Chapter 3, detailed intervention modules and cost estimates; Chapter 4, a cost-benefit analysis of guinea worm prevention, utilizing the intervention strategies costed in the previous chapter; and Chapter 5, policy options and conclusions.

Chapter 2

DRACUNCULIASIS--THE DISEASE AND ITS EFFECTS

2.1 Symptoms and Life Cycle

Dracunculiasis is a parasitic infection caused by human ingestion of a larval nematode contained within the body of a copepod vector, the water flea commonly known as "cyclops." Copepods are typically found in shallow pools, ponds and stepwells used for drinking and washing in rural areas of developing countries. Within the body the larvae are released, molt twice, and mate when mature, approximately 3 months after initial ingestion. The male worm(s) die at about 6 months of age, while at about 8 months of age the female worm(s) migrate to the subcutaneous tissue, 85 percent of the time in the lower extremities. Approximately one year after initial infection, the female worm is ready to emerge and emit larvae, and the disease symptoms first become apparent to the infected individual.

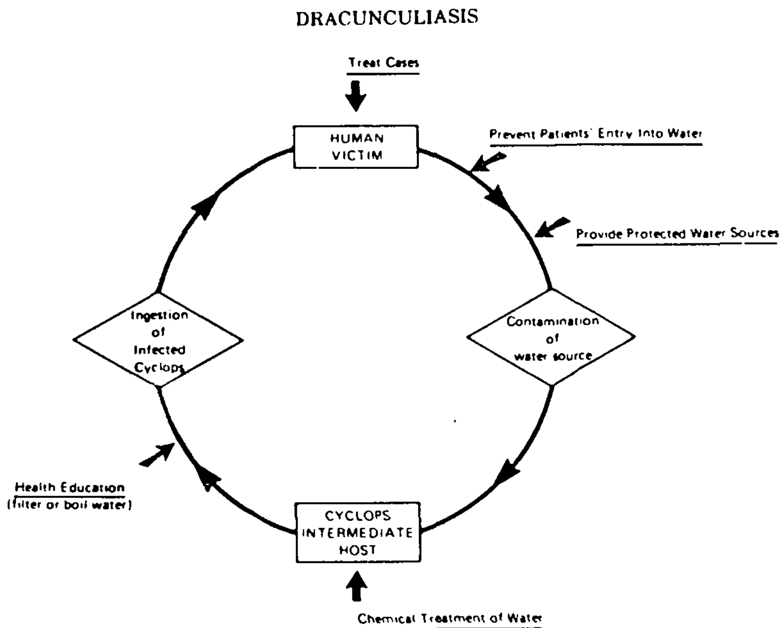
Dracunculiasis is recognized and well known by local names in endemic areas. Symptoms begin with a characteristic painful blister caused by a secretion from the emerging worm. Secondary symptoms caused by host reaction to the worm antigens include urticaria, nausea, vomiting, diarrhea, asthma, giddiness, and fainting. Later symptoms may be produced by secondary bacterial infection after the blister bursts. Finally, if the worm is injured or lacerated while lying in the subcutaneous tissue, additional local and systemic reactions may occur. The affected area often becomes extremely painful, inflamed and edematous. Cellulitis may result from secondary growth of staphylococci and streptococci, and gangrene is not uncommon. Arthritis, synovitis, epididymitis, contraction of the tendons, and ankylosis of joints are among the crippling conditions that may ensue. In a small percentage of cases death can result due to systemic bacteremia or tetanus.

The disease cycle is perpetuated through release of hundreds of thousands of larvae by the female worm when the ulcer with the protruding worm is immersed into water by the infected individual when fetching water or to relieve the pain and burning sensation. The released larvae are then ingested by copepods where they go through additional development stages. In approximately 14 days the third-stage larvae contained in the cyclops are able to reinfect humans and produce another generation of worms which will emerge one year later.

2.2 Treatment and Prevention

Current treatment of active dracunculiasis is at best unsatisfactory, although some drugs have been shown to provide symptomatic relief of the pain and inflammation, and can speed up the expulsion of the worm (Kale, 1982). No drug has yet been released which is proven effective in killing the adult worm prior to emergence; however, a drug of some promise in this effort, ivermectin (Merck, Sharpe, and Dohme), is under current development for use in onchocerciasis, and may also prove effective against guinea worm larvae and adults. The traditional and centuries-old technique of extracting the worm by rolling it a few centimeters a day around a stick or piece of gauze is effective if done slowly and correctly, and if the ulcer is kept covered with a clean, occlusive bandage.

Figure 1. Control Measures Against Dracunculiasis at Different Points of Intervention



Source: Hopkins, D., Centers for Disease Control, Atlanta, 1982.

Figure 1 shows the disease/transmission cycle of dracunculiasis and the possible points of intervention. As mentioned above, the role of treatment for the disease is currently very small when compared to the role of preventive strategies and surveillance activities.

Strategies involved in the control of dracunculiasis discussed in this paper include four major lines of action:

1. Epidemiologic surveillance to follow trends in disease incidence and distribution, and to evaluate control efforts (Weniger, 1983a-c; Fontaine, 1983). It is interesting to note that, assuming no imported or exported cases, one year's dracunculiasis incidence rate becomes the next year's point prevalence rate since there is little or no immunity to the disease and since the period of time between infection and emergence of the worm is approximately one year.

2. Community participation/community health education/personal preventive strategies, including the promotion of filtering drinking water through either double-thickness cotton cloth or a monofilament cloth filter/screen to remove suspended copepod vectors (Adeniyi, 1983; Akpovi et al., 1981; Duke, 1984). An additional approach accomplishing the same end is the use of simple sand filters at the water source (Sridhar et al., 1985). Sand filters, moreover, have collateral benefits in potentially filtering out other harmful substances. Boiling drinking water is usually impractical due to fuel scarcity, time required and cost (Ilegbodu, 1983); however, solar

killing of the cyclops through leaving collection vessels in the full sun for several hours could perhaps serve the same purpose.

3. Community water supply improvement through new construction or repair and improved operation and maintenance of existing systems (Adeniyi and Brieger, 1983; Fontaine, 1983); and

4. Chemical treatment of all local sources of drinking water to control the infected copepod vector (Muller, 1970; Krishna Rao et al., 1982; Sastry et al., 1978).

Of these four lines of action, epidemiologic surveillance is not, by itself, a control measure. It is, however, an essential component of any overall intervention strategy. Community participation/community health education activities are also integral to any intervention effort; moreover, these activities alone can offer much potential for control of the disease. The last two activities--community water supply and vector control through chemical treatment--represent specific "hard" technology interventions that can be used together but normally are used independent of each other in conjunction with the first two activities.

Finally, current research has demonstrated the possibility of early detection of guinea worm infection through use of serodiagnostic ELISA (Enzyme Linked Immuno-specific Assay) techniques (Kliks and Rao, 1984). These detection techniques may provide the means for evaluating the efficacy of several new drugs, in particular ivermectin and other avermectins and benzimidoles, which may be effective in killing developing larvae if administered to the infected individual in the pre-symptomatic period. Serodiagnostic techniques may also provide the means of screening for treatment (once effective and safe treatment has been identified) if they can be provided inexpensively and carried out by local field personnel.

2.3 Geographic Distribution and Prevalence

Dracunculiasis is most prevalent in the countries of West Africa (Ivory Coast, Ghana, Togo, Benin, Cameroon, Nigeria, Mali, Niger, and Burkina Faso), but also exists in East Africa (Kenya, Uganda, Ethiopia, and Sudan), and in South Asia (India--in the states of Rajasthan, Gujarat, Karnataka, Maharasthra, Madhya Pradesh, and Andra Pradesh--as well as in Pakistan). Small foci of the disease are also suspected to exist in the Arabian peninsula, particularly Yemen. Figure 2 presents a global view of the distribution of dracunculiasis.

Dracunculiasis incidence peaks at different times of the year, depending upon the climatic conditions of the country. In the inland parts of Africa where the dry season is long, the disease has its greatest incidence in the wet season when many shallow pools and ponds appear. In the coastal areas where the rainy season is longer, the greatest incidence occurs during the dry season when there is a greater concentration of the copepod vectors at the bottom of permanent water sources.

Additionally, the disease does not uniformly affect populations in endemic areas. Villages with and without dracunculiasis may be found in the same geographic region, and depending upon use patterns of polluted water sources, some communities may have only a few people affected while others may have many affected.

Figure 2. Areas in Which Dracunculiasis is Reported or Probably Exists

Source: World Health Organization, 1985.

2.4 Economic Effects of the Disease

Dracunculiasis occurs mainly among the adult population and can have a severe affect on local economic productivity because the symptoms characteristically appear during the season of greatest agricultural activity. In some endemic areas of West Africa nearly every adult carries at least one worm, and on average 4 to 6 weeks may elapse before an uncomplicated worm emergence completely heals. Assuming that 40 percent of those afflicted are completely disabled for a period of approximately 40 days, Ward (1984) has calculated that for every 6 percent of the population aged 15 to 44 affected by the disease, one day of productivity per worker is lost annually. As an example to show the extent of this loss, in a village where 36 percent of the population aged 15-44 is affected, and where the population of productive workers is 300, the calculation of the number of lost productive days would be as follows:

36 percent affected / 6 percent = factor of 6;

6 x 300 potential productive workers x 1 day

= 1800 expected days of overall lost productivity.

An attack rate of approximately 35 percent would represent a week's work lost for each member of the productive population (Ward, 1984). In any predominantly agricultural society with a relatively short growing season (4 months or under) that number of days or weeks lost during the peak working periods would result in a considerable negative economic impact. Depending upon the use patterns of polluted water sources, the community-wide prevalence may, however, vary from only a few persons to up to 80 percent of the population. Furthermore, villages with and without dracunculiasis may be found in the same geographic region.

In another calculation of economic loss specific to Upper Volta (Burkina Faso), Guiguemde et al. (1983) consider both the cost of lost agricultural production and estimates of the costs of treatment for the disease. Age-specific prevalence rates, mean number of days of disability, and average annual family income due to agricultural activities are used to arrive at a cost figure for lost agricultural production of approximately 7,600 CFA[2] per person over six years of age, regardless of whether or not they are affected by the disease. Costs of treatment are calculated for both uncomplicated and severe cases and are based only on the costs of drugs and dressings. These costs vary from 7,150 CFA (US $17) to 61,600 CFA (US $147). The total cost of the disease (with agricultural costs adjusted if treatment costs are incurred) was estimated as 3,919,583 CFA (US $9,332) per village per year. More general calculations quoted in "Opportunities for Control of Dracunculiasis" (National Academy of Sciences, 1983) place the global loss in production due to dracunculiasis between $210 million and $3 billion annually; using these figures and assumptions regarding the number of people at risk globally (10 to 48 million), indicates that these specific estimates of per person cost for Burkina Faso may, in fact, be quite conservative.

Finally, dracunculiasis significantly affects school participation in endemic areas. Nwosu, et al. (1982) calculated the rate of school absenteeism in 13 schools in endemic areas to increase from an average of 13.2 percent to nearly 60 percent at the height of the guinea worm season. Ilegbodu (1983) determined for a region in Nigeria that dracunculiasis is a leading cause of school absenteeism, with infected pupils out for an average of 9 weeks. Often the same students are out year after year.

2.5 Popular Beliefs and Practices

Because of the dramatic onset and nature of the symptoms of the disease (following an approximately one-year period of asymptomatic infection), emergence of guinea worms is a condition which often is surrounded by substantial and long standing folk wisdom regarding its etiology and

[2] $18 at 420 CFA/US Dollar. Note that this is over 10 percent of the 1981 per capita income of Upper Volta (Burkina Faso).

treatment. Health education programs must be appropriately adapted, therefore, to account for the local belief patterns, regardless of how inaccurate they might be. In many areas of West Africa, dracunculiasis is attributed to external or supernatural causes over which the individual or community feels little control. Merely convincing the local population that it is a disease related to water usage habits can be a very time consuming and difficult health education activity. In Togo, this aspect of the program was estimated to have taken over two years to accomplish (World Neighbors, 1984). Also, the problem of credibility of health education programs is further complicated by the long cycle of the disease. Despite intensive efforts during a current year, subsequent guinea worm emergence during the next year may still be high due to infection prior to the program onset. The resulting apparent lack of program results may be discouraging to villagers involved in its implementation. On the other hand, however, few diseases have such a direct link between changes in behavior and incidence of disease. Guinea worm offers health educators/health promoters a great opportunity for evaluation of the effectiveness of their efforts.

Because there is little effective treatment and the condition is normally non-fatal and self-limiting, the majority of infected people neither seek nor receive medical treatment. In any case traveling to seek treatment is difficult due to the crippling nature of the disease during its manifest period. This situation results in severe underreporting of dracunculiasis and the necessity of improved epidemiologic surveillance of the disease to reliably understand its incidence and distribution.

Finally, because the disease is uniquely related to water usage patterns, local practices, taboos, and taste preferences must also be considered in the design of any strategy to control the disease. Intervention programs must address both the use of water in the household (involving education of women) and the consumption of water by men working in fields sometimes several days' distance from the home. It should be noted in this context that provision of tube wells or other protected water supplies in villages will not be enough, for many cases of dracunculiasis result from field workers drinking from contaminated water supplies while working elsewhere. The World Neighbors program in Togo has addressed this problem by successfully encouraging the use of cloth filtration into the drinking gourds commonly used by male field workers away from home.

Chapter 3

INTERVENTION MODULES AND COST ESTIMATES

This paper discusses four distinct components important for the investigation, control, and eradication of dracunculiasis. Two of these components or modules (epidemiologic surveillance and community participation/community health education) are necessary for any general strategy to address the problems of dracunculiasis, or for that matter virtually any other problem of community public health in the developing world. The other two approaches (community water supply and chemical treatment to control the vector) comprise technical interventions that normally are considered as mutually exclusive and alternative approaches. The costs for each of these two aproaches are considered separately in conjunction with the cost of the first two modules.

The discussion below presents approaches to controlling dracunculiasis, and contains the modules necessary for a comprehensive program of dracunculiasis control in an endemic country where few, if any, other programs are underway. In reality, however, comprehensive, vertically-oriented programs for the control and eventual elimination of dracunculiasis will be difficult to initiate; additional vertical program efforts such as that for malaria control probably will not be encouraged by bilateral and multilateral funding agencies within current-day funding and programmatic restrictions. More practical might be a core focus relating to guinea worm coordination, with the major effort being on integrating guinea worm control activities with other projects, e.g., primary health care, water and sanitation, and other disease eradication efforts such as those for schistosomiasis and onchocerciasis. The largely categorical program model for dracunculiasis control in India appears only partially applicable to the West African situation, although it does provide examples of necessary program components.

The purpose of breaking out approaches to the control of dracunculiasis into four distinct modules (with separate cost estimates developed for each) is to allow ease of integration of these elements with many existing rural development projects, whether these projects exist in the water supply and sanitation sector, the health sector, or the agriculture/rural development sector. Integration with existing projects would reduce additional salary, per diem, fuel, transportation, and other costs from what they would be for a vertical program effort. It is felt that many existing projects, such as those mentioned above, have the possibility of being modified in relatively minor ways which would result in these projects also being effective in the effort to control guinea worm. It is further anticipated that the appeal of relatively cost-effective project modifications for the possibility of a very visible program outcome would facilitate the adoption of the necessary components to allow existing projects to serve as the foundation for effective dracunculiasis control/eradication projects.

Costing by modules also recognizes that the benefits of any one activity may extend beyond the immediate objectives of guinea worm control. Estimated costs related to guinea worm control alone are therefore provided for each of the modules. Conservative (i.e. high cost) estimates of the percent of costs attributable to guinea worm are made, varying from 100 percent (for the epidemiologic surveillance and chemical control modules) to 50 percent (for the community participation/community health education module) and 40 percent (for the community water supply module) of the total module's cost. Overall program costs are presented in both a "total" and an "estimated cost related to guinea worm control" format.

Example costs are developed for an inland West African country, such as Burkina Faso. Costs for a coastal West African country, such as Benin (as discussed by Isely and Jordan, 1984) would be relatively lower due to reduced costs for transportation of goods and equipment. Costs for Pakistan, as a guinea worm-endemic Asian country not currently having an ongoing dracunculiasis eradication program, may be inferred from the India experience to the extent that step wells (for which chemical treatment/vector control is particularly appropriate) are common water sources. In actual practice, the components of each country's infrastructure are sufficiently different that separate cost estimates for each program are necessary. For accurate cost estimates of any possible dracunculiasis control project, or add-on to an existing project, the particular situation of the endemic country setting must be fully taken into account. The purpose of the cost estimates in this chapter is to provide examples of the items that need to be considered, to provide the basis for the cost-benefit analysis in the next chapter, and to give a relative scale of their costliness in relation to each other and to other program costs with which the reader might be familiar.

Cost information was integrated from several different sources, all with their origin in West African projects. These sources include: (1) Centers for Disease Control (CDC) reports on Togo, Benin, and Ivory Coast prepared by Weniger (1983a-c); (2) a project proposal prepared for dracunculiasis control in Burkina Faso (Yada, et al., 1984); (3) experience from the Agu Community Health Project in Togo, implemented by World Neighbors (1985); and (4) various WASH reports and sources (e.g., Isely and Jordan, 1984; Preble, 1984; Preble and Rumph, 1984).

Costs are developed for a program to address dracunculiasis where a target 100 villages would be reached in two years with a program of epidemiologic surveillance, community participation/health education, and either community water supply or chemical treatment. An extended program where 400 villages would be reached in five years provides an alternative scenario for which the costs can be developed by simple multiples of the first program's costs, with allowances for inflation and other cost increases. It is assumed that there would be an average total population of 500 persons per village for a total of 50,000 people to be served. This program represents an immediate, short-term effort of the minimum length possible within which a program effect to address dracunculiasis could be expected. The longer (5 year) program would represent an extended effort which could achieve substantial progress toward more thorough dracunculiasis control. The extended program would also provide the means which, coupled with similar efforts in other endemic locales, might allow eradication of the disease.

Finally, when considering costs, it should be noted that dracunculiasis control/eradication efforts differ from most other communicable disease control efforts in that, if ultimately successful, they do not have long-term recurring costs. Guinea worm disease is unique in that effective programs can theoretically break the cycle of transmission in one year, with "dracunculiasis elimination" being defined as 24 continuous months of complete absence of new indigenous (i.e., non-imported) cases, given the presence of an active surveillance system (National Academy of Sciences, 1983). As discussed above, therefore, two years represents a minimum length program, with five years representing the more extended length of time effective programs would be necessary to move toward eradication of dracunculiasis in a particular region, country, or area.

3.1 Epidemiological Surveillance Module

3.1.1 Objectives

The objectives of epidemiologic surveillance efforts in a dracunculiasis control program would be to: (1) conduct specialized baseline and follow-up epidemiologic assessments to identify endemic areas of dracunculiasis and determine the disease prevalence and distribution; (2) maintain ongoing contact with health workers and other public officials to improve overall recognition and reporting of the disease; and (3) conduct appropriate epidemiologic data analysis and reporting activities regarding dracunculiasis.

3.1.2 Activities

Baseline surveys/studies need to be conducted to identify endemic areas and determine disease incidence and distribution based on: (1) a review of existing health surveys, documents, and routinely reported statistics; (2) soliciting expert opinion or knowledge; and (3) conducting field epidemiological surveys through village/household interviews during the transmission season for dracunculiasis, or through serodiagnostic techniques at other times of the year as such tests are developed and shown practical. It is assumed that short screening surveys would be conducted annually at all villages, with a random selection of 10 percent of the villages receiving a more in-depth survey effort. Annexes to Weniger's (1983a-c) reports provide guidelines for enhanced surveillance of dracunculiasis, including budget estimates and sample search forms.

In Benin, a simple screening system was adopted in which a single identified case resulted in the village as a whole being classified as endemic. Although this method does not distinguish imported cases from local infection, and does not quantify prevalence, it does provide a rapid means of assessing the scope of the problem if carried out over a large area. In-depth surveys can be used for more reliable assessments where they are needed, and serodiagnostic screening offers future promise of even more precise assessment of disease prevalence. It is important to stage the intensity of the surveillance effort to the surveillance needs, and not collect more detailed data than is actually needed in the control effort. However determined, dracunculiasis endemicity can be used as one criteria for targeting of water supply projects. To summarize, baseline and ongoing survey efforts regarding dracunculiasis can be free-standing or part of a larger health survey program, and can use existing or specially recruited personnel.

Liaison with health workers and other public health officials allows ongoing epidemiologic surveillance of dracunculiasis through use of existing or modified health records as part of the health reporting system. Use of the existing reporting system, however, implies the necessity for assessment of existing forms, the design of possible modifications, and gaining approval and support for new forms or modifications that are found necessary. At the present time, unfortunately, dracunculiasis is a reportable disease in only a few of the endemic West African countries. In addition to gaining official recognition for the disease, training and instructions for any new or modified forms, as well as printing, distribution, promotion, and follow-up all are necessary. In a country setting where effective and ongoing primary health training programs exist, the development of special materials, programs, and/or manuals might be appropriate and necessary to gain attention to the disease.

Gathering of information from "sentinel" sites comprises another method of epidemiologic surveillance. This method, as described for the India dracunculiasis eradication program, involves establishment of sentinel sites for dracunculiasis reporting, usually schools, markets, or health centers (National Institute of Communicable Diseases, 1983). Establishment of a sentinel site system also involves the training and support of people to take reports of disease incidence, and the need for follow-up of reported cases. Since most persons in the symptomatic period of dracunculiasis are immobilized and do not go to the marketplace or school, only second-hand reporting can be expected at sentinel sites; however, because the disease is so easily recognizable such reporting can be considered fairly reliable.

As with the use of the existing health information, use of sentinel sites reporting will also involve the design or modifications of forms and reporting materials. An information campaign could be designed to promote reporting, involving both the printed media (newspapers, billboards, posters, flyers) and electronic media such as radio and traveling filmstrip, film, or videotape shows. Further, information campaigns should go beyond the roadside market towns and reach out into the more remote village areas where dracunculiasis exists as a severe problem. Cooperation and involvement of diverse and sometimes only loosely related organizations and agencies may be necessary. Finally, the costs and problems of design and production of creative and locally-appropriate promotional/informational materials must be considered. Depending upon the extent of current work load, existing "animateurs" used for other programs, such as family planning or community development, could be fairly simply retrained to fill the epidemiologic surveillance field worker role for dracunculiasis.

Among other active epidemiologic surveillance techniques are: (1) in-depth case finding at the house-to-house or village level; (2) identification of copepod-infested water supplies when chemical treatment comprises part of the dracunculiasis eradication strategy; and (3) as a potentially sensitive but technology-dependent method, serodiagnostic techniques to quantify disease prevalence, as described above. The first two methods are most reliable when undertaken as a seasonal activity during the peak periods of infection/ disease manifestation; this implies the possible use of seasonal employees, or cooperative employment of part-time persons who act in other capacities during other seasons.

Because of the well-known and easily recognizable nature of dracunculiasis in endemic areas, active surveillance through seasonal case finding does not generally require individuals with highly specialized training, and thus could be accomplished with less expensive personnel than might be necessary in other health monitoring efforts. Drawbacks to active case finding include the time required and underreporting that still might result from overlooking some pre- and post-symptomatic cases, cases of cryptic infection where the worm does not emerge, and cases where the affected individual, if female, may be sequestered for cultural reasons. Since most interventions are community- or at least family-based, it is not necessary, however, that every case be detected. If one truly indigenous case in a community is detected, then intervention is indicated for the whole community.

The second method of active surveillance, identification (and subsequent treatment) of vector-infested water supplies, is confronted by special problems of identifying occasional and ephemeral drinking water sources, which may change during a season and quite often from year to year. Further, surveillance for the copepod vector itself requires the use of specialized equipment for collection and counting, thus requiring additional training and material support for the workers. Finally, ephemeral sources may occur in areas frequented most often by nomadic or dispersed populations, thus making the use of local informants difficult for identifying these sources.

The last method for active surveillance, serodiagnostic techniques as described by Kliks and Rao (1984), offers promise because these techniques could be utilized at any point during the year and, given proper sampling techniques, could provide accurate estimates of disease prevalence. At the present time, however, the field methodologies for their use have not been tested in a large scale effort.

3.1.3 Assumptions

It is assumed that moderate epidemiologic surveillance capacity would be available in any country undertaking a dracunculiasis control program; this would include an existing, if rudimentary, health reporting/health information system, a cadre of service delivery-level health workers to carry out baseline and follow-up surveys, and basic transportation availability. If surveillance of infested drinking water supplies for potential chemical treatment is to be carried out, then a more sophisticated system of monitoring and reporting would be required, perhaps involving other ministries (such as agriculture). It is further assumed that the country would not have any capacity to implement serodiagnostic techniques.

3.1.3.1 Scope of initial effort/baseline assessment

It is assumed that the scope of the initial effort would include assessment of local expert knowledge, review of existing reports, surveys, and records, and development of whatever supplementary effort is necessary to make an adequate epidemiologic assessment to identify the endemic areas of dracunculiasis, as well as disease incidence and distribution. Cost items would include: (1) reporting and recording forms for the initial assessment and surveys (if any), as well as for ongoing surveillance work; (2) promotional/informational material, including a manual or other material on dracunculiasis for training of health workers or others in the primary health care system who might be involved in the surveillance effort; and (3) the actual training itself. Additionally, there are costs for epidemiology/public health consultants (local or expatriate) to assist in the development of the surveillance system.

3.1.3.2 Scope of ongoing effort

Determining the scope of the epidemiologic surveillance effort necessary in a particular country setting will require examining in detail the systems currently in existence. For an active surveillance effort implementation would involve setting up a structure for conducting village surveys, hiring and training of a small permanent staff to handle administration, field supervision, and data analysis, and the means of hiring, training, and supporting a part-time or temporarily-assigned field staff to conduct the actual surveys.

Passive surveillance efforts, if undertaken, would involve identification and recruitment of local "sentinel sites" and informants, establishment of a reporting and follow-up and visitation system at the sentinel sites, and development and annual dissemination of promotional/informational material.

Finally, the epidemiologic surveillance effort would need to include a system for ongoing data analysis and reporting to provide program feedback based on epidemiologic data. Because of the nature of the disease, this system could be as simple as an annual evaluation of reported cases along with progress reports regarding program implementation. Ongoing feedback on disease incidence and prevalence is necessary to allow program modifications as might be appropriate during implementation.

3.1.4 Cost Items

Four categories of cost items related to epidemiologic surveillance are shown in Table 1: (1) baseline and follow-up screening surveys; (2) baseline and follow-up in-depth surveys; (3) liaison with health workers and other public officials; and (3) data analysis and reporting. Assumptions and comments relating to the various line items, other than those discussed above, are provided in the table. The total estimated per-village costs for epidemiologic surveillance relating to guinea worm control would be $18,650 for 100 villages over 2 years, or approximately $187 per village.

3.2 <u>Community Participation/Community Health Education Module</u>

3.2.1 Objectives

The objectives of community participation and community health education efforts are to gain community and individual understanding, involvement, and initiative for the local control of dracunculiasis. Although the two efforts integrally fit together, distinct sets of activities are described, relating to both community participation and community health education.

3.2.2 Activities--Community Participation

Community participation/community organization is necessary to involve the local community directly in the design, implementation, and ongoing support and management of any dracunculiasis intervention, including epidemiologic surveillance, community health education/information/personal prevention, community water supply, or chemical application. Community participation is further useful in involving the local residents as informants, particularly for case finding and identification of contaminated water sources, and in gaining widespread acceptance of behavior changes such as use of protected water sources or filtration of potentially polluted water. Control of dracunculiasis can serve as the starting point for more active participation by the village people in other activities. As both a highly visible condition and one amenable to interventions carried out by the villagers themselves,

Table 1. Cost Items: Epidemiologic Surveillance Module
Immediate Program—100 villages, 2 years, 50,000 people

Activities/Items	Assumptions	Units	Unit Cost (US$)	Number of Units	Cost US$	Comments
A. Baseline and Follow up Surveys						
(Screening surveys)	90% of sites	villages		100		All villages to be visited both years.
1. Technical labor						
--salaries, perdiem						
a. Local, skilled	2 villages/3 days	person-days	5	270	1350	assume 10 local survey specialists (13-15 days/yr to complete)
b. Expatriate	1 consultant	person-days	300	18	5400	Includes 3 travel days but not ticket cost. First year only.
—material development						
2. Training						
a. Local personnel	annual sessions	person-days	8	40	320	10 indiv, 2 days training, 2 years
b. Expatriate	1 consultant	person-days	300	4	1200	
3. Transportation	fuel, oil, repairs;	km	.60	3600	2160	Operating costs only; assumes 4 WD vehicle or motorcycle
to conduct surveys	20 km btwn villages					availability.
a. Drivers	for 1/2 of surveyors	person-days	3	70	210	
4. Materials						
a. Training material	per surveyor	persons	4	20	80	
b. survey material	per village	villages	1	180	180	printing and duplic. costs (WN)
c. recognition cards	per village	villages	.50	180	90	printing and duplic. costs (WN)
5. Total, screening surveys	both years	villages		180	10990	
B. Baseline and Follow up Surveys						
(Indepth surveys)	10% of sites	villages		20		10 villages ea yr
1. Technical labor						
--salaries, perdiem						
a. Local, skilled	1 village/3 days	person-days	5	60	300	3 indiv., 10 days to complete
b. Expatriate	1 consultant	person-days	-	-	-	include in consultancy for screening surveys.
—material development						
2. Training	annual sessions					
a. Local personnel		person-days	8	12	96	3 indiv, 2 days training, 2 years
b. Expatriate		person-days	-	-	-	include in consultancy for screening surveys.
3. Transportation	fuel, oil, repairs;					
to conduct surveys	20 km btwn villages		.60	400	240	Operating costs only; assumes vehicle or motorcycle
a. Drivers	for 1/2 of surveyors	person-days	3	30	90	availability.

4. Materials						
a. Training material	per trainee	persons	4	6	24	
b. survey material	per village	villages	2	20	40	printing and duplic. costs (WN)
c. recognition cards	per village	villages	.50	20	10	printing and duplic. costs (WN)
5. Total, indepth surveys	both years			20	800	consultant costs included under screeening surveys
Total, surveys	both years	villages		200	11790	cost per survey approx. $60.
C. Liaison with health workers and other public officials	(at district and national level)					to promote the use of improved reporting and data collection regarding Guinea worm
1. Technical labor —salaries, perdiem						
a. Local, skilled	existing personnel, part-time	person-days	5	180	900	3 indiv; 30 days per year
2. Training/District Meetings						For health workers and other personnel
—district personnel		person-days	4	160	640	20 persons, 2 districts, 2 days, 2 yrs.
a. Planning costs		per session	100	4	400	district level training meeting (2 districts, 2 years)
3. Forms and material development —design —production	initial year only		500	1	500	Design and produce hierarchy of reporting forms (CDC)
D. Data analysis and reporting						
1. Technical labor —salaries, perdiem						
a. Local, skilled	existing personnel, part-time	person-days	5	180	900	3 indiv; 30 days/yr
2. Training						
a. Local personnel	5 day session	person-days	8	15	120	First year only.
b. Expatriate	1 consultant	person-days	300	8	2400	Includes 3 travel days but not ticket cost. First year only.
3. Reports and materials	per year		500	2	1000	preparation, duplication, and distribution (CDC)
				Total	18650	Cost per village approx. $187
	Percent assumed "chargeable" to guinea worm control program				100%	
	Estimate cost related to guinea worm control				18650	Cost per village approx. $187

guinea worm control can be the initial success from which other strong community participation efforts result. As an example, the World Neighbors Togo project did not start out as a guinea worm control project. Guinea worm control, however, was an initial perceived need by the villagers, and success in its control has led to subsequent efforts in promoting oral rehydration therapy and vaccination campaigns.

For community participation efforts, it is often necessary to work with existing organizations, such as a village health committee, a village development committee, or a traditional structure such as a council of elders. It might be necessary first to establish such an organization, if none exists, in order to promote and maintain the interventions. It is also necessary to work with such an organization to establish a system to collect and manage contributions for materials and necessary spare parts and equipment. In some cases, village school teachers can be utilized as on-site contacts who often have the trust and respect of the villagers, and who have some exposure to concepts involved in change and development.

3.2.3 Activities--Community Health Education/Information

Community health education/information activities require the direct involvement of health workers to provide personal prevention information for dracunculiasis, specifically a simplified natural history of the disease: its causes, consequences, and preventability. Part of this effort might be showing villagers the copepods in the contaminated water. Promotion and use of materials or manuals developed for the training of primary health care workers (as necessary for proper epidemiological surveillance as described above) would be necessary to gain the full involvement of the existing cadre of primary health care workers.

Because of the remarkable cycle of the disease, there can be an effective seasonal nature to health information activities, thus allowing the possible use of shared or part-time workers. Community health education activities, in addition to providing information regarding the disease, should emphasize personal preventive activities such as filtering water with non-clogging monofilament cloth (an item which must be supplied from the outside and which has an associated but relatively minor cost) or with double-folded cotton cloth (less effective and convenient, but universally available). The more efficient monofilament filters can be set up on fixed frames either at the home or at the source to facilitate their use, or can be built into small portable funnels to encourage their use by field workers away from their usual sources of water. Additionally, two other potential means of personal prevention include fixed sand filters and solar killing, as discussed earlier.

Other community and personal preventive activities that would be included in any community health education effort regarding dracunculiasis include: (1) advice on avoiding consumption of untreated surface water; and (2) information on treatment of the condition, such as keeping the ulcer/worm covered with a bandage, avoiding entering water sources when disease is symptomatic, tetanus immunization, and reporting the occurrence of the disease to health center or other health authorities (e.g., at one of the sentinel sites).

Finally, community health education activities regarding the disease intersect with community participation activities through the organization, training, follow-up, and ongoing support of village activities for direct intervention strategies such as community water supply and vector control/chemical treatment strategies.

With improved community water supplies, it is necessary that community health education and long-term community participation strategies be developed for: (1) system operation and maintenance; (2) spare parts acquisition and storage mechanisms; and (3) village contributions for ongoing operation of the system.

Regarding vector control/chemical treatment strategies, organization, training, and support at the village level is necessary for: (1) proper storage and application procedures for chemical usage; (2) training in water source measurement and reading of chemical application tables after they have been developed; and (3) village contributions for purchases and resupply procedures.

3.2.4 Assumptions

To carry out the activities of the community participation/community health education module, it is assumed that one health promoter, health educator, or health assistant, each with a motorbike, would be sufficient per 10 villages with an average population of 400-600. For the purposes of supervision, it is assumed that one district-level supervisor per 5-10 promoters will be adequate. It is assumed that transportation in the form of a light motorcycle or "camionette" would be available to each supervisor. Although a portion of the training and promotional material developed for the epidemiologic surveillance module may be directly applicable for the community health education module, new material related to this module may have to be developed as it relates to community participation.

3.2.5 Cost Items

Cost items for the community participation/community health education and information module as shown in Table 2 include the following:

A. Local personnel--promoters (1 per 10 villages) and supervisors (1 per 5 promoters);

B. Training of promoters and supervisors in community participation and health education. It is proposed that this be accomplished through annual training sessions of three days length;

C. Technical training of promoters and supervisors. Costs and details for this item will vary according to specification of other intervention modules; e.g., use of improved water supply methods and/or chemical treatment for vector control. Seven-day annual training sessions are assumed, including travel time;

D. Transportation costs, in terms of transportation reimbursement for the purposes of the training programs, and in terms of purchase and upkeep of motorcycles/motorbikes for on-the-job usage; and

E. Materials and support costs relating to: (1) training programs; (2) community participation/health education material development and distribution; and (3) filtering sieve material.

Table 2. Cost Items: Community Participation/Community Health Education Module
Immediate Program—100 villages, 2 years, 50,000 people

Activities/Items	Assumptions	Units	Unit Cost (US$)	Number of Units	Cost US$	Comments
A. Technical labor	salaries, perdiem					
1. Promoters	1 per 10 villages	person-month	60	240	14400	village recruited; 10 promoters, 24 months
2. Supervisors	1 per 5 promoters	person-month	90	48	4320	2 supervisors, 24 months
B. Training, commun. participation and health education						
1. Community participation	3 day annual sessions	person-days	8	96	768	10 promoters, 2 supervisors per session. Includes salary
2. Health education	3 day annual sessions	person-days	8	96	768	and perdiem for travel days to/from training.
3. Expatriate	consultant	person-days	300	8	2400	Includes 3 travel days but not ticket cost. First year only.
C. Technical training —community water supply —chemical treatment	7 day annual sessions	person-days	8	240	1920	As appropriate for selected strategies. Includes salary and perdiem for travel days to/from training.
1. Expatriate	consultant	person-days	300	8	2400	Includes 3 travel days but not ticket cost. First year only.
D. Transportation						
1. Training programs	ave trans costs	per trainee	10	24	240	transportation per person, both years, for training
2. On-the-job						
a. Motorcycle purchase	per promoter	per cycle	1000	10	10000	WN
b. Motorcycle operation	fuel, oil, repairs	per cycle	500	20	10000	operation and maintenance per year (WN)
E. Materials and Support						
1. Training						
a. Planning costs		per session	500	2	1000	
b. CP/Hlth Ed		per session	100	2	200	
c. Technical training —equip and supplies	CWS or chem control	per session	200	2	400	
2. CP/Hlth Ed materials —posters, brochures, A/V	per promoter per year disease & intervention specific		500	20	10000	resource and training materials provided to promoter
a. Mater. devel. & product.	new material	per year	2000	2	4000	WN
3. Filtering sieves	monofil. sieve material	per sieve	.80	5000	4000	$4 per sq meter; approx 15 pieces sieve material
	other material	per sieve	.50	5000	2500	500 sieves per promoter; 50 per village
				Total	69316	Cost per village approx. $693
	Percent assumed "chargeable" to Guinea worm control program				50%	
	Estimate cost related to Guinea worm control				34658	Cost per village approx. $347

Assumptions and comments relating to the various line items, other than those discussed above, are provided in the table. The total estimated costs for the community participation/community health education module would be approximately $69,316 for 100 villages over two years, or approximately $693 per village. It is assumed that approximately 50 percent of the benefits of a community participation/community health education program would accrue to other health and community efforts. Estimated costs related to dracunculiasis control alone, therefore, are 50 percent of this total, or approximately $347 per village over two years.

3.3 Community Water Supply Module

3.3.1 Objectives

The objectives of community water supply interventions are to provide protected and acceptable water free from infestation by the copepod vector in a quantity sufficient (20 to 30 liters per person per day--this figure including water for drinking, cooking, bathing, and washing) to prevent the necessity of the population seeking drinking water from other, possibly contaminated, sources. This objective might be met by prioritizing existing drinking water programs in order to target dracunculiasis-endemic areas first, or at least early, in the project.

3.3.2 Activities

Community water supply improvement can proceed by at least four main approaches, depending upon local conditions and resources: (1) tube well construction or rehabilitation; (2) dug well construction; (3) capped springs; and (4) gravity system construction. It should be noted, however, that just the provision of a clean water source is not sufficient. Additionally, the population must be convinced that the new source or sources are preferable compared to the traditional sources, even if they might be less convenient, taste different, or have other drawbacks. Further, any community water supply schemes require the initial participation of the local population for the planning and execution of the project, and ongoing organization and participation of the local population for operation and maintenance.

Initial activities have to include a hydrologic assessment of areas targeted for the intervention effort, including: (1) identification of usual sources of water; (2) determining the feasibility of new boreholes; and (3) determining the potential for existing borehole rehabilitation and/or spring capping and gravity systems. A simple classification scheme for the water sources which could be helpful might be similar to the classification scheme used in Uganda (Fontaine, 1983) where water sources were classified as either protected, man-made, unsafe, or naturally occurring.

3.3.2.1 Tube wells

Activities necessary for tube well construction or rehabilitation are by far the most expensive, complex, and capital equipment-dependent approach to improvements in community water supply. Tube wells have the advantage, however, of being resistant to surface pollution and functional over a long period of time if a system can be established for the reliable maintenance of the handpumps and other mechanical components. Requirements for tube well construction or rehabilitation include heavy equipment such as drill rigs and drill rig maintenance vehicles as well as skilled and semi-skilled labor to operate the rigs. Specific steps necessary to implement a tube well project include: (1) community organization and education; (2) well site selection; (3) drilling, testing, and necessary masonry work; (4) pump installation; and (5) training in, and ongoing maintenance for, the systems. If well drilling/rehabilitation is done by private contractor and not through the government or a specific water supply program, then the additional intermediate step of negotiation with the contractor must be added; however, the substantial costs of purchasing drilling equipment and setting up the necessary systems for carrying out a well drilling program could be avoided.

3.3.2.2 Dug wells

Activities regarding dug well construction are more amenable to local initiation and participation than tube well construction, and may also be substantially less expensive. Further, dug wells can have other advantages over tube wells in that: (1) they are more familiar to the local people, facilitating training for maintenance; (2) they tend to avoid the disagreeable mineral taste common with tube wells; and (3) they can often be utilized cooperatively or by more than one person at a time, thereby being more time-efficient in providing water, assuming an adequate recharge rate for the well. In some areas, however, dug wells may not be feasible due to the depth of the water table or the necessity for blasting through rock layers. In those cases, tube well drilling may prove less expensive than rock blasting and aspiration. An additional disadvantage is that dug wells are also more likely to be contaminated by external sources.

As in tube wells, specific steps for implementation include: (1) community organization and education; (2) well site selection; (3) negotiation with potential contractors; (4) digging and blasting as necessary; (5) well lining and other masonry work; (6) pump installation for closed wells; and (7) training in and ongoing maintenance for the systems.

3.3.2.3 Capped springs

Activities regarding capped springs are only slightly more complex than those for dug wells. In the few dracunculiasis endemic areas where these types of systems are appropriate, it is likely that the local people will have some orientation or knowledge toward the methods, and will be able to respond to levels of support and initiation similar to those necessary for dug well construction. Specific steps include: (1) establishing the necessary community involvement and determining the appropriate sites for capped springs systems, taking into account not only the hydrologic characteristics of the site but also the population distribution and preferences of the potential users; (2) preparing of designs and material and cost estimates; (3) acquiring, transporting, and storing the necessary materials and supplies, including cement, sand and gravel, PVC pipe and connectors, as well as tools and other materials as necessary; and (4) establishing community participation for the initial construction of the system and for its long-term operation and maintenance.

3.3.2.4 Gravity systems

Although requiring few mechanical parts, gravity systems can be complex in terms of the quantity of material required for their installation (pipe, connectors, concrete and cement, etc.) and in terms of local negotiation regarding where the pipe should be laid, and where distribution tanks, reservoirs, and taps should be constructed. Further, the substantial logistics behind preparing the trench, laying the pipe, and building the tanks or reservoirs must also be considered.

In conjunction with gravity systems, slow sand filters to remove the vector (as well as other pollutants) might also be considered (Sridhar, Kale, and Adeniyi, 1985). Although regular maintenance is necessary, upkeep of sand filters is relatively straightforward, and would lessen concerns about contamination of the source of the gravity system, which may be several kilometers away from the point(s) of consumption of those responsible for the system's upkeep, and therefore less under their control.

3.3.3 Assumptions

A critical assumption regarding a tube well construction or rehabilitation program is that an adequate road system exists to move equipment and supplies. The fact that most dracunculiasis endemic areas are remotely located indicates that this assumption may not be acceptable in parts of many countries. The appropriate water supply intervention, therefore, may be other than a tube well; or a different intervention strategy entirely, such as chemical treatment, may be the most feasible in some areas.

For the illustrative purposes of this paper it is assumed, however, that the proportion of various types of water supply systems among the systems presented above will be as follows:

1. Tube well construction/rehabilitation--45 percent of all villages to be served (35 percent new construction, 10 percent well rehabilitation). Costs include the purchase and maintenance of major well drilling equipment. If such equipment is already available and functioning in-country then substantial cost-savings per well can be realized.

2. Dug well construction--45 percent of all villages to be served.

3. Capped springs--2 percent of all villages to be served. Costs are assumed to be in same range as dug wells; separate site-specific estimates will have to be made.

4. Gravity systems--8 percent of all villages to be served. Costs are assumed in same range as dug wells, although again site-specific surveys and estimates will have to be made.

3.3.4 Cost Items

Cost items for a water supply improvement module are shown in Table 3. Activities for the four specific types of water source interventions described above are costed, as well as the initial activity of hydrogeologic surveys necessary to determine the feasibility of different alternatives, and ongoing maintenance activities necessary for any system.

Table 3. Cost Items: Community Water Supply Module
Immediate Program—100 villages, 2 years, 50,000 people

Activities/Items	Assumptions	Units	Unit Cost (US$)	Number of Units	Cost US$	Comments
A. Hydrogeologic surveys		villages		100		
1. Technical labor	salaries, perdiem					
a. Local, skilled	senior professionals	person-days	30	150	4500	5 indiv, 30 days (2 villages/3 days)
b. Expatriate	consultant team	person-days	300	26	7800	Includes 3 travel days but not ticket cost; 2 indiv, 10 days
—hydrology						
—geology						
—sanitary engineering						
2. Materials and supplies	for survey effort		2500	1	2500	
—survey equipment	(first year only)					
—supplies						
3. Transportation to conduct surveys	fuel, oil, repairs; 20 km btwn villages	km	.60	2000	1200	operating costs only; assumes 4 WD vehicle availability
a. Drivers	for 1/2 of surveyors	person-days	3	75	225	
4. Total, hydrogeologic surveys					16225	
B. Tube well constr. and repair						
1. New construction	at 35% of sites	wells		35		12500 per well (BF)
a. Labor	salaries, perdiem					
(1) Local, skilled		person-days	5	3500	17500	10 indiv, 10 days per well
—drilling						
—testing						
—pump install.						
—masonry						
—maintenance						
(2) Local, unskilled	volunteer labor avail.	person-days	--	5250	--	15 indiv., 10 days
(3) Expatriate	consultant team	person-days	300	36	10800	Includes 3 travel days but not ticket cost; 2 indiv, 15 days
—sanit. engineering						
—maintenance advisors						
b. Equipment and materials						
(1) Drill rigs	new or recondit. vehicle	per rig	100000	2	200000	cost based on new vehicle
—operators	local personnel	person-days	25	280	7000	4 days per well; 2 operators
(2) Drill rig spare parts		per rig	25000	2	50000	
(3) Well test equipment		per well	200	35	7000	
(4) Maintenance vehicles		per vehicle	12500	1	12500	BF
(a) Operation		per year	6250	2	12500	operation cost per year assumed one-half purchase cost.
—fuel, oil, spare parts		km				operation cost by distance travelled: \$2.50/mi = \$1.55/km (WASH)
—drivers, mechanics	local personnel	person-days				included in operation cost estimate

(5) Handpumps		per pump	225	35	7875	
(6) Equip. to install handpumps		per pump	100	35	3500	
(7) Handpump spare parts		per pump	25	35	875	
(8) Cement, other material		per pump	500	35	17500	50 bags of cement; reinf. bar and tools
(9) Warehousing and storage		per year	500	2	1000	
—vehicle repair facilities						
c. Total, tube well contruction					348050	Cost per well approx. $9444 (35 wells)
2. Well rehabilitation	at 10% of sites	wells	7955	10	79554	Assume 80% of the cost of new well construction.
C. Dug well construction	at 45% of sites	per well		45		
1. Labor	salaries, perdiem					
a. Local, skilled		person-days	5	9000	45000	10 indiv, 20 days, per well, 45 wells
—digging						
—masonry						
—pump install.	at 25% of wells	person-days	5	300	1500	5 indiv, 5 days, per well, 12 wells
b. Local, unskilled	volunteer labor avail.	person-days	—	6750	—	15 indiv, 10 days, per well, 45 wells
2. Equipment and materials						
—excavating tools	1 set per well	per set	200	45	9000	
—blasting and aspiration equipment	at 25% of wells	per well	500	12	6000	
—head frame, pulleys	at 75% of wells	per well	250	34	8500	
—handpumps	at 25% of wells	per pump	225	12	2700	
—equip. to install handpumps		per pump	100	12	1200	
—handpump spare parts		per pump	25	12	300	
—cement, other material		per well	500	45	22500	cement, reinf. bar, and tools
3. Total, dug well construction					36700	Cost per well approx. $2149. (45 wells)
D. Capped springs	at 2% of sites	per spring	2149	2	4298	Assume costs in same range as dug wells;
1. Labor	salaries, per diem					Site-specific surveys and estimates have to be made
a. Local, skilled		person-days				
—surveyors						
—pipelayers						
—masonry						
—maintenance						
b. Local, unskilled	volunteer labor avail.					
—maintenance						

2. Equipment and materials						
a. Survey equipment						
b. PVC, GI pipe and connectors						
c. Tools						
d. Cement and other supplies and connectors						
c. Tools						
d. Cement and other supplies						
E. Gravity systems	at 8% of sites	per system	2149	8	17192	Assume costs in same range as dug wells;
1. Labor	salaries, perdiem					Site-specific surveys and estimates have to be made
a. Local, skilled		person-days				
—surveyors						
—masonry						
—maintenance						
b. Local, unskilled	volunteer labor avail.					
—maintenance						
2. Equipment and materials						
a. Survey equipment						
b. PVC, GI pipe and connectors						
c. Tools						
d. Cement and other supplies and connectors						
c. Tools						
d. Cement and other supplies						
F. Maintanence requirements	all systems	per system	100			
a. Labor						
—local, unskilled	volunteer labor avail.	per village	--	2	--	assume elected/appointed by vill committee
b. Training	3 day annual sessions	person-days	8	1200	9600	both years
—transportation	average cost	per person	10	400	4000	aver. transportation costs to training sites, both years
c. Equipment and materials	per year	per village	75	400	30000	both years
				Total	605619	Cost per village approx. $6056
Percent assumed "chargeable" to guinea worm control program					40%	
Estimate cost related to guinea worm control					242248	Cost per village approx. $2422

Costs incurred for the water supply module will repay much greater benefits than just dracunculiasis control alone, and, as discussed earlier, total costs should not be considered "chargeable" solely to the dracunculiasis control program. The broad health and economic benefits of provision of clean water are well known and actively promoted through the International Drinking Water Supply and Sanitation Decade. The total costs presented here are for water supply programs in endemic dracunculiasis areas which would have controlling guinea worm as an important objective. Approximately 40 percent of the total costs of water supply improvements, therefore, are assumed chargeable to guinea worm control. The total costs for providing improved water supplies to 100 villages and with the distribution of water system types as described above is approximately $605,619 over two years, or $6,056 per village ($12.11 per person). The estimated cost per village related to guinea worm control would be approximately $2,422 ($4.84 per person).

3.4 Chemical Treatment Module

3.4.1 Objectives

The use of chemical treatment would interrupt the cycle of dracunculiasis through control/local elimination of the infected cyclops vector as the intermediate host. The objective of this strategy is to establish an effective ongoing system of chemical treatment of water supplies infested with cyclops. This strategy would have to include consideration of multiple and ephemeral water sources, resistance to drinking water perhaps having a peculiar taste, and training and community involvement for the purchase, storage, and application of the control chemical.

3.4.2 Activities

Chemical treatment of water can be undertaken when water supplies need to be made safe immediately and permanent sources of safe water cannot be provided soon. Chemical treatment allows an effective "quick response" to control dracunculiasis transmission, but must be accompanied in the long run by adequate provision for training, safety monitoring, storage, transportation, resupply, and evaluation of effectiveness. Further, functions and properties of the chemicals chosen must be explained to the villagers consuming the water, for the chemicals may impart particular flavors or odors to the water which may be found objectionable, and which could result in the villagers using alternative, untreated, and possibly contaminated sources.

Initial activities relating to chemical treatment include: (1) determining usual and seasonal sources of drinking water through interviews and surveys; (2) conducting surveys to map sources and measuring quantities and flows; (3) adapting application tables for specific use of the chemical of choice; (4) preparing the local population for use of the treated water supplies, or planning to treat all water supplies potentially used by the local population; (5) establishing local storage and resupply procedures; and (6) training of local personnel in measurement, table reading, and chemical application. Timing of the initial application of chemicals to just before the appearance of the guinea worm lesions is important to reduce copepod populations before contamination of drinking water sources occurs. Follow-up and support by the implementing agency is necessary for this strategy, as in all the others. The scheduling of this follow-up is facilitated by the need for water source retreatment at six- to eight-week intervals.

3.4.3 Assumptions

3.4.3.1 Technological

Control of the infected copepod vector in dracunculiasis through addition of chemicals to water presents a significant problem because the water being treated is used for human consumption. It is important, therefore, that the chemical be highly effective against the cyclops but additionally have low mammalian toxicity and low adverse effects on non-target organisms (Sharma et al., 1981). A number of different organochlorine and organophosphorus chemicals have been tried in laboratory situations (Muller, 1970; Sharma et al., 1981) and field settings (Krishna Rao et al., 1982; Sastry et al., 1978; Lyons, 1973). The resulting chemical of choice from these studies has consistently been temephos, an organophosphorus compound manufactured by American Cyanamid and marketed under the name "Abate" (Abate Larvacide, 1985). For the purposes of this discussion and the subsequent costing of the intervention, it is assumed that temephos/abate is the chemical being used. If further research indicates support for another chemical agent instead of temephos, then the cost estimates for chemical control may need revision.

3.4.3.2 Village level

For a chemical treatment strategy at the village level to be of maximum effectiveness, several conditions need to be present. First, there have to be consistent and reliable sources of still or slow moving water utilized by the population. The regular use of step wells in India is an example; however, this type of water source is not generally found in West Africa where water sources tend to be more transitory and not as well developed for usage. Second, in order to establish a village-level purchasing, storage, and application system, it is assumed a settled population is being served which can be organized through community participation for the tasks of water level/ water flow measurement, table reading, and chemical application in specific amounts. Third, there must be a reliable source of chemical, and a reliable storage and distribution system from the manufacturing center or point of importation on down to the village level. This system must include consideration of storage conditions (space needed, heat, humidity, etc.) as well as security. Finally, it is assumed that specific monitoring of levels of the chemical in the separate water sources is not necessary, although it may be necessary to monitor the strength and purity of chemical formulations prepared in-country.

Regarding utilization of this intervention, it is assumed that 80 percent of the endemic settings in West Africa will have appropriate water sources for chemical treatment with temephos/abate. Costs are developed for this module as an intervention distinct from that of the protection or improvement of community water supplies. It is further assumed that three applications of temephos/abate will be necessary per village for the duration of the dracunculiasis transmission season, the first right before the season begins, and two additional applications at six- to eight-week follow-ups.

Finally, the only current use of temephos/abate in West Africa relates to malaria and onchocerciasis control, and that introduction of temephos/abate in dracunculiasis control represents a new and perhaps unfamiliar strategy. India, on the other hand, has an ongoing program utilizing temephos/abate in the control of dracunculiasis, and that experience (and the prevalence of step wells suited to the strategy) may make the use of temephos/abate particularly appropriate in South Asia.

3.4.4 Cost Items

Cost items for the vector control/chemical treatment module are provided in Table 4. Chemical treatment activities include: (1) baseline surveys; (2) training of village-level applicators; (3) purchase of temephos/abate; (4) storage and transportation; and (5) ongoing follow-up and support.

Baseline surveys would be to determine feasibility for chemical treatment and to carry out the measurements and mapping necessary to prepare application tables. It is assumed that agricultural workers will be available to be trained and utilized for the field work involved in this task.

Village-level training includes both the training necessary at the village level for local people to be able to apply the chemical and the simple equipment and material (measuring rods, scoops, charts, etc.) necessary for village applicators. This equipment would be distributed as part of the training program.

Calculation of the necessary amount of temephos/abate for treatment of village water supplies in 100 villages was based on the following assumptions. First, an average water consumption of 20 liters/day/person, was assumed as a minimum target water usage. For a village of 500, therefore, the daily village water usage (drawdown) would be 10,000 liters (10 cubic meters). The total volume of the water sources was assumed to be ten times the average daily usage, or approximately 100,000 liters. Three different scenarios on water replenishment were considered: (1) no replenishment, as in a solely rain-fed pond in which the water level consistently drops; (2) replenishment at the rate of drawdown, in which the source water level and volume remain constant; and (3) replenishment greater than drawdown, with resultant overflow. It is felt that scenario 3 is unlikely in most of the drought-stricken areas affected by guinea worm disease, and as regards chemical application, scenario 2 represents higher demands for the chemical than scenario 1. Calculations, therefore, are conservatively based on water source replenishment at approximately the same rate as drawdown.

Temephos/abate is available in three forms: (1) 98 percent technical grade; (2) "50 percent" emulsifiable concentrate (500E--500 grams/l); and (3) 1 percent sand granule (S.G.) formulation (Abate Larvacide, 1985). For the purposes of this paper, estimates are developed for use of both the 500E liquid and the 1 percent sand granules. In general, the sand granule formulation is preferred due to ease of application and greater effectiveness against the vector over time (Krishna Rao et al., 1982; Muller, 1970); however, the disadvantages of increased weight and bulk per unit of active product must also be considered. In countries with port-of-entry formulation capability, importation of technical grade temephos/abate and formulation of the 500E liquid or sand granules in-country could result in substantial transportation savings. These capabilities, however, require a substantially developed country infrastructure, and cannot be expected in most areas affected by guinea worm.

Table 4. Cost Items: Chemical Treatment Module
Immediate Program—100 villages, 2 years, 50,000 people

Activities/Items	Assumptions	Units	Unit Cost (US$)	Number of Units	Cost US$	Comments
A. Baseline surveys		villages		100		feasibility for chem treat determined through village surveys
1. Forms, materials, tables		villages		80		assume 80% of villages feasible for chem treatment
2. Surveys		villages		80		map sources; estim. frequency and applic amounts
a. Technical Labor						
—salaries, perdiem						
(1) Local, skilled	2 vill/3 days	person-days	5	150	750	assume 10 workers (15 days to complete)
—agric. ext. workers						
—health workers						
(2) Expatriate	consultants (2)	person-days	300	26	7800	Includes 3 travel days but not ticket cost; 2 indiv, 10 days
—entomology						
—public health						
b. Transportation	fuel, oil, repairs;					operating costs only; assumes 4 WD vehicle or
to conduct surveys	20 km btwn villages	km	.60	2000	1200	motorcycle availability.
(1) Drivers	for 1/2 of surveyors	person-days	3	75	225	
3. Survey training		person-days	8	20	160	2 days training, 10 indiv
4. Total, surveys for chem treatment					10135	cost per village approx. $100
B. Village-level training						
1. Training days	annual sessions	per village	10	320	3200	2 day village training sessions, incl materials
a. Trainers	agri or health workers	person-days	8	400	3200	10 trainers; includes prep and travel time and expense
2. Equipment and materials		per village	25	80	2000	
—chemical storage containers						
--scoops, measuring rods						
—charts and tables						
3. Total, village-level training					8400	
C. Purchase of Temephos/Abate	purchase for 100 villages					assume 100 cu meter water supply (100,000 l)
1. Sand formulation (1%)		kg.	1.90	3000	5700	100 gr/cu. meter for 1 ppm conc., 3 applications
2. 500E liquid formulation	500 gr/l active ingred	liter	16.10	120	1932	1 liter/500 cu. meter for 1 ppm conc

3. Transportation to POE						
a. Sand formul.		kg.	.25	3000	750	
b. Liquid formul.	5.49 kg/l	kg.	.25	120	30	
4. Total, sand formul	purchase and transp.				6450	
5. Total, liquid formul	purchase and transp.				1962	
D. Storage and transportation						
1. Warehousing costs	20% purchase cost	per year			2280	for secure storage; assume sand formulation
—National level						
--Regional/district level						
2. Repackaging for distribution						
--labor	local, skilled	person-days	5	5	25	
—containers, material		per village	2	160	320	
3. Transportation	vehicle availability	km	.60	3200	1920	to deliver chemical treatment supplies
a. Drivers		person-days	3	40	120	
4. Total, storage and trans.					4665	
E. Ongoing follow up and support						
1. Technical labor						
—salaries, perdiem						
a. Agric. or health workers	2 vill/3 days	person-days	5	240	1200	3 follow up visits per year relating to chem applic (10 workers)
b. Technical supervisors		person-days	8	90	720	2 supervisors, half time
2. Transportation		km				
3. Materials	for tech workers	per year	100	20	2000	forms, replacement supplies for chem applic.
4. Total, follow up and support					3920	
				Total	33570	1% sand formulation assumed
	Percent assumed "chargeable" to guinea worm control program				100%	
	Estimated cost related to guinea worm control				33570	Cost per village approx. $168 per year

Storage and transportation costs involve both secure and protected warehousing at both the national and regional levels, repackaging costs at the national (and perhaps the regional) level, and transportation. It is assumed that vehicle space will be available as the amounts to be transported would not justify separate vehicle purchase.

Ongoing follow-up and support involves visits by trained agricultural workers to determine proper application procedures, provide further training, and replenish supplies or materials.

Total costs and costs related solely to dracunculiasis control are the same for the chemical treatment module since no other program can be expected to accrue significant benefits from the effort. These total costs amount to $33,570 over two years, or approximately $168 per village per year.

3.5 Overall Program Costs

Table 5 shows the total cost for two guinea worm control approaches, the first (A) giving the cost for epidemiologic surveillance, community participation/community health education, and community water supply as the specific intervention modality, and the second (B) giving the cost for epidemiologic surveillance, community health education, and chemical treatment as the specific intervention modality. In addition, the estimated costs attributable to guinea worm control alone are provided, based on the percentage estimates for each component (epidemiologic surveillance--100 percent; community participation/community health education--50 percent; community water supply (CWS)--40 percent; and chemical treatment--100 percent).

Table 5. Overall Program Costs Immediate Program--100 villages, 2 years, 50,000 people	Total Cost	Cost Per Village	Cost Per Capita
	(US $)		
A. Estimated total cost of program, water supply alternative	693585	6936	13.87
Estimated cost related to guinea worm control	295556	2956	5.91
B. Estimated total cost of program, chemical treatment alternative, 1% sand formulation assumed	121536	1215	2.43
Estimated cost related to guinea worm control	86878	869	1.73

The estimated total cost for a dracunculiasis control program through providing improved water supplies for 100 villages over two years would be approximately $693,585. The estimated costs attributable to guinea worm control alone would be approximately $295,556. The estimated total cost for a similar program utilizing chemical treatment with sand formulation temephos/ abate would be $121,536, with the proportion attributable solely to guinea worm control being $86,878. Although the use of chemical treatment appears substantially less expensive, factors such as appropriateness of the intervention in terms of country infrastructure and ongoing programs, long term supply and maintenance, transportation, and other desired outcomes for the program must be taken into consideration in designing the approach. Finally, overall costs per capita are approximately $13.87 for community water supply and $2.43 for chemical control with temephos/abate. Considering only the costs which are assumed to accrue to guinea worm control, the per capita costs fall to $5.91 for CWS and $1.73 for chemical control. Chapter 4 carries forward the cost estimates developed in this chapter and proposes a cost benefit model relating to guinea worm control.

Chapter 4

COST-BENEFIT ANALYSIS OF GUINEA WORM PREVENTION

In order to carry through the discussion of different intervention models for guinea worm control, a microcomputer-based cost-benefit model was developed with Burkina Faso as an example country. Similar analyses to those performed for Burkina Faso, utilizing the same or different assumptions, can be easily carried out for other countries using the microcomputer spreadsheet model.[3]

Table 6 is an example work sheet based on mid-range parameter assumptions for a cost-benefit analysis of potential guinea worm control programs. Table 6 is divided into eight sections comprising different aspects of the model; a sensitivity analysis is also provided showing the effect of changes in the assumptions.

4.1 Model Parameter Assumptions

Section 1 of Table 6 shows the assumptions on which production benefits and health costs are based.

4.1.1 Working Population/Demographics

For 100 villages with 50 persons each, using estimates for the population age structure of Burkina Faso (UN Demographic Yearbook, 1984) and the Guiguemde et al. (1983) assumption that all persons aged 16-45 and 50 percent of those aged 5-15 or over 45 participate in the labor force, we estimate full-time equivalent work force of 30,575 individuals (i.e., 61.15 percent of the total population of 50,000 to be served).

By multiplying the population's age distribution by Guiguemde et al.'s (1983) age-specific disease prevalence rates, we estimate an average disease prevalence of 36.3 percent in the working population and 35 percent in the population as a whole over the 100 villages assumed for the model. Estimates were made of the number of working days lost per year using Ward's (1984) estimate of one day lost for every 6 percent of the productive population affected by the disease.

4.1.2 Agricultural Gross Domestic Product

Burkina Faso (1982 population 6.2 million) had a gross domestic product (GDP) in 1983 of $900 million, 41 percent of which ($369 million) was from the

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[3] Details regarding the model and its software/hardware requirements are available from John E. Paul or Gary M. Ginsberg, Research Triangle Institute, P. O. Box 12194, Research Triangle Park, North Carolina 27709 USA.

Table 6. Cost Benefit Analysis Work Sheet; Mid-Range Assumptions
Example Country: Burkina Faso

Section 1:

Model Parameters	Assumption	Comments
Population to be served	50000	100 villages, 500 population per village
Percent of population working	61.15	1975 census, UN Demographic Yearbook, 1982
Total productive population	30575	
Disease prevalence, working popul.	36.3	Percent (average prevalence over 100 villages)
Disease prevalence,total population	35	Percent (average prevalence over 100 villages)
Working days lost/year	184979	1 day lost for every 6% of prod. popul. affect. (Ward, 1984)
Total GDP of served population	4070636	US Dollars; derived from 1983 national agri. GDP
Adjusted agri. GDP/person/year	140.20	US Dollars (adjusted for guinea worm-related work absences)
No. of days in agricultural season	120	
Adjusted agri. GDP/person/day	1.17	US Dollars; assuming all occurs in agri. season
Total production loss/year	216124	US Dollars
Intervention effectiveness, CWS	.9	Community water supply (CWS)
Interven. effect., chemical control	.7	Chemical treatment of water supplies with ABATE
Year 1 implementation factor	0	
Year 2 implementation factor	.25	
Year 3 implementation factor	.75	
Interven. effect., hlth care, yr 1	0	Effect of treatment in reducing disease prev. (Kale, 1982)
Interven. effect., hlth care, yr 2	.1875	"
Interven. effect., hlth care, yr 3	.346	"
Interven. effect., hlth care, yr 4	.435	"
Interven. effect., hlth care, yr 5	.49	"
Interven. effect., hlth care, yr 6+	.4975	"
Health care effect on days lost	.5	Effect of treatment on reducing work days lost
Cost of treatment per case	18	US Dollars (Guiguemde, et al., 1983)
Discount rate	.075	

Section 2:
Costs of Interventions
[Totals include epid surveill and CP/hlth educ along with specific technical intervention]

	Epidemio. Surveillance Module	Commun. Particip./ Health Education Module	Commun. Water Supply	Chemical Control Module	Total, CWS Inter-vention (A)	Total, Chemical Control Intervention (B)
Factor "chargeable" to guinea worm:	1.00	.50	.40	1.00		
Year 1	9325	17329	121124	16785	147778	43439
Year 2	6625	12529	121124	12885	140278	32039
Year 3	6625	12529	8720	11718	27874	30872
Year 4	6625	12529	8720	11718	27874	30872
Year 5	6625	12529	8720	11718	27874	30872
Year 6	6625	12529	8720	11718	27874	30872
Year 7	6625	12529	8720	11718	27874	30872
Year 8	6625	12529	8720	11718	27874	30872
Year 9	6625	12529	8720	11718	27874	30872
Year 10	6625	12529	8720	11718	27874	30872
Net Present Value (NPV)					400134	224605

Table 6 (cont'd)

Section 3: Production Benefits With Community Water Supply	Intervention, No Health Care (C)	Intervention, Health Care (D)	No Intervention, Health Care (E)	Benefits of CWS Intervention Given Health Care Available (F) [= (D) - (E)]
Year 1	0	108062	108062	0
Year 2	48628	148079	128324	19755
Year 3	145884	193156	145452	47704
Year 4	194512	210019	155069	54950
Year 5	194512	210613	161012	49600
Year 6	194512	210694	161823	48871
Year 7	194512	210694	161823	48871
Year 8	194512	210694	161823	48871
Year 9	194512	210694	161823	48871
Year 10	194512	210694	161823	48871
Net Present Value (NPV)	988822	1281886	1012968	268919

Section 4: Production Benefits With Chemical Control	Intervention, No Health Care (G)	Intervention, Health Care (H)	No Intervention, Health Care (I)	Benefits of Chem. Control Given Health Care Available (J) [= (H) - (I)]
Year 1	0	108062	108062	0
Year 2	37822	143689	128324	15365
Year 3	113465	182555	145452	37103
Year 4	151287	197808	155069	42739
Year 5	151287	199591	161012	38578
Year 6	151287	199834	161823	38011
Year 7	151287	199834	161823	38011
Year 8	151287	199834	161823	38011
Year 9	151287	199834	161823	38011
Year 10	151287	199834	161823	38011
Net Present Value (NPV)	769083	1222127	1012968	209159

Section 5: Costs of Health Care for Disease, Community Water Supply	No Intervention (K)	With CWS Intervention (L)	Treatment Cost Reduction Due to CWS Intervention (M) [= (K) - (L)]
Year 1	315000	315000	0
Year 2	255938	198352	57586
Year 3	206010	66953	139057
Year 4	177975	17798	160178
Year 5	160650	16065	144585
Year 6	158288	15829	142459
Year 7	158288	15829	142459
Year 8	158288	15829	142459
Year 9	158288	15829	142459
Year 10	158288	15829	142459
Net Present Value (NPV)	1371579	587684	783896

Table 6. (cont'd)

Section 6: Costs of Health Care for Disease, Chemical Control	No Intervention (N)	With Chem. Control Intervention (O)	Treatment Cost Reduction Due to Chemical Control (P) [= (N) - (O)]
Year 1	315000	315000	0
Year 2	255938	211148	44789
Year 3	206010	97855	108155
Year 4	177975	53393	124583
Year 5	160650	48195	112455
Year 6	158288	47486	110801
Year 7	158288	47486	110801
Year 8	158288	47486	110801
Year 9	158288	47486	110801
Year 10	158288	47486	110801
Net Present Value (NPV)	1371579	761883	609697

Section 7: Total Production Benefits Due To Intervention When Health Care Available	Community Water Supply (CWS) (Q) [= (F) + (M)]	Chemical Control (R) [= (J) + (P)]
Year 1	0	0
Year 2	77341	60154
Year 3	186761	145258
Year 4	215127	167321
Year 5	194185	151033
Year 6	191330	148812
Year 7	191330	148812
Year 8	191330	148812
Year 9	191330	148812
Year 10	191330	148812
Net Present Value (NPV)	1052815	818856

Section 8: Resulting Benefit-Cost Ratios, mid-range assumptions			Internal Rate of Return	Years to Payback
Benefit-Cost Ratio (CWS, no health care avail.)	2.47	[= NPV (C) / NPV (A)]	47 %	4
Benefit-Cost Ratio (chemical control, no health care avail.)	3.42	[= NPV (G) / NPV (B)]	114 %	3
Benefit-Cost Ratio (CWS, w/ health care)	2.63	[= NPV (Q) / NPV (A)]	56 %	4
Benefit-Cost Ratio (chemical control; w/ health care)	3.65	[= NPV (R) / NPV (B)]	150 %	3
Benefit-Cost Ratio (health care alone)	.74	[= NPV (E) / NPV (K)]		

agricultural sector (World Development Report, 1985). With approximately 82 percent of the labor force work in agriculture, we can calculate the GDP per working person in agriculture per year by:

$$\frac{\text{Total GDP in agricultural sector}}{\text{Tot. popul. x \% of popul. working age x \% Working in agriculture}}$$

$$= \frac{\$369,000,000}{6,500,000 \times 52\% \times 82\%} = \$133.14 \text{ GDP per person per year working in the agricultural sector.}$$

Thus, the 30,575 productive full-time equivalent (FTE) workers in the villages under consideration will have a total annual product on average of:

$$30,575 \times \$133.14 = \$4,070,636$$

Now, assuming that all agricultural activity occurs in a 120-day agricultural season, we see that production per day per worker given by the formula:

$$\frac{\text{Total product}}{\text{Days in working season x No. of FTE workers - Days lost through illness}}$$

$$= \frac{\$4,070,636}{(120 \times 30,575) - (\text{FTE labor x Prev. in work. popul. x 1 Day})}$$

$$= \frac{\$4,070,636}{(3,669,000 - 184,979)\text{ days}} = \frac{\$4,070,636}{3,484,021} = \text{US } \$1.17 \text{ per day.}$$

The "adjusted" GDP per person day takes into account the fact that the total number of working days is diminished by 184,979 estimated working days lost as a result of the disease, derived using the estimation techniques of Ward (1984). Thus, the product per actual working day rises from $1.11 per day overall ($133.14 divided by 120) to $1.17 per day for actual days worked ($140.20 divided by 120).

We can therefore estimate the total production loss due to the disease by:

No. of working days lost x Adjusted GDP per person per day

= 184,979 x $1.17 = $216,124 annual total production loss.

4.1.3 Other Model Parameters

Other parameters chosen for the model include assumed long- term effectiveness of the interventions, "phase-in" or implementation factors for the first three years, the effectiveness of current treatment modalities in reducing guinea worm morbidity and working days lost, the cost of such treatment per case, and the discount rate. The role of these parameters in the overall model is discussed below. The effects of changes in the values assumed for these parameters is discussed in the sensitivity analysis.

4.2 Costs of Interventions

Chapter 3 presented in detail the respective costs of the two main intervention strategies, community water supply (CWS) or chemical control. Section 2 of Table 6 shows the flow of costs of these interventions over a ten year time period, with a net present value (NPV) based upon the assumed discount rate given in section 1 of the table. Costs are highest in the first two years as these include considerable capital costs in the building of the wells and initial non-recurring costs relating to the use of chemicals. Use of expatriate consultants is mostly limited to the first year in order to aid in program implementation. Higher recurring costs for chemical control strategies, as compared with community water supply (CWS) strategies, are due to higher ongoing material and transportation requirements. Finally, it should be noted that the recurring costs are conservatively carried forward over the entire ten year period, although conceptually the guinea worm cycle could be broken in as little as two years, given effective program implementation.

The totals for both the CWS and chemical control costs are shown in columns A and B of section 2, and include the costs of the epidemiological surveillance and community participation/health education activities described in Chapter 3.

4.3 Implementation Phase-in Effects

The effect of the intervention method should be to gradually decrease the population's morbidity and work days lost from the disease. Table 7 illustrates the phase-in effects of a CWS guinea worm intervention program assumed to operate with 90 percent efficiency.

In the first year, it is assumed approximately 25 percent of the targeted villages will have wells built by the program, but in any case no effect on the current prevalence rates of the disease will show up due to the incubation period from the previous year's infected persons. However, the number of newly infected persons during the first year is projected to fall from 36.3 percent to 28.13 percent, and this should show up as the lower prevalence rate in the second year.

It is assumed that by the second year 75 percent of the wells will be installed and operating with the same effectiveness of 90 percent, thus potentially reducing the newly infected population rate to only 11.8 percent. Since the prevalence rate then would be 22.51 percent lower, approximately 41,633 production days could be saved at an estimated benefit of around $48,628.

Table 7. Phase-In Effects, CWS Intervention (No Health Care Available)

Time	% Systems Installed	Effective-ness	Disease Preval.	Disease Incidence	Production Gains Days	Production Gains Dollars
Prior to intervention	0%	-	36.3%	36.3%	0	0
Year 1	25%	0.9	36.3%	28.13%	0	0
Year 2	75%	0.9	28.13%	11.80%	41,633	48,628
Year 3	100%	0.9	11.80%	3.63%	124,848	145,884
Year 4	100%	0.9	3.63%	3.63%	166,481	194,512

Similarly, if the prevalence rate falls to 11.8 percent in year 3 and to 3.63 percent in year 4 and subsequent years, the production benefits could increase to $145,884 in year 3 and $194,512 in year 4 and subsequent years.

4.4 Production Benefits: No Health Care Available

Assuming little appropriate health care is available for the treatment of the disease in the village populations (a likely situation among guinea worm endemic countries), the benefits that can most easily be put in monetary terms are the production benefits due to reduced morbidity and reduced number of working days lost.

This flow of production benefits, taking into account implementation phase-in, is shown in Table 6 in section 3, column C for the CWS intervention, and section 4, column G for the chemical control intervention. These benefits are discounted to a NPV by means of the assumed discount rate shown in section 1. Note that the level of benefits differs for the two interventions due to the assumed difference in intervention effectiveness (0.9 for CWS versus 0.7 for chemical control).

4.5 Production Benefits: Health Care Available

If there is health care available to treat the symptoms of guinea worm disease in the villages, the calculation of the benefits from intervention (from either CWS or chemical control) is more complicated.

First, estimates were made of changes in prevalence rates which might occur if health care were available to half of the population being served. The scenario where health care is available to the entire population is regarded as unrealistic due to the obvious health care resource constraints in the guinea worm endemic countries.

as unrealistic due to the obvious health care resource constraints in the guinea worm endemic countries.

Kale's (1982) study in western Nigeria showed progressive yearly reductions in dracunculiasis prevalence rates of 0 percent, 37.5 percent, 69.2 percent, 87 percent, 98 percent, and 97.5 percent, respectively, in the first six years of the study. These potential prevalence rate reductions were halved under our assumptions to reflect the perception that health care will be available to only half (or more likely even less) of the population being served. We then calculated the estimates of production gains where there is no intervention but health care is available to half the population (section 3, col. E), under the further assumption that health care for guinea worm infection (including drugs and dressings for the ulcer) reduces the total number of working days lost by 50 percent (health care effectiveness = 0.5 in section 1) in any one year in an infected individual (Guiguemde et al., 1983).

Next, the total production benefits are calculated for the CWS intervention where health care is available (section 3, col. D). The benefits calculated are those attributed to the 50 percent health intervention and the further reduction related to the CWS intervention effect for the still-infected population.

The net marginal potential yearly effects of the CWS intervention, over and above the health care effects, are shown in section 3, column F. These effects are obtained by subtracting the effects of health care alone (section 3, col. E) from those of CWS and health care together (section 3, col. D).

However, additional gains from the CWS intervention are to be found in the fact that the potentially lowered prevalence rates should result in fewer total people (not just the working population) in need of health care for guinea worm disease. Treatment in the form of drugs and bandages is estimated to cost approximately $18 per person per year to treat (Guiguemde et al., 1983). These additional savings are shown in section 5, column M, calculated by taking the costs of health care with CWS intervention (section 5, col. L) from the costs of health care with no intervention (section 5, col. K).

The total expected benefits of intervention (section 7, col. Q) would thus be those due to increased production (section 3, col. F) plus those due to reduced expenditure on health care for the disease (section 5, col. M).

Similarly, the calculations for the benefits of the chemical control intervention are shown in sections 4 and 6, with the total benefits of the intervention shown in section 7, column R. In all cases, discounted net present value figures are provided for the 10 year flow of costs and benefits.

4.6 Methods of Comparing Benefits to Costs

4.6.1 Benefit-to-Cost Ratios

The benefit-to-cost ratio (BCR) is the ratio of the net present value (NPV) of benefits [NPV(b)] to the net present value of costs [NPV(c)] for a particular project. Using a discount rate of "r" over a ten year time period (t = 1,..,10), the BCR is expressed mathematically as:

$$\frac{NPV(b)}{NPV(c)} = \frac{\sum_{t=1}^{t=10} benefits(t) / (1-r)^t}{\sum_{t=1}^{t=10} costs(t) / (1-r)^t}$$

If NPV(b) divided by NPV(c) exceeds unity then the benefits of the product are greater than its costs (Sugden and Williams, 1978). In our analysis we take the baseline period (t=0) to be the year before the intervention actually occurs, i.e. the year when the project's financing might be assured by the funding agency.

4.6.2 Internal Rate of Return (IRR)

This standard measure (Mishan, 1971) is the discount rate (r) which reduces the stream of costs and benefits to a zero net present value (NPV):

$$NPV = 0 = \sum_{t=1}^{t=10} \frac{benefits(t) - costs(t)}{(1 + r)^t}$$

where t takes on the values 1 to 10 corresponding to the 10 years of the project under consideration. International projects have in the past often been subjected to an 8-10 percent test discount rate criteria, i.e., projects in the undertaking must yield an internal rate of return of at least 8-10 percent per year.

4.6.3 Years-to-Payback

Years-to-payback indicates the year of the project in which the initial outlays and running costs become covered by the accumulating benefits, i.e., the year in which the net present value of the benefits exceed the net present value of the project's costs:

$$NPV(b) > NPV(c).$$

Years-to-payback can be thought of in another way as the time period one has to wait in order to theoretically pay back the costs of the project out of the accrued benefits.

4.7 Results for Mid-Range Assumptions

Values for these three measures are summarized for the CWS and chemical options with and without health care availability in section 8 of Table 6 for the various parameters defined in section 1 of the table. It can be seen that all of the benefit-to-cost outcome measures are greater than unity, with slightly more favorable outcomes being for the situation where the intervention occurs in an area that already has health care available to half of the population for treatment of guinea worm disease. Further discussion of the significance of these outcomes is included below.

4.8 Sensitivity Analysis

Since many of the parameters shown in section 1 of the example worksheet (Table 6) are estimates, a sensitivity analysis is required to see how outcome measures vary in response to changes in these parameters.

Table 8 presents the results of some of these parameter combinations for the following scenarios:

4.8.1 Mid-Range Assumptions

The age distribution is taken from the 1975 Census resulting in the equivalent of 61.15 percent of the population working full-time. Prevalence rates are taken as an average 36.3 percent in the working rural population and 35.0 percent in the overall rural population as explained previously. The number of days in the agricultural season is 120 days and the effectiveness of the CWS and chemical intervention varies from 0.7 to 0.9. The discount rate also is allowed to take on the values of 5 percent, 7.5 percent and 10 percent, respectively. Note that the assumptions contained in the example worksheet, Table 6, are included as possible mid-range values.

4.8.2 High Range Assumptions

As a best case scenario, the percentage of population working (FTE) is set at 66.0 percent based on Guiguemde et al. (1983) age distribution in three study villages. In fact, however, this parameter does not affect the outcome measures for the model since it merely serves to decrease the GDP per person per day to compensate for the overall increase in the numbers of those working. The overall GDP of the village population acts as the actual constraint.

The average prevalence of disease in the rural working and total populations is increased by 20 percent over the mid-range estimates. The effectiveness of both interventions is assumed to be 90 percent (or 0.9), i.e., the interventions will reduce the infection rate by 90 percent.

Table 8. Cost-Benefit Sensitivity Analysis

Parameter Assumptions:	High Range			Mid Range						Low Range		
Percent of population working		66				61.2					55	
Dis.prevel.working population		43.6				36.3					29	
Dis.prevel. total population		42				35.0					28	
No.days in agricultural season		120				120					160	
Intervention effectiveness		.9			.9			.7			.7	
Discount rate	.05	.075	.10	.05	.075	.10	.05	.075	.10	.05	.075	.10
Sensitivity Outcomes:												
CWS, no health care available												
Benefit to Cost ratio	3.22	3.00	2.8	2.65	2.47	2.31	2.06	1.92	1.8	1.21	1.13	1.05
Internal Rate of Return		58%			47%			34%			12%	
Years to payback	4	4	4	4	4	5	5	5	5	8	9	10
Chem.control, no health care												
Benefit to Cost ratio	5.52	5.34	5.17	4.54	4.4	4.26	3.53	3.42	3.31	2.07	2.01	1.94
Internal Rate of Return		178%			148%			114%			61%	
Years to payback	3	3	3	3	3	3	3	3	3	4	4	4
CWS, health care available to 50% of population												
Benefit to Cost ratio	3.38	3.17	2.97	2.8	2.63	2.47	2.18	2.05	1.92	1.63	1.53	1.43
Internal Rate of Return		69%			56%			40%			25%	
Years to payback	4	4	4	4	4	4	4	5	5	6	6	6
Chem. control, health care avail. to 50% of popul.												
Benefit to Cost ratio	5.79	5.64	5.49	4.81	4.69	4.56	3.74	3.65	3.55	2.79	2.72	2.65
Internal Rate of Return		237%			196%			150%			107%	
Years to payback	2	2	2	2	2	2	3	3	3	3	3	3
Health care alone												
Benefit to Cost ratio	.76	.75	.73	.76	.74	.72	.76	.74	.72	.55	.54	.53

CWS = Community water supply intervention

Chem.control = Use of temephos/abate for control of infected insect vector.

4.8.3 Low Range Assumptions

As a worst case scenario, the percentage of population working (FTE) is set at 55 percent. The average prevalence of disease in the working and total populations is reduced by 20 percent over the mid-range estimates. The effectiveness of both interventions is assumed to be 0.7, and the length of the agricultural season is increased by a third to 160 days, thereby reducing the GDP per person per day.

Table 8 shows that even under the worst case scenario (the low range option with a high discount rate of 10 percent) the BCR is still above unity for both interventions.

4.8.4 Discussion

We see from Table 8 that CWS with no available health care (a likely scenario when considering the availability of adequate health care in most guinea worm endemic countries) yields Benefit-to-Cost Ratios (BCRs) ranging from 1.05 to 3.22 and Internal Rates of Return (IRRs) from 12 to 58 percent. This form of intervention seems justifiable, therefore, since the BCRs exceed unity and the IRRs indicate a high return on capital invested. The payback periods are estimated to be between four and ten years. Slightly higher BCRs (1.43 to 6.24) and IRRs (25 percent to 69 percent) are obtained when health care provision is available, also reducing the payback periods to between four and six years.

The potential returns gained by chemical control interventions appear to be even more advantageous than those from CWS, with BCRs ranging from 1.94 to 5.52 with no health care and from 2.65 to 5.79 when health care is available. The IRRs are from 61 to 178 percent with no health care, and from 107 to 237 percent with health care available, rates of return which are substantial. These higher benefits indicate potentially reaching "payback" between the second and fourth year of the project.

4.9 Other Factors Affecting Benefit-Cost Outcome Variables

In addition to the parameters included in the model as described above, there are other factors that have not been considered which could serve to increase (+) or decrease (-) the BCR or IRR of the project. Some of these factors are as follows:

1. We assumed there is no surplus labor available in the agricultural season, so the fact that one person remains off work through illness means that he/she is not substituted for by an unemployed person, and means that there is a true production loss due to the disease. If, however, there is unemployment (i.e., surplus labor), then there will be replacement workers available to cover for sick persons unable to work. In this situation production losses due to the disease will be less than estimated in our calculations. (-)

2. No quantification is given to such intangible benefits as decreases in pain, inconvenience, and grief to self or others resulting from the interventions, in both the working and non-working populations. (+)

3. No quantification is given to the increase in "mental energy" of a less-morbid population. This is especially important in the long-term effect of breaking out of some part of the poverty-illness vicious circle in which apathy and fatalism are generally a joint product of disease and poverty (Conn, 1972). (+)

4. Distributional aspects have been ignored. In this project the costs will be covered by external funds taken from populations whose income is considerably higher than that of the poorer village recipients of the project's benefits. Economists regard the transfer of the same dollar amount from a rich person to a poor person as a net gain since the rich person's marginal utility of income is held to be lower than that of the poor person's. This project is therefore perceived to have positive distributional benefits, a value which is not accounted for in the model. (+)

5. No valuation has been put on the fact that there will be less absenteeism of children from schooling owing to the lower disease prevalence rates. (+)

6. No valuation of benefits accruing from the CWS intervention other than those relating to guinea worm control have been included. These could be substantial; however, the costs of these benefits have also not been included since only 40% of the total CWS project costs were imputed to guinea worm control. (+/-)

7. Epidemiological surveillance costs in the modules were 100 percent attributed to guinea worm control. To the extent these can be coordinated with other surveillance efforts, such as for onchocerciasis or yaws, or made part of the national reportable disease system for an endemic country, the costs are overstated. (+)

Finally, the estimate of output per head in the villages is based on the average income of all rural residents in Burkina Faso. This may, however, be an overestimate of the income in villages affected by guinea worm since these villages tend to be in the more remote and less productive rural areas. A sensitivity analysis was performed with the mid-range assumptions of Table 6 to determine the break-even point regarding agricultural GDP per person for a CWS intervention with no health care available. In this case, agricultural GDP per person could be decreased nearly 60 percent, from $1.17 to $0.47, before the BCR would fall below unity. For other intervention possibilities, the agricultural GDP per person could be decreased even more. It is apparent, therefore, that guinea worm control can be cost-beneficial even if the productivity of the population in areas affected by guinea worm is assumed to be, on average, dramatically lower than that for the rural population as a whole.

Chapter 5

POLICY OPTIONS AND CONCLUSIONS

5.1 Policy Options

5.1.1 Doing Nothing

In the case where neither health care nor preventive measures are provided, the estimated costs of the disease are approximately $216,124 per year for our sample population of 50,000 located in 100 endemic villages (184,979 lost production days at $1.17 per day--see Table 6). At a 7.5 percent discount rate, discounted lost production over the ten year time frame would be approximately $1,593,000, or $15,930 per village, or $52 per "productive" person. Even with no valuation given to the accompanying pain and suffering also resultant from guinea worm, the option of "doing nothing" could be in fact a very costly one.

5.1.2 Health Care Strategies

5.1.2.1 For the entire population

An active intervention strategy could be to supply just health care with the objective to treat guinea worm disease in those endemic villages where no health care is currently available. Calculations of prevalence rates were based on Kale's (1982) prevalence estimates for the first four years of the study. For years 5 to 10 a prevalence rate of 0.1 (i.e., an intervention effectiveness of 0.9) was used to be consistent with the maximum effectiveness factors of 0.9 assumed for the CWS and chemical control interventions. Under the assumption that health care (treatment) for guinea worm would be available to 100 percent of the population, a BCR of 1.81 is reached; however, despite the implicit unrealistic assumption of universal health care availability, this still does not compare favorably to the mid-range BCRs of CWS and chemical control, as shown in Table 8.

5.1.2.2 To cover half the population

A more plausible but still optimistic assumption would be to provide health care treatment for one-half of the affected population. The net costs from this option (section 5, col. K, Table 6) considerably exceed the net benefits of supplying health care (section 3, col. E); under the mid-range assumptions of the worksheet, the benefits amount to only 74 percent of the costs. Adjusting health care costs within the assumptions of Table 6 reveals that cost per case for treatment would have to be lowered by 27 percent from that estimated, or to approximately $13.20 per case, before the BCR of providing health care alone reaches the break-even point of unity.

Therefore, it is apparent that under the assumptions of this model ameliorative health care strategies alone are not cost-effective in the control of guinea worm disease. Instead, health care should be enhanced by intervention strategies such as CWS or chemical control which prevent the disease and which yield highly favorable benefit-to-cost ratios and internal rates of return.

5.1.3 Community Water Supply Versus Chemical Control

Both CWS and chemical control appear to provide benefits which exceed their costs. The chemical control intervention scenarios would provide higher BCRs, IRRs and shorter payback periods than the CWS interventions, even when CWS is assumed to have a greater short- and long-term effectiveness in preventing guinea worm disease. The mid-range intervention effectiveness assumptions used in Table 6 were 0.9 for CWS and 0.7 for chemical control; even with this differential we see from section 8 of the table that chemical treatment still could result in more favorable financial outcomes over the ten year horizon.

Referring to Table 9, however, we can see the net "cash flow" of the CWS project (benefits less costs) after the second year of the project is greater than that of the chemical option. This results in the discounted cumulative "cash flow" of the CWS project exceeding that of the chemical option in the ninth year when no health care is available, and in the eighth year if health care is available.

Table 9. Excess of Benefits over Costs for Possible Projects
Guinea Worm Control Program; Mid Range Assumptions.
Example Country: Burkina Faso

Project Year	CWS, no health care avail (A)	Chem Control, no health care (B)	CWS, health care avail (C)	Chem Control, health care (D)
Cumulative discounted excess of benefits over costs				
Year 1	-137468	-40408	-137468	-40406
Year 2	-216775	-35404	-131329	-16079
Year 3	-121782	31080 (Note 1)	-64031	75397 (Note 1)
Year 4	2996. (Note 1)	121247	76184 (Note 1)	178171
Year 5	119069	205124	192030	261871
Year 6	227044	283148	297943	338292
Year 7	327486	355729	396466	409381
Year 8	420320	423247	488116 (Note 2)	475510 (Note 2)
Year 9	507835 (Note 2)	486053 (Note 2)	573372	537026
Year 10	588687	544478	652680	594250

Note 1. Year in which "payback" is reached for particular intervention.
Note 2. Year in which the net cumulative discounted excess of benefits over costs for community water supply as an option exceeds that of chemical control as an option.

We can see, therefore, that the increased initial costs of the CWS intervention, despite generating lower benefit-to-cost ratios, eventually yield higher net paybacks on account of the assumed increased effectiveness and lower recurring costs of this intervention. Additionally, the potential for collateral benefits is higher in CWS than for chemical control. Broad health and economic benefits of CWS are usually held to be substantial; however, these benefits are not estimated for the purposes of this paper; neither are their share of the total costs included.

Either CWS or chemical control in a guinea worm program appear highly justifiable in financial terms. Further, the benefit-to-cost ratios of either of these strategies exceed the benefit-to-cost ratios obtained when a "health care only" option is considered. The choice between the two intervention strategies (CWS versus chemical control) should be made taking into consideration other ongoing in-country programs, the endemic country's health and development infrastructure, availability of resources, possible points of integration with other programs, and other factors.

5.2 Conclusions

This paper has attempted to provide an overview of dracunculiasis, its effects, and measures necessary for its control and eventual elimination. Cost estimates were developed as examples and potential starting points to show the variety of items that would need to be considered. For a particular specific country situation, however, context of the control effort would have to be considered, and specific cost estimates developed. A cost-benefit analysis was carried out to demonstrate the feasibility and cost-effectiveness of guinea worm programs.

Guinea worm control can be accomplished directly by specifically focused programs, or indirectly, through cost-effective modifications in existing water and sanitation, primary health care, agriculture, or health education projects. As a disease with substantial economic and human cost, and as a disease which presents significant opportunities for intervention, dracunculiasis control efforts offer high potential for low-cost, high-benefit, and highly visible results for the rural poor of West Africa and other afflicted areas of the world. It would also represent an important outcome for the ongoing International Drinking Water Supply and Sanitation Decade.

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