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GUIDELINES FOR IMPLEMENTATION PLANNING FOR GUINEA WORM CONTROL PROGRAMS: AN APPROACH TO ASSESSMENT OF COST-EFFECTIVENESS AND COST BENEFIT

Operated by
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Prepared for the Office of Health,
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by

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GLOSSARY OF ACRONYMS

CBA	Cost-benefit analysis
BCR	Benefit-to-cost ratio
CEA	Cost-effectiveness analysis
GDB	Gross Domestic Product

PREFACE

These guidelines were developed from an earlier concept paper, WASH Technical Report No. 38, "Cost-Effective Approaches for the Control of Dracunculiasis," and from a field test of the approach in the Pakistan Guinea Worm Eradication Program. Additional details of the approach are presented in WASH Technical Report No. 38 and WASH Field Report No. 231, which describes the Pakistan field test.

The guidelines are not a "cookbook" for carrying out the implementation planning and cost-benefit approach that is described; however, it is hoped that host country mid-level analysts and program managers will be able to follow the general thrust of the approach and will be able to assess its potential for their needs. For interested programmers and planners with some experience, it should be possible to adapt the model software and approach to the particular conditions of a given program.

It should be noted that the model was developed using IBM PC-based spreadsheet software (available in either Lotus 1-2-3 or SuperCalc4 format) and is completely dependent upon the use of a microcomputer to generate useful information. It is beyond the scope of this report to provide instruction either in the use of microcomputers or in spreadsheet software. Access to and familiarity with an IBM-PC or IBM-AT or one that is compatible with them, as well as the appropriate spreadsheet software, is therefore assumed.

Chapter 1

INTRODUCTION

Implementation planning and cost-benefit analysis of guinea worm intervention programs are not inherently different than for any other health intervention. Guinea worm disease, however, has several characteristics that make it particularly amenable to intervention and thus attractive for analysis. These characteristics include, most importantly, the ease with which it is recognized and the vulnerability of its life cycle to interventions. As compared with diseases whose symptoms overlap with many other diseases, the emergence of a guinea worm is unmistakable. As compared with diseases that have multiple reservoirs from which infection can be transmitted, the guinea worm cycle is a "closed loop" consisting of infected human hosts and pools of water contaminated by the vector. The cycle can be broken with relative ease at several points, thus effectively interrupting disease transmission.

The disadvantages of guinea worm disease for diagnoses and control by health care workers show: (1) The long latency period between infection and symptoms, making cause-effect relationships hard to demonstrate; (2) the magical/evil aspects often attributed to the disease, making it difficult to convince affected populations that they can control its incidence through their own actions; and (3) the lack of any effective treatment for those already infected, which leads to low reporting of the disease and a lack of credibility for the health care profession in dispensing preventive information.

These guidelines describe an approach to using a microcomputer-based implementation planning model for guinea worm control programs and an approach to cost-benefit/cost-effectiveness analysis for these programs.

Chapter 2

STATEMENT OF PROBLEM AND APPROACH [1/]

2.1 Implementation Planning

A recurring problem in planning health and development programs is the implementation of these programs in the face of scarce resources and conflicting goals and objectives. It is assumed that many countries are unable to mount categorical or vertical guinea worm disease control programs. There are two exceptions to this, one in India, where there has been such a program for a number of years, and one in Pakistan, where the Pakistan National Institute of Health has spearheaded a drive to eradicate the disease by 1992.

However, it is not a foregone conclusion that categorical, vertically-organized programs for guinea worm control are necessarily the most practical or desirable from either a programmatic or financial standpoint. The large categorical program model for guinea worm control, although it provides examples of necessary program components, appears only partially applicable to West Africa due to severe financial constraints in many countries there. A more practical approach might be to integrate guinea worm control activities within other projects, e.g. primary health care, water and sanitation, and other disease control efforts such as those for schistosomiasis or onchocerciasis. Guinea worm health education efforts or a national guinea worm secretariat to coordinate information exchange among other ministries or implementing agencies may be all that a particular country can afford in the way of a dedicated guinea worm effort. In this case, it is all the more important that ways be devised to integrate guinea worm control into other programs.

The implementation planning approach presented in these guidelines follows standard systems analysis techniques (see, for example, Grubb and Loddengaard, 1981; WHO, 1976; Blum 1974). The approach assumes that there is a consensus on health goals and specific policy objectives regarding guinea worm disease control or eradication. Impact objectives would be the degree of control that is sought over a particular period of time or the time period intended to bring about eradication. Service objectives are defined in terms of the different modules presented below. It is at the level of resource and implementation objectives, however, where the most critical work has to be carried out. Tasks to reach service objectives must be specified within the context of country and program conditions, and broken out so that performance of the task and component sub-tasks is manageable. Resources necessary to

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1/ This report does not present a discussion or overview of the guinea worm disease cycle itself. For a general overview, consult WASH Technical Report No. 38, mentioned above, or other sources such as Hopkins (1983) or National Academy of Sciences (1983).

perform the tasks must be identified in considerable detail, and costs determined. Conscientious application of this type of approach should result in program in which:

1. Budgeting becomes increasingly systematic and realistic;

2. Progress is easy to monitor; and

3. Trouble-shooting becomes much more focused.

In addition, planning and budgeting for subsequent years is facilitated, and a straight-forward program end-point can be determined.

The model, therefore, is a method for defining a comprehensive guinea worm control program in terms of "modular" strategies, broken out into activities and tasks with specified task resources and costs. Existing projects and programs could select modules or parts of modules as add-ons. Alternatively, a comprehensive and dedicated guinea worm strategy could be developed by combining appropriate modules.

2.2 Cost-Benefit Analysis

Cost-benefit analysis (CBA) is a method of economic analysis customarily used to determine broad policies and gross economic allocations, either among sectors or within sectors. To carry out CBA, the various costs and benefits of policy options must be known or estimated. Moreover, they must be presented expression in monetary terms as a "lowest common denominator" to allow comparison of unlike things. When the costs and benefits occur over time (as they do in a health care program), they must be "discounted" to a present value or net present worth to allow comparison. The time period over which the flow of costs and benefits are considered is particularly important in an eradication program in which the costs are by definition limited while the benefits continue indefinitely.

The output of a cost-benefit analysis is a benefit-to-cost ratio (BCR) which expresses in numerical form the relationships between the monetary value of the returns (benefits) and expenditures (costs) of each policy or program. For example, if three policy or program alternatives have BCRs, respectively, of 3.23, 1.02, and 0.75, the first is to be preferred on the basis of the CBA because it returns nearly 3 1/4 times the expenditure. The second provides a near break-even on the investment; while the third costs more than the value of the benefits.

CBA can be used to provide a means of allocating resources between sectors such as road systems, public education, or health. Within a sector, CBA can be used to compare returns from investments in a rural versus an urban health strategy or between a program to control one disease versus another.

With regard to cost-benefit, health care programs are traditionally seen as a "social good," and justifiable on that basis. Health care programs also can be justified as a necessary investment for improving human capital or human resources which, given poor enough conditions, can be the restraining factor on other investments. Generally, however, health programs do not fare well under the close scrutiny of CBA. First, few social programs (health included) generate the easily-measurable returns that can be generated by many economic development programs. Second, economic analysis in health is difficult because health and disease are multi-causal in nature, and ascribing cause-and-effect and attaching monetary benefit to health outcomes are difficult. Finally, many true benefits of health programs, such as improvement of the quality of life, alleviation of suffering and grief, etc., are too intangible to be expressed in monetary terms at all.

The model demonstrates an approach to the assessment of the cost-benefit of guinea worm control programs within the data (and time) constraints that probably exist for conducting the analysis. In addition, relative BCRs can be used as criteria in cost-effectiveness determinations regarding alternative strategies, as discussed below. Finally, "rough cut" CBAs, if done conservatively and with explicit assumptions, can be useful for program planners and managers in presenting their programs to decision makers. Definitive assessment of cost-benefit requires substantially more data and expertise than is assumed for this model and is more properly the domain of economic planners rather than program planners or implementors.

2.3 Cost-Effectiveness Analysis

Given a commitment to the clearly defined objective of guinea worm control or eradication (whether reached through CBA or some other method), cost-effectiveness analysis (CEA) in the context of this model provides information to answer the question:

> Which of the available and feasible (i.e., appropriate) strategies can produce the desired outcome at the lowest cost?

Cost-effectiveness analysis requires clear specification of the anticipated results of each strategy under consideration and the estimated costs associated with each strategy. CEA presupposes that the level of benefits justifies the program effort.

In this model, CEA compares benefit-cost ratios for the different strategies. As described below, each intervention strategy is assigned an estimated "effectiveness" in controlling guinea worm disease. The BCR for the strategy is then determined by dividing the resulting benefit by the costs for the strategy.

Chapter 3

PROGRAM DESIGN

It is useful in any program planning activity to break down the larger task into component activities. In the case of guinea worm disease, the following typology of activities or service objectives is suggested:

1. Epidemiologic surveillance;
2. Community participation/Health education/personal prevention;
3. Improved water supplies; and
4. Chemical control of the intermediate vector.

Two of these service objectives--epidemiologic surveillance and community participation/health education--are necessary for any general strategy to address the problems of guinea worm or, for that matter, virtually any public health problem anywhere. The other two components--community water supply and chemical treatment to control the vector--comprise technological interventions that normally are mutually exclusive and alternative approaches; however, they can be implemented very effectively in serial fashion--control of the vector by chemical treatment until such time as the water supply is improved.

By combining the first two activities with different combinations of the second two more-technology-dependent interventions, different strategies can be developed with different cost-effectiveness implications. It is intended that these four activities, elaborated separately as modules or combined as a broader-based strategy, could define an approach to guinea worm disease, either through a comprehensive program or in parts as cost-effective guinea worm adjuncts to existing programs. The costs for each of the two technological approaches are considered, both separately and in conjunction with the cost of the the epidemiologic surveillance and health education modules.

3.1 Intervention Modules and Cost Estimates

The purpose of breaking out approaches to the control of guinea worm into four distinct modules (with separate cost estimates developed for each) is both to define a comprehensive program and to facilitate 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 costs of additional salary, per diem, fuel, transportation, and other costs from what they would be for a vertical program. It is possible to modify many existing projects, such as those mentioned above, 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 relatively cost-effective project modifications resulting in a very visible program outcome would lead to the adoption of the necessary components by existing projects which would serve as the foundation for effective guinea worm control efforts.

Costing by modules can also show how recognition of the benefits of any one activity may extend beyond the immediate objectives of guinea worm control; i.e., a water supply intervention to control guinea worm disease will have large residual benefits beyond those related directly to control of guinea worm. Estimated costs related to guinea worm control alone are therefore provided for each of the modules by multiplying total costs by some percentage, i.e., that percentage devoted solely to guinea worm control. These percentages can vary widely, for instance, 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.

Finally, when considering costs, it should be noted that guinea worm eradication efforts differ from most other communicable disease programs in that, if ultimately successful, there are no long-term recurring costs. Guinea worm disease is unique in that effective programs can theoretically break the cycle of transmission in one year. Under active surveillance, "guinea worm elimination" is defined as 24 continuous months of complete absence of new indigenous (i.e., non-imported) cases (National Academy of Sciences, 1983). As discussed above, therefore, two years represents a program of minimum length and five years the required length of time for eradication of guinea worm in a particular region, country, or area, assuming no new imported cases.

3.2 Implementation Planning

There are five steps involved in designing or adapting modules to a particular country or program.

Step 1: Defining Objectives

In this step specific service objectives are developed, such as establishing an epidemiologic monitoring system for guinea worm disease or establishing an ongoing effective system of chemical treatment of water supplies contaminated with the insect vector. Defining the objectives for each module helps set the parameters and focus for the activities within each module. Without clearly stated objectives the program effort can become diffuse, inefficient, and difficult to monitor.

Step 2: Specifying Activities or Tasks and Defining Strategies

Within each service objective, the necessary activities or tasks to accomplish the objective must be broken out. Results from these activities are the resource and implementation objectives necessary for the success of the program. Examples from the epidemiologic surveillance program include:

1. In-depth baseline surveys and establishing a system for follow up;

2. Establishing a contact system with existing health authorities for the purposes of disease monitoring; and

3. Appropriate data analysis and reporting.

With regard to community water supply, activities might include construction of a certain number of protected water supplies or establishment of an operations and maintenance system for existing systems. For health education, activities would include distribution of filters, and the implementation objective might be expressed in terms of coverage.

Once the activities within a module have been specified, putting modules together to form a strategy appropriate for the specific area requires knowledge of the particular areas and judgments about the appropriateness and potential success of different interventions. For example, in Pakistan use of the chemical ABATE to treat contaminated water sources was determined as more feasible for one of the provincial strategies than for the other two. Improving water supplies was perceived as rather minor for all strategies.

How the modules are combined into strategies can have dramatic cost implications, and the strategies may be modified as part of the feedback/iteration process, either during the implementation planning or cost-benefit stage of the model.

Step 3: Detailing Activities and Costs and Developing Cost Estimates

After activities and tasks have been specified, cost estimates are developed by breaking these tasks down into the following resource categories:

1. technical labor;
2. transportation;
3. training;
4. material; and
5. other.

In the Pakistan field test of the implementation model, three subcategories for technical labor are considered: (1) senior professionals/consultants; (2) junior professionals; and (3) clerical personnel/drivers. Salaries and per diem are the two areas of personnel costs that are considered in the model. It is desirable to limit the number of labor categories to provide sufficient discrimination among the types of labor in the field implementation of the project without making the labor categories too numerous and complex for planning purposes. Under different field conditions more (or fewer) categories than those used in Pakistan may be appropriate.

Within each of the resource categories, then, the appropriate units, unit cost, and number of units of services or commodities are specified, and the cost for that "line item" calculated. The units for labor may be in person-days or person-months, for example, and the unit cost would be the cost of one person-day or person-month.

Vehicle usage units could, alternatively, be in terms of kilometers traveled and a per-kilometer cost or in terms of vehicle-days and a per day cost. In the case of vehicles, the analyst has to consider whether or not vehicles are being purchased, rented, or "borrowed" from other agencies, and whether or not there is to be reimbursement for the use of the vehicles. Expenses associated with drivers must also be considered as well as transportation associated with training and implementation of the program in the field.

Similar detail with regard to the design and cost of training programs or spraying programs can be developed. Examples are provided in the appendices and discussed below. At the implementation planning stage it is important to require the complexity of task development and the many places where assumptions are made regarding availability of resource or costs.

Step 4: Making Assumptions Explicit

In the planning of activities although implicit assumptions may be clear to those involved in the program, they rarely are for those outside who may be key to success. An example is the assumption that workers from other sectors, such as malaria eradication, will be available part-time to conduct spraying campaigns for guinea worm control or that EPI workers can incorporate guinea worm health education messages and materials into their routine. Similar implicit assumptions are also often made with regard to materials, space, and the availability of transport. Questioning all assumptions, making them explicit, and confirming them with the person/agency whose cooperation is required will go a long way toward their realization. It is important for program planners to remember that nearly all development programs are under-funded and their staffs overworked, and that other managers understandably are not as enthusiastic and committed to the goals of "outside" programs (whatever they might be) as are its sponsors.

Assumptions regarding national and local infrastructure are as important as assumptions regarding resource availability. With regard to guinea worm control, these assumptions might include the existence of adequate roads in the endemic areas to provide access for drilling equipment, the availability of primary health care for treatment of guinea worm symptoms, or the in-country capability of formulating ABATE sand granules or emulsifiable concentrate from imported active ingredient. Proposed strategies must be reconsidered particularly where infrastructure assumptions are found lacking.

Step 5. Feedback and Iteration

Information received during the process of verifying assumptions may well call into question the reality/feasibility of some of them. Similarly, estimation of costs may indicate that the approach needs to be modified to meet budget requirements, or that different levels of interorganizational or interagency cooperation need to be sought. Information gathered during the entire verification process should be used in the next, and perhaps immediate, iteration of the process, with further refining until it is felt that another cycle of refinement will produce information of only marginal value.

3.3 Spreadsheet Implementation

Sample implementation spreadsheets detailing activities and costs are shown in the two appendixes. In Appendix A, example spreadsheets are provided from WASH Technical Report No. 38, the original concept paper. These spreadsheets were developed with an inland West African country in mind and attempted to be comprehensive and "generic." Appendix B presents implementation spreadsheets from the 1987 field test in Pakistan and presented in WASH Field Report No. 231. These spreadsheets are substantially shorter and represent the adaptation of the larger, more comprehensive model to the realities of the country and program. The components of any endemic country's infrastructure will be sufficiently different that separate cost estimates for each program are necessary. For accurate cost estimates of any possible guinea worm control project or add-on to an existing project, the particular conditions of the endemic country setting and guinea worm control program must be taken fully into account. The cost estimates shown in Appendix A provide examples of the items that need to be considered, provide the basis for a cost-benefit analysis, and give a scale of their costliness in relation to each other and to other program costs with which the reader might be familiar.

For the generic (Appendix A) spreadsheets, cost information was integrated from several different sources, all originating in West African projects. Costs are developed for a program in 100 villages over two years with a program of epidemiologic surveillance, community participation/health education, and either community water supply or chemical treatment. 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 within which an effective guinea worm program could be expected. A longer (five year) program would represent an extended effort toward a more thorough guinea worm control. The extended program coupled with similar efforts in other endemic locales would also provide the means which might allow eradication of the disease.

Appendix B shows the implementation spreadsheets for one of the three provincial strategies proposed for the program in Pakistan. These spreadsheets resulted from the detailing of the particular strategy for a province and followed the general format of the spreadsheets in the original technical report. Such parameters as number of health education teams necessary were determined from the number of villages and the average village size, as previously determined through the national guinea worm search. Parameters relating to use of ABATE were also determined from available information relating to usual sources of drinking water. (This information was also critical in decisions regarding the appropriate strategic approach--whether or not to rely more on health education and filtration than chemical treatment with ABATE). The fact that there would be no water supply improvement costs, except for minor expenses for operation and maintenance, was an important cost assumption in Pakistan. This was justified because improved water supplies are not feasible in the guinea worm-endemic areas and therefore are relatively minor in any of the proposed strategies. In addition, the short-term perspective of the eradication program in Pakistan does not allow water improvement programs that usually take several years or more from planning to implementation.

Supporting improved operation and maintenance of existing systems was emphasized as was encouraging the water implementing agencies (the Government of Pakistan Public Health Engineering Department and UNICEF) to perhaps focus on guinea worm areas for rapid implementation in current programs.

Chapter 4

APPROACH TO ASSESSMENT OF COST-BENEFIT AND COST-EFFECTIVENESS

4.1 Steps in the Process

Step 1. Assigning Proportion of Costs "Chargeable" to Different Modules

An important concept suggested by this model is that of assigning or allocating only a portion of the costs of the intervention program to guinea worm control. The concept, as mentioned earlier, is that the benefits from any one activity may extend beyond the immediate objectives of guinea worm control. Improving water supplies to control the disease will also control other diseases, and additional economic gains can be projected. Similar reasoning can be applied to health education/community participation programs. However, in the case of chemical treatment with ABATE, the full costs of the effort must be "charged" to guinea worm since benefits to other health or development objectives cannot be expected to accrue from this activity. In the case of epidemiologic surveillance, the full amount would be charged to guinea worm if the surveillance were solely dedicated to this disease. If, however, other information is gathered or the survey covers other activities, then perhaps somewhat less than 100 percent should be charged to a guinea worm program. In the case of Pakistan, the first national survey was focused entirely on guinea worm disease; however, the second gathered information relating to other diseases. In the case of the first survey, 100 percent would be charged to the program; in the second case, perhaps 75 percent.

The proportions of the modules charged to guinea worm control from the original formulation of the model (WASH Technical Report No. 38) are as follows:

- epidemiologic surveillance--100 percent;
- community health education/community participation--50 percent;
- community water supply--40 percent;
- and chemical treatment--100 percent.

The assigning of such values is essentially a political decision, for an empirical study to accurately determine them would probably not be feasible, even if it were determined to be worthwhile. They can also be varied and examined in the context of a sensitivity analysis. What is important, however, is the concept that intervention programs for guinea worm disease, particularly in areas like Pakistan where the distribution is relatively limited, have substantial positive effects beyond just guinea worm control. Estimates, therefore, need to be made of the costs related to guinea worm control alone in order to be measured accurately against the benefits due to guinea worm control.

Step 2. Determining Benefits and Valuation of Benefits

Benefits for disease prevention programs are usually considered to have two components: direct costs related to expenditures for health care and services delivery for the disease and indirect costs related to value of lost productivity due to morbidity and mortality. Because of the special characteristics of guinea worm disease and the characteristics of the areas where the disease is endemic, health care services related to guinea worm are both currently minimal and in many countries have minimal potential for expansion. Furthermore, cost-benefit simulations of health care alone for control of guinea worm disease were carried out for WASH Technical Report No 38 and were found to result in low benefit-cost ratios.

More important for guinea worm disease are the indirect benefits that would accrue from control of the disease through improved productivity. Guinea worm disease usually affects the adult population during the agricultural season and often results in total disability (i.e., non-productivity) for the individual for a significant portion of that crucial period. To the extent that one disabled worker is not substituted for by another healthy worker, the potential production of the worker disabled by guinea worm disease is a benefit that could be realized through control of the disease.

WASH Technical Report No. 38 and the follow up WASH Field Report present a methodology developed by Ward (1984) for estimating expected days of lost productivity due to guinea worm disease. Ward's methodology uses data on or assumptions about: (1) percentage of those afflicted who are totally disabled during the period of affliction; (2) the duration of the period of total disability; and (3) the annual incidence of disease symptoms among those 15 to 44 years of age. His calculations indicate that for every six percent of the population 15 to 44 affected, approximately one day of productivity per worker is lost annually.

In WASH Technical Report No. 38, the valuation of the estimates of working days lost due to guinea worm disease was made by multiplying these days by a per capita, per day, gross domestic product (GDP), adjusted for guinea worm-related absences and assuming that all productivity occurred during an agricultural season of particular length. Some of the restrictive assumptions in this method were: (1) all economic productivity affected by guinea worm disease was agricultural in nature; (2) all affected productivity occurred during the agricultural season; and (3) reported and published GDP measures were accurate and valid. Effects of the first two assumptions should cancel each other to some extent; the effect of the third assumption is unknown; however, it probably inflates the potential benefits due to the fact that guinea worm endemic areas tend to be poorer than average.

In the Pakistan field test, GDP measures were not available below the provincial level. Since wide variations are known to exist in productivity in some of the relatively affluent and guinea worm-free districts within the provinces under consideration compared to the poorer and more isolated guinea worm-endemic areas within the same province, a provincial-level GDP was felt to be inadequate. The search for a proxy measure uncovered district-level agricultural data, which provided information more accurately reflecting the actual areas affected by the disease. When combined with government fixed prices or prevailing market prices, a per capita per day agricultural productivity figure was obtained. This figure, when multiplied by estimates of days lost, yielded the estimates of potential benefits of guinea worm control.

It is necessary to emphasize the need for creativity in formulating proxy measures and perseverance in getting information. It is unrealistic to think that desired data elements will be available in any one place or in the desired format. Substantial ingenuity and "brainstorming" may be necessary to obtain data and come up with adequate proxies for this and other measures necessary for the analysis.

Step 3. Calculation of Ratios and Indexes

The calculation of benefit-cost ratios and other indexes, such as internal rates of return and years-to-payback, becomes mechanical once the valuation of benefits and costs has been determined. (See WASH Technical Report No. 38 for an elementary definition of these measures. Several of the references to this paper go into CBA in greater detail.) An additional assumption for BCRs relates to the discount rate and time period over which the calculation is made; commonly the starting discount rate is taken as the current market interest rate, which is then examined through sensitivity analysis.

The resultant ratios and indices are useful at several levels. For the program planners/managers, they can be used to assess the cost-effectiveness of strategies, as discussed in Step 5 below. The results can also be useful in presentations to policy makers, funding agencies, and other outside groups to demonstrate that, at a minimum, benefits have been thought about and attempts made to quantify them in an assessment of the program. Unless done with a great deal more sophistication, either by or under the close scrutiny of a professional economist, however, working through this model does not constitute a definitive cost-benefit analysis. The goal of the entire exercise is primarily operational in nature, rather than economic or political.

Step 4. Cost-Effectiveness Assessment of Strategies

Cost-effectiveness of different *strategy configurations* is determined by the relative BCRs resulting from the simulated application of the strategy. Different costs are associated with different strategies because of the differing resources in each; different benefit flows can also be realized through assumptions about relative levels of effectiveness of a particular strategy in addressing the disease problem. For example, a strategy focusing on distribution of health education materials may be relatively inexpensive, but may also be less effective in controlling the disease, and therefore the proportion of total benefits realized will be relatively low. A strategy of improved water supplies would be very expensive initially, but would be highly effective in controlling the disease, thus returning the full benefit flow very rapidly. Despite much greater costs, the outcome measures for the water supply intervention could be greater than the simple health education intervention.

Step 5. Sensitivity Analysis and Feedback/Iteration

In CBA, feedback/iteration takes the form of sensitivity analysis. Sensitivity analysis refers to procedures for estimating the errors in the cost-benefit outcome parameters by varying one or more of the input parameters. Commonly, the analyst selects high and low values on a number of key parameters, including both economic parameters like the discount rate, as well as substantive parameters such as, in this case, disease prevalence or value of agricultural productivity. New outcome parameters are estimated, and the analyst can then estimate how "sensitive" they are to changes in the key input parameters. For example, we could find that small changes in estimates of disease prevalence make a large change in the outcome parameters, thus indicating that the epidemiologic surveillance systems need to be refined (and therefore probably more expensive). The opposite could also be true for that or other variables. When variables are recombined it is often possible to uncover patterns and relationships that lead to better understanding of the model and its assumptions and which can lead to further model refinement. The usefulness of dedicated microcomputers is at its most apparent when conducting sensitivity analyses, for the virtually instantaneous feedback allows many different scenarios and combinations of variables to be tested in rapid succession.

4.2 Spreadsheet Development

The microcomputer model links the implementation planning and cost spreadsheets with a spreadsheet projecting cost and benefit flows over time. The following is intended to provide an overview of the spreadsheets without discussing the detailed significance of the results. The emphasis is on summarizing the process rather than presenting the analytical results.

The cost-benefit spreadsheets from the original model (as shown in Appendix C) presented analyses relating to two different strategies (water supply emphasis versus chemical control emphasis) and did the calculations both in the context of limited health care availability and the absence of health care availability. Four different benefit flows and four BCR outcomes were thus determined. In addition, a BCR for health care alone (assuming health care availability) was also calculated for comparison.

In the case of Pakistan, the spreadsheets (Appendix D tables) are, as they were with the implementation spreadsheets, substantially less complicated due to simplifying assumptions and adaptation to actual field conditions. The first spreadsheet provides model assumptions and starting values for the three different provinces where guinea worm eradication programs are planned. Important differences among the provinces include total population (and population per village), disease prevalence, and agricultural productivity per capita, adjusted for guinea worm-related lost productivity. Level of intervention effectiveness and rate of implementation were assumed the same even though strategies with different emphases are planned. In addition, there is an assumption of no health care availability relating to guinea worm disease since simple health care provided by the intervention teams is incorporated into the strategy for each of the three areas.

The next four tables in Appendix D present program cost and program benefit flows over a period of ten years for each of the three provincial programs, as well as for the national program, which is the total of the three provincial programs. It should be noted that program costs extend no further than year six, with the actual interventions (community health education, water supply, chemical treatment) being completed within three years. Production benefits will continue indefinitely, but are terminated in this analysis at the ten-year point. Benefit-cost ratios, by province, are calculated at a discount rate of 7.5 percent. The BCRs for the provincial-level programs demonstrate all three conditions: unfavorable, marginally favorable, and favorable. When taken together through totaling costs and benefits for all three sites, the result for the national program as a whole has a favorable BCR of 1.14. In other words, the discounted value of the estimated production benefits over a ten-year period from implementing the program to eradicate guinea worm disease would be 14 percent greater than the discounted costs of the field eradication effort over the projected six-year period.

The final table in Appendix D displays a selective sensitivity analysis which examines the effect of assumed annual agricultural productivity (a benefit factor) and number of villages to be treated (a cost factor) on resultant BCRs. In addition, the effect of considering a 15-year rather than 10-year time frame is also examined. Guinea worm prevalence figures could also be varied within a sensitivity analysis. They were not in this analysis because the figures came from a household prevalence survey in endemic areas and are felt to be quite reliable. Other tests of model outcomes, however, found the model to be very sensitive to changes in the disease prevalence figures.

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APPENDIX A

Example Implementation Spreadsheets
WASH Technical Report No. 38

"Cost-Effective Approaches to the Control of Dracunculiasis"

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		180		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 --district personnel		person-days	4	160	640	For health workers and other personnel 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

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

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	fuel, oil, repairs;	km	.60	2000	1200	operating costs only; assumes 4 WD vehicle availability
to conduct surveys	20 km btwn villages					
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					340050	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					96700	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. Maintanance 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

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			2200	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

APPENDIX B

Example Implementation Spreadsheets

WASH Field Report No. 231

PAKISTAN: Field Test of Implementation Planning and Cost-Benefit Model for Guinea Worm Eradication.

Table 1. Implementation Planning Spreadsheets for Cistern-based Interventions (NWFP)
Section 1. Cost Items: Epidemiologic Surveillance (100 percent of intervention villages; sample others)
Province: NWFP Population: 147610 Villages: 79

Activities/Items	Assumptions	Units	Unit Cost (Rupees)	No. of Units	Cost (Rupees)	Comments
A. Ongoing monitoring, intervention areas	all interven. villages	villages		79		
1. Labor	salaries, TA/DA					
a. Village monitors		person-month	100	1896	189600	# of monit. per vill. * # of vill. * 12 mo.
b. Technical personnel --supervision and review	GW program staff					
1) Senior professional		person-days	600	25	15000	10 % , 1 yrs. (.1 *21 days/mo *12)
2. Training						
a. Village monitors	2 day annual sessions	person-days	100	316	31600	
b. Technical personnel --to conduct training	GW program staff	person-days				
1) Senior professional			600	10	6000	
2) Junior professional			300	20	6000	
3. Transportation						
a. Supervision and review						
1) Drivers	GW prog. vehicle	person-days	240	25	6000	
2) Fuel, oil, repairs	GW prog. vehicle	per day	100	25	2500	
b. Training						
1) Village monitors		per session	200	158	31600	
4. Materials						
a. Monitoring materials	per village monitor	persons	200	158	31600	
b. Training material	per monitor	persons	100	158	15800	printing and duplic. costs
5. Total, ongoing monitoring		villages			335700	
B. Monitoring of Surrounding Areas (screening surveys)	sample of villages	villages		16		sample of surrounding villages (20% of interven. villages)
1. Labor	salaries, TA/DA					
a. Technical personnel						
1) Senior professional	GW program staff	person-days	600	25	15000	10% of time
3) Field teams	3 person team	team-days	1200	24	28440	1 senior and 2 junior prof.
2. Training for field teams	annual sessions	team-days	1200	2	2400	2 day sessions
a. Technical personnel --to conduct training	senior professional	person-days	600	2	1200	

Section 1. (continued) NWFP

Activities/Items	Assumptions	Units	Unit Cost (Rupees)	No. of Units	Cost (Rupees)	Comments
3. Transportation						Operating and leasing costs; assumes 4 WD vehicle
a. Driver	for GW prog. vehicle	person-days	240	20	4800	
b. Fuel, oil, repairs	for GW prog. vehicle	per day	100	20	2000	
c. Vehicles/Drivers	2nd and subseq. teams	per veh./day	600	0	0	
4. Materials						
a. Training material	per field team trainee	persons	500	32	15800	
b. Survey material	per team	persons	500	16	7900	development, printing, and duplic. costs
5. Total, screening surveys					77540	
C. Liaison with health workers *and other public officials*	*(at district and provincial level)*					*to promote the use of improved reporting*
1. Technical personnel	salaries, TA/DA					
a. Senior professional	GW program staff	person-days	600	10	6000	
2. Training/Public relations						For health workers and other personnel
--district personnel	salaries, TA/DA	person-days	300	40	12000	assume 10 persons, 2 districts, 2 days
a. Planning costs		per session	5000	2	10000	district level training meeting (2 districts)
b. Transportation costs	GW prog vehicle	per day	340	10	3400	
3. Forms and materials --production, duplication		per year	10000	1	10000	Design and produce hierarchy of reporting forms
4. Total					41400	
D. Data analysis and reporting						
1. Technical labor	salaries, no travel					
a. Senior professional	GW program staff		200	25	5000	10% time
2. Reports and materials	per year		10000	1	10000	preparation, duplication, and distribution
3. Total					15000	
				Total	469640	

Table 1. Implementation Planning Spreadsheets for Cistern-based Interventions (NWFP) -- continued
Section 2. Cost Items: Community Health Education (100 percent of villages)
Province: NWFP Population: 147610 Villages: 79

Activities/Items	Assumptions	Units	Unit Cost (Rupees)	Number of Units	Cost (Rupees)	Comments
A. Technical labor	salaries, TA/DA					
1. Senior professional	GW program staff	person-days	600	50	30000	20 % , planning, supervision, and review
2. Field teams	3 person teams	team-days	1200	237	284400	1 sr. and 2 jr. prof.
--number of teams necessary:		6				
B. Training for field teams	prior to field imple.	team days	1200	18	21600	3 day training session
--filter distribution						As appropriate for selected strategies. Includes salary and perdiem.
--health education/ personal prevention						
--community participation						
--chemical treatment						
--water system maintanence						
1. Technical personnel	senior professional	person-days	600	10	6000	includes planning time for training in Punjab and Sind
--to conduct training						
C. Transportation						
1. Training programs	ave trans costs	per partic.	300	18	5400	transportation per person for training
2. Field work						
a. Driver	for GW prog. vehicle	person-days	250	40	10000	
b. Fuel, oil, repairs	for GW prog. vehicle	per day	75	40	3000	
c. Vehicles	2nd and subseq. teams	per veh./day	600	200	120000	
3. Total					138400	
D. Materials and Support						
1. Training						
a. Planning costs		per session	5000	1	5000	
b. Tech. training materials	equip. and supplies	per session	5000	1	5000	
2. Health educ materials	per village	per year	1000	79	79000	development cost of health educ materials not included
--posters, flip charts, etc.						
3. Filters (precut polyester)	monofil. sieve material	per filter	12	32802	409372	US $6.50 per sq meter; approx 9 pieces sieve material per meter
a. Other material		per filter	2	32802	65604	assume 1 filter/hsehld. (ave. # of fam. members = 4.5)
4. Medical treatment kits		per village	400	158	63200	per team per visit
--bandgages, simple meds.						
5. Total					627176	
				Total	1182776	

Table 1. **Implementation Planning Spreadsheets for Cistern-based Interventions (NWFP) -- continued**
Section 3. **Cost Items: Community Water Supply Module** (assumed for 10% of the villages)
Province: NWFP Population 14761 Villages: 8

Activities/Items	Assumptions	Units	Unit Cost (Rupees)	Number of Units	Cost (Rupees)	Comments
A. Hydrogeologic surveys	Assumed available from other sources			8		
B. Tube well constr. and repair						
1. New construction	at 10 sites	per well	800000	4	3160000	Per well 8 lakh rupees (NWFP PHED). Cost per well approx. $46377
2. Well rehabilitation	at 2 sites	per well	320000	2	505600	Estimated 40% of the cost of new well construction.
C. Borehole/Hand Pump Systems	at 3 sites	per well	31500	2	49770	UNICEF estimates (new program). Cost per well aprox. US$ 1800.
D. Maintanence requirements	all systems	per system		8		
1. Labor						
--village-level	volunteer labor	2 pers./vill	0	16	0	assume elected/appointed by village
2. Training	2 day annual sessions	person-days	100	32	3160	training costs as for village monitors
--transportation	average cost	per person	200	16	3160	aver. transportation costs to training sites, both years
--trainers	senior professsionals	person-days	600	6	3600	
3. Equipment and materials	per year	per village	2500	8	19750	
4. Total, maintanence					29670	
				Total	3745040	
	Less construction costs assumed to other programs				3715370	tube wells and hand pump systems by others (PHED and UNICEF)
				Net to GW progr.	29670	

Table 1. Implementation Planning Spreadsheets for Cistern-based Interventions (NWFP) -- continued
Section 4. Cost Items: Chemical Treatment with Abate (assumed for 13% of the villages)
Province: NWFP Population 18451 Villages: 10

Activities/Items	Assumptions	Units	Unit Cost (Rupees)	Number of Units	Cost (Rupees)	Comments
A. Baseline surveys and initial application		villages		10		feasibility for chem treat determined through village surveys
1. Technical labor	salaries, TA/DA					
a. Technicians	1 day/village	person-days	300	0	0	at same time as health educ visit
--malaria/health workers						
2. Training for technicians		person-days	300	0	0	incorporated as part of health education team training
3. Transportation						included as part of health education team field work
4. Equipment and materials	per technician	person	2000	1	2000	
--chemical storage containers						
--measuring rods, tapes						
--sprayers, funnels, flags/paint						
--forms, tables, log books						
5. Total, survey and first application					2000	
B. Purchase of Abate	50 EC liquid formulation					assume 1500 cu. meter total water supply to be treated per village
1. 50 EC liquid formulation	500 gr/l active ingred	liter	390	90	35100	2 ml per cu. meter for 1 ppm conc., 3 treatments/yr.
2. Transportation to POE	5.49 kg/l	kg.	40	0	0	assume delivery
3. Total, chemical purchase	purchase and transp.				35100	
C. Storage and transportation						
1. Warehousing costs	10% purchase cost	per year			3510	for secure storage; liquid formulation
--National level						
--Regional/district level						
2. Transportation	vehicle availability					to deliver chemical treatment supplies
a. Drivers		person-days	600	0	0	
3. Total, storage and trans.					3510	
E. Follow up and support (2nd and 3rd applications)						
1. Technical labor	salaries, TA/DA					
a. Malaria/health workers	1 vill/day	person-days	300	0	0	2 follow up visits per year for chem applic; w/ hlth. ed. visits
b. Technical supervisors		person-days	600	0	0	
2. Transportation						incl. as part of health ed. team field work (as for 1st applic.)
3. Materials	for tech labor	per year	500	10	5000	forms, replacement supplies for chem applic.
4. Total, follow up and support					5000	
				Total	45610	

APPENDIX C

Example Cost-benefit Spreadsheets
WASH Technical Report No. 38

"Cost-Effective Approaches to the Control of Dracunculiasis"

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 Intervention (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	100062	100062	0
Year 2	40628	140079	120324	19755
Year 3	145804	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)	980822	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	100062	100062	0
Year 2	37822	143689	120324	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)]		

APPENDIX D

Example Cost-benefit Spreadsheets
WASH Field Report No. 231

PAKISTAN: Field Test of Implementation Planning and Cost-Benefit Model for Guinea Worm Eradication.

Table 4

Cost-Benefit Worksheets -- Model Assumptions and Starting Values

Parameter	Province NWFP	Punjab	Sind	
Population at risk	147,610	54,229	153,359	Estimates from GW Special/General Search (Spring, 87)
Percent of popul. working in agri.	66.75	66.73	61.75	1985-86 Dept. of Labor Statistics, Govt. of Pakistan
Total population in agriculture	98,530	36,187	94,699	
Disease prevalence	1.46	4.14	3.20	Percent. Estimates from prevalence survey (Fall, 87)
Working days lost/year	23,976	24,969	50,506	1 day for ea. 6% of prod. popul. affect. (Ward, 1984)
Agri. prod/person/year	2,534	2,843	6,927	Rupees
Total agri. output (000 rupees)	249,684	102,866	655,996	From agricultural statistics and local prices.
Adjusted agri. prod/person/year	2,572	2,965	7,156	Rupees (adj. for guinea worm-related work absences)
No. of days in agricultural season	120	120	120	
Adjusted agri. prod/person/day	21	25	60	Rupees; assuming all loss occurs in agri. season
Total production loss/agri. season	513,805	617,024	3,011,919	Rupees
Intervention effectiveness	0.90	0.90	0.90	Overall expected effectiv. in reducing guinea worm
Year 1 implementation factor	0	0	0	All interventions
Year 2 implementation factor	0.90	0.90	0.90	"
Discount rate	0.075	0.075	0.075	

Table 5
Cost-Benefit Summary Spreadsheets -- NWFP Cistern-based Strategy

Section 1. Program Costs Province: NWFP

Year Following Project Start	Epidemiolog. Surveillance	Commun. Health Education	Commun. Water Supply	Chemical Control	Field Costs Alone	Non-Field Related Costs	Total Cost
Factor:	1.00	1.00	1.00	1.00	1.00	0.42	(Rupees)
Year 1 (1988)	469,640	1,182,776	29,670	45,610	1,727,696	1,041,339	2,769,035
Year 2 (1989)	469,640	709,666	17,802	27,366	1,224,474	948,939	2,173,412
Year 3 (1990)	281,784	354,833	8,901	13,683	659,201	474,469	1,133,670
Year 4 (1991)	93,928	0	0	0	93,928	94,894	188,822
Year 5 (1992)	93,928	0	0	0	93,928	47,447	141,375
Year 6	0	0	0	0	0	47,447	47,447
Year 7	0	0	0	0	0	0	0
Year 8	0	0	0	0	0	0	0
Year 9	0	0	0	0	0	0	0
Year 10	0	0	0	0	0	0	0
Net Present Value (NPV)							5,639,741

Section 2. Production Benefits Province: NWFP

Year 1 (1988)	0
Year 2 (1989)	416,182
Year 3 (1990)	462,425
Year 4 (1991)	462,425
Year 5 (1992)	462,425
Year 6	462,425
Year 7	462,425
Year 8	462,425
Year 9	462,425
Year 10	462,425
Net Present Value (NPV)	2,703,943

Section 3. Outcome Parameters Province: NWFP

Benefit-Cost Ratio	0.48	Discount Rate: 0.075
Internal Rate of Return	-10 %	No. of Years: 10
Years to Payback	>8	

Table 6

Cost-Benefit Summary Spreadsheets -- Punjab Pond-based Strategy

Section 1. Program Costs Province: Punjab

Year Following Project Start	Epidemiolog. Surveillance	Commun. Health Education	Commun. Water Supply	Chemical Control	Field Costs Alone	Non-Field Related Costs	Total Cost
Factor:	1.00	1.00	1.00	1.00	1.00	0.15	(Rupees)
Year 1 (1988)	324,500	783,297	26,700	67,415	1,201,912	371,907	1,573,819
Year 2 (1989)	324,500	469,978	16,020	40,449	850,947	338,907	1,189,854
Year 3 (1990)	19,4700	234,989	8,010	20,225	457,924	169,453	627,377
Year 4 (1991)	64,900	0	0	0	64,900	33,891	98,791
Year 5 (1992)	64,900	0	0	0	64,900	16,945	81,845
Year 6	0	0	0	0	0	0	0
Year 7	0	0	0	0	0	0	0
Year 8	0	0	0	0	0	0	0
Year 9	0	0	0	0	0	0	0
Year 10	0	0	0	0	0	0	0
Net Present Value (NPV)							3,129,635

Section 2. Production Benefits Province: Punjab

Year 1 (1988)	0
Year 2 (1989)	499,790
Year 3 (1990)	555,322
Year 4 (1991)	555,322
Year 5 (1992)	555,322
Year 6	555,322
Year 7	555,322
Year 8	555,322
Year 9	555,322
Year 10	555,322
Net Present Value (NPV)	3,247,142

Section 3. Outcome Parameters Province: Punjab

Benefit-Cost Ratio	1.04	Discount Rate:	0.075
Internal Rate of Return	9 %	No. of Years:	10
Years to Payback	8		

Table 7

Cost-Benefit Summary Spreadsheets -- Sind Tarai-based Strategy

Section 1. Program Costs Province: NWFP

Year Following Project Start	Epidemiolog. Surveillance	Commun. Health Education	Commun. Water Supply	Chemical Control	Field Costs Alone	Non-Field Related Costs	Total Cost
Factor:	1.00	1.00	1.00	1.00	1.00	0.44	(Rupees)
Year 1 (1988)	826,380	2,576,075	0	911,322	4,313,777	1,066,133	5,379,910
Year 2 (1989)	826,380	1,545,645	0	546,793	2,918,818	971,533	3,890,351
Year 3 (1990)	495,828	772,823	0	273,397	1,542,047	485,766	2,027,813
Year 4 (1991)	165,276	0	0	0	165,276	97,153	262,429
Year 5 (1992)	165,276	0	0	0	165,276	48,577	213,853
Year 6	0	0	0	0	0	0	0
Year 7	0	0	0	0	0	0	0
Year 8	0	0	0	0	0	0	0
Year 9	0	0	0	0	0	0	0
Year 10	0	0	0	0	0	0	0
Net Present Value (NPV)							10,348,793

Section 2. Production Benefits Province: Sind

Year 1 (1988)	0
Year 2 (1989)	2,439,655
Year 3 (1990)	2,710,727
Year 4 (1991)	2,710,727
Year 5 (1992)	2,710,727
Year 6	2,710,727
Year 7	2,710,727
Year 8	2,710,727
Year 9	2,710,727
Year 10	2,710,727
Net Present Value (NPV)	15,850,477

Section 3. Outcome Parameters Province: Sind

Benefit-Cost Ratio	1.53	Discount Rate:	0.075
Internal Rate of Return	21 %	No. of Years:	10
Years to Payback	7		

Table 8

Merged Cost Spreadsheets/Joint Cost-Benefit Analysis

Section 1.
NWFP, Punjab, and Sind Intervention Programs
Total (Joint) Program Costs (Rupees)

Year	Epidemi. Surveillance	Commun. Health Education	Commun. Water Supply	Chemical Control	Field Costs Alone	Non-Field Related Costs	Total Costs (Rupees)
Year 1 (1988)	1,620,520	4,542,148	56,370	1,024,347	7,243,385	2,479,378	9,722,763
Year 2 (1989)	1,620,520	2,725,289	33,822	614,608	4,994,239	2,259,378	7,253,617
Year 3 (1990)	972,312	1,362,644	16,911	307,304	2,659,172	1,129,689	3,788,861
Year 4 (1991)	324,104	0	0	0	324,104	225,938	550,042
Year 5 (1992)	324,104	0	0	0	324,104	112,969	437,073
Year 6	0	0	0	0	0	47,447	47,447
Year 7	0	0	0	0	0	0	0
Year 8	0	0	0	0	0	0	0
Year 9	0	0	0	0	0	0	0
Year 10	0	0	0	0	0	0	0
Net Present Value (NPV)							19,118,168

Section 2.
Joint

Production Benefits	Rupees
Year 1 (1988)	0
Year 2 (1989)	3,355,626
Year 3 (1990)	3,728,474
Year 4 (1991)	3,728,474
Year 5 (1992)	3,728,474
Year 6	3,728,474
Year 7	3,728,474
Year 8	3,728,474
Year 9	3,728,474
Year 10	3,728,474
Net Present Value (NPV)	21,801,562

Section 3.
Joint

Outcome Parameters	10 Year Time Frame	15 Year Time Frame
Benefit-Cost Ratio	1.14	1.52
Internal Rate of Return	11 %	17 %
Years to Payback	9	9

Discount Rate: 0.075

Table 9

Sensitivity Analysis
Pakistan Guinea Worm Control Programme

I. Number of villages determined from national search data

Province	Assumed GW preval. in Population	No. of Vill.	Assumed annual adj. agri. prod. (Rp.)	10-year time frame BCR	10-year time frame IRR	15-year time frame BCR
NWFP	1.46%	79	2543 *	0.48	-10%	0.64
			3543	0.67	- 3%	0.90
			5300	1.00	8%	1.34
Punjab	4.14%	70	2843 *	1.04	9%	1.39
			3843	1.40	18%	1.87
Sind	3.20%	252	4510	1.00	7%	1.33
			5927	1.31	16%	1.76
			6927 *	1.53	22%	2.05

Joint (overall) 10-year BCR using *'d values = 1.14. IRR 11 %.

II. Decreasing number of villages to be treated by 25% (following case-counting implications)

Province	Assumed GW preval. in Population	No. of Vill.	Assumed annual per cap. GDP (Rup.)	10-year time frame BCR	10-year time frame IRR	15-year time frame BCR
NWFP	1.46%	60	2543	0.53	- 8%	0.70
			3543	0.73	- 1%	0.98
Punjab	4.14%	53	2843	1.18	13%	1.58
			3843	1.60	23%	2.14
Sind	3.20%	190	5927	1.58	23%	2.11
			6927	1.84	29%	2.46

Notes: Benefit-cost ratios estimated using a 7.5 percent discount rate.

Guinea worm prevalence figures are from the case-counting study, Sept.-Oct. 1987.

For reference, the annual GDP per capita in Pakistan, agricultural sector (1983): 4828 rupees (World Bank, World Development Report)

WASH