PN-AAG-057

AGENCY FOR INTERNATIONAL DEVELOPMENT WASHINGTON, D. C. 20523 **BIBLIOGRAPHIC INPUT SHEET**	FOR AID USE ONLY Batch 92 ARDA D

1. SUBJECT CLASSIFICATION	
A. PRIMARY	Science and technology TC00-0000-0000
B. SECONDARY	Applications

2. TITLE AND SUBTITLE
Socio-economic analysis of impact of water projects on schistosomiasis; results of cost-effective analysis

3. AUTHOR(S)
Rosenfield, P.L.; Gestrin, P.J.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1978	22p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Resources

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

9. ABSTRACT

10. CONTROL NUMBER	11. PRICE OF DOCUMENT
PN-AAG-057	

12. DESCRIPTORS

Economic analysis	Tanzania
Environmental factors	Water resources
Cost analysis	Water supply

13. PROJECT NUMBER
931113300

14. CONTRACT NUMBER
AID/La-C-1465 Res.

RESOURCES FOR THE FUTURE, INC.

1755 MASSACHUSETTS AVENUE, N.W.

WASHINGTON, D. C. 20036

SOCIO-ECONOMIC ANALYSIS OF IMPACT OF WATER PROJECTS ON SCHISTOSOMIASIS

Results of Cost-Effective Analysis

AID-Contract No. 931-1133

by

Patricia L. Rosenfield, Ph.D.

and

Phyllis J. Gestrin, Ph.D.

Resources for the Future
Washington, D. C.

August 1978

INTRODUCTION

Decisions about which control strategy to use for preventing or controlling schistosomiasis transmission need to take into account both epidemiological and economic conditions. Knowledge of the epidemiological situation assists in determing the appropriate physical measures for control. In an irrigated area, for example, one could consider engineering measures in addition to chemotherapy and mollusciciding. In an area where contact with snail habitats is due to domestic activities, controls might include protected drinking water supplies and sanitation facilities in addition to chemotherapy and mollusciciding. The use of a transmission model would enable the decision maker to decide which single control measure, or combination, would be most effective in reducing infection in the population, thus limiting transmission.

Control measures, however, involve costs of manpower, materials, and money. How these costs vary for each control measure needs to be considered when deciding which control measure to use. Control measures may then be compared for their costs and effectiveness in reducing schistosomiasis prevalence. It should be noted, however, that "while cost-effectiveness provides the necessary criterion to choose between alternatives to achieve a specified goal or between different degrees of goal achievement for a specified input, it provides no information about the desirability of goals" (1).

It is assumed in this report that the goal of reducing schistosomiasis prevalence or transmission has already been set. Thus, cost-effectiveness analyses may be used to define "the efficiency of different input combinations to achieve a given goal or set of goals." (2).

In this section, by means of the transmission model and Tanzania data, we compare the costs and effectiveness of three control strategies with use of no controls: molluscciding, chemotherapy, and molluscciding plus chemotherapy. Because the Tanzania control project was experimental, we are not evaluating the actual situation in Misungwi. The aim of this section is to use the data to show how the model provides an analytical framework for project evaluation. With cost data available from the project, the cost-effectiveness of the strategies may then be compared.

The section is organized as follows. The measure of effectiveness is described and the results of using the model to compare control strategy effectiveness are given. With the cost data, we then compare the cost-effectiveness of each strategy. Research needs for new techniques and additional data requirements are suggested in the conclusions.

Measures of Effectiveness

The prediction of incidence involves variables that are affected by control activities: feet of snail habitats and number of infected persons or total eggs passed. Thus, the effectiveness of molluscicide in reducing snail habitats and of chemotherapy in reducing number infected or total eggs may be examined through changes in prevalence predictions. From the changes in number infected as predicted by the model, the control strategies may be compared for their effectiveness.

The measure of effectiveness used in this analysis is case-years of infection prevented (3). Although other measures may be used, such as percent reduction in prevalence from one time period to another, case year or infection prevented is more desirable because it includes both as infection and time component. Effectiveness is measured as follows: the cases occurring with use of controls are subtracted from those occurring without, to obtain cases prevented for each year; the sum of the differences gives the case-years of infection prevented over the time-frame used in the analysis.

The control strategy which prevents the greatest number of case-years of infection is the most effective. The time-frame of analysis we chose was twenty years or ten cycles after control in 1968 (baseline year) through 1978. Again, only the two through nine year olds were considered. An additional aspect we looked at was the comparison in effectiveness results between using number infected or total eggs in the model. We thought that perhaps chemotherapy would affect eggs in such a dramatic way as to reduce prevalence predictions more effectively than use of number infected.

For the calculation of the no controls situation, we changed the habitat term to account for seasonal variation. We used the results in Sector V, where no controls of any kind were used, to estimate how habitats would have changed with no controls. The percents used are given in table 2. The description of how we reduced habitats is similiar to that for mollusciciding given in Appendix 1.

We first looked at the effectiveness of molluscicides from six cycles of mollusciciding. From Project reports, we calculated the percentage of snail habitats where snails were still found and used that to reduce accordingly each type of habitat for the use of control measures (4). In the model, we changed the volume of habitat used to estimate incidence in both 1970 and 1972 as described in Appendix I. The percentage reductions in habitat are given in Table 1. The results from the mollusciciding are given in Table 2.

For chemotherapy we calculated the achieved percent reduction in prevalence by using results from Sectors II and III where chemotherapy was used.

Mollusciciding was also used but the data showed that most of the reduction came from chemotherapy used with a 40% reduction in prevalence after the first treatment (5). Since there was no second round of treatment, we took the results from the chemotherapy study area where the second year of treatment resulted in only a 25% reduction in prevalence due to infected immigrants (6). Again, the results are given in Table 3.

The third control strategy examined as the combination of molluscicide and chemotherapy use. We used the same corrections as above and ran the model to predict case years of infection. The results from this strategy are given in Table 3.

We compared results from the three control strategies with no use of controls for two different periods. The first was the control program time frame used plus one additional cycle to account for the second year of chemotherapy, 1968-1974. The second time frame was 10 cycles or 20 years to see what long term effects a short period of control would have. Results for the first time frame show that with both number infected and total eggs the combined strategy is more effective in preventing case-years of infection (Table 3). Chemotherapy is itself more effective than mollusciciding. It is interesting to note that total eggs show more cases prevented by mollusciciding when compared with number infected than does chemotherapy. The numbers from which these calculations were made are given in Table 4.

The long term results are similar, although the combined control strategy shows far greater results than the other two, especially when using total eggs (see Table 5).

Cost Calculations

The project estimated total costs for both mollusciciding and chemotherapy. The mollusciciding costs were calculated for the entire project area of four sectors; the chemotherapy costs were for 1,000 persons who were diagnosed and treated, if necessary (7). We corrected these costs for Sector IV data by dividing the mollusciciding total costs by four to get an approximate per sector cost. For chemotherapy, we corrected the total costs by our population size of two through nine year olds: 212 in 1970 and 223 in 1972.

The total costs we used were:

Mollusciciding	Chemotherapy	Mollusciciding plus chemotherapy
US$5,223	US$1,465.95	US$6,688.95

Many assumptions are made in using these costs which could be taken care of with more detailed cost information. Our stated objective, moreover, is to demonstrate model use for cost-effectiveness; the data were sufficient for this purpose.

Cost-Effectiveness Comparisons

To determine the cost-effectiveness of the different strategies, we divided the total control costs by the appropriate case-years of infection prevented to get cost per case year of infection prevented. We determined these values only for the years 1968-1974, since cost data applied to that time frame.

Results given in Table 6 indicate that chemotherapy is the most cost-effective strategy. The combined effort is most effective in reducing case-years of infection, yet its costs are on a per case basis three times more expensive than chemotherapy. Mollusciciding is considerably more expensive and less effective. There are no significant differences in cost-effectiveness results between use of number infected and total eggs.

It should be mentioned that these analyses do not include usual components of project analyses, such as budget constraints and sequencing concerns. The optimal control strategy from cost and effectiveness perspectives may be determined within the framework of an optimization procedure that accounts for such aspects. To apply optimization techniques involves detailed knowledge of investment requirements for the control measures, resource capacity constraints, labor supply, wage rates, interest rates, and salvage costs. A study at the World Bank is now underway using a dynamic programming framework for optimization (8). The results from this study will yield information on the optimal control strategy under budgetary or capacity constraints. The cost data available to us, however, were not extensive enough to warrant using sophisticated analytical techniques.

Conclusions

The results from this study indicate that a transmission model may be used to demonstrate the effectiveness of control measures. The necessary input data are the number of habitats treated or of habitats where snails remain, and the number of people treated or fraction of the population treated.

The effectiveness runs showed the combined controls were most effective in preventing case-years of infection from occuring. The cost-effectiveness analysis indicated that chemotherapy was the most cost-effective treatment. Mollusciciding might be even more costly over time because of the need to maintain snail-free habitats. In addition, drug costs will decline over time as individuals needing treatment become fewer.

This analysis has not included other controls such as water supplies to limit human contact with snail habitats and engineering measures to reduce snail habitats. Further work is needed to evaluate their role in reducing schistosomiasis transmission.

An additional conclusion from these analyses is the lack of difference between use of total eggs and number infected to estimate prevalence in the short run. Over time, the differences appear to be greater but it is unclear whether that is due to our assumptions or, in fact, the differences in the terms. Nonetheless, in the short-run, it is likely a project planner may base his decisions to use either one of these terms on cost considerations and not worry about the degree of information he may lose by his choice.

Further work in estimating more accurate cost functions for the range of control strategies available is needed. It will be necessary to consider additional terms, e.g., discount rates, for long-term cost analyses. The main conclusion is that a transmission model may be used in conjunction with cost analysis to evaluate different control strategies.

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Table 1. For Sector IV, fraction of habitat with snails before next treatment cycle, a measure of success of mollusciciding to be used in reducing the amount of habitat affecting transmission (based on Project reports from 1971 and 1972)

Habitat type	pre-cycle 3/pre-cycle 1		pre-cycle 7/pre-cycle 3	
	% with snails/ % with snails	fraction with snails	%/ %	fraction with snails
Pond	32/56	0.571	0/32	0.0
Dam	12/30	0.40	16.7/12	1.39
Furrow	100/100	1.00	0/100	0.0
Drinking Pond	33/50	0.66	0/33	0.0
Residual Pool	0/0	0.0	0/0	0.0
Other	0/0	0.0	0/0	0.0

Table 2. Percentage of habitats where snails were found in Sector V (no controls used).

Habitat type	pre-cycle 3/pre-cycle 1 % with snails/ % with snails	pre-cycle 3/pre-cycle 1 fraction with snails	pre-cycle 7/pre-cycle 1 %/ %	pre-cycle 7/pre-cycle 1 fraction with snails
Pond	39/56	0.696	41.7/39	1,069
Lawn	0/43	0.0	28.5/43	0.663
Furrow	14/71	0.197	50/71	0,704
Drinking Pond	32/34	0.941	46.8/34	1,376
Rendual Pod	70/62	1,129	40/62	0,645
Pher	0/1	0,0	0/1	0.1

Table 3. Case-years of infection prevented as estimated by model runs over years of project and one additional cycle (1968-1974). Number infected and total eggs were run as separate examples for 2 through 9 year olds in Sector IV.

Years	Estimated Case-Years of Infection (no control)	case-years of infection prevented		
		Molluscciding	Chemotherapy	Molluscciding plus Chemotherapy
Number Infected				
1968 - 1974	552	86	162	232
Total Eggs				
1968 - 1924	551	95	153	250

Table 4. Predicted case-years of infection prevented over years of project plus 1 additional cycle: 1968-1974. Results given for use of: molluscicides, chemotherapy, molluscicides plus chemotherapy. Results are given for separate use of number infected and total eggs.

Years	Number Infected: 1 Estimated Case-years no control	Number Infected: 2 Estimated Case-years with molluscciciding	Number Infected: 3 Estimated Case-years of infection prevented	Total Eggs: 1 Estimated Case-years no control	Total Eggs: 2 Estimated Case-years with molluscciciding	Total Eggs: 3 Estimated Case-years of infection prevented
1968	101	101	0	101	101	0
1970	129	113	16	128	100	18
1972	152	122	30	151	118	33
1974	170	130	40	171	127	44
Total	552	466	86	551	456	95
	with chemotherapy			with chemotherapy		
1968	101	101	0	101	101	0
1970	129	77	52	128	78	50
1972	152	87	65	151	85	56
1974	170	125	45	171	124	47
	552	390	162	551	388	153
	with chemotherapy and molluscciciding			with chemotherapy and molluscicidin[g]		
1968	101	101	0	101	101	0
1970	129	67	62	128	67	61
1972	152	63	79	151	59	92
1974	170	79	91	171	74	97
	552	411	232	551	301	250

Table 5. Case-years of infection prevented as estimated by model for 10 cycles - twenty years after start of control activities. (1968-1988). Number infected and total eggs run as reported examples, for 2 through 9 year olds, based on Sector IV data.

Years	Estimated Case Years of Infection (no control)	Case-years of infection prevented		
		Mollusciciding	Chemotherapy	Mollusciciding plus chemotherapy
Number Infected				
1968 - 1978	2115	465	242	793
Total Eggs				
1968 - 1978	2132	542	240	931

Table 6. Estimated costs per case-years of infection prevented for three different control strategies over years of analysis 1968-1974. (U. S. dollars)

Years	Mollusciciding	Chemotherapy	Mollusciciding plus Chemotherapy
1968-			
1974			
# infected	$ 60.73	9.05	28.83
Total Eggs	$ 54.98	9.58	26.76

APPENDIX

Control Operations

In order to take control operations into account at appropriate times, we developed a chart that summarizes project activities on a quarterly basis (see figure 1). With the data available from the project quarterly reports we are able to identify on a sectoral basis which kinds of habitats were treated, the date of treatment, and the success of treatment (whether or not snails were found in the habitat before the next cycle of mollusciciding) for each type of habitat. It was not possible to identify by number which habitats were actually treated.

Chemotherapy trials are also summarized in the chart (figure 1). Data in the quarterly reports and in the data file include information on who was treated, and egg counts after treatment. Although no treatment was given in Sector IV, we include this information for later use in the cost-effectiveness analyses.

The project measured, for each type of habitats the percent habitats found with schistosomiasis snail hosts before each mollusciciding cycle began. The cycles were times as follows:

Cycle 1	16 June - 23 June 1970
Cycle 2	14 Sept. - 16 Sept. 1970
Cycle 3	13 Jan. - March 1971
Cycle 4	17 May - 16 June 1971
Cycle 5	16 Aug. - 3 Sept. 1971
Cycle 6	15 - 20 March 1972
Cycle 7	17 - 18 July 1972

Figure 1. Chronology of Control Activities in Schistosomiasis Control Project, Mwanza District, Tanzania (summarized from project reports and papers).

	Qtr. 1: Jan. - Mar.	Qtr. 2: Apr. - June	Qtr. 3: July - Sept.	Qtr. 4: Oct. - Dec.
SNAILS	Wet season flooding January to April (or February - May in one report)			Small November rains
		April peak snail activity (approximately) August		Secondary snail peak
JRE	Intense agricultural activity December to February or (October to January in one report)			
.S			Start habitat survey. One-third completed July to September	Resurvey of selected sites during rainy season; surveyed Mitindo/Mwamanga. October--small rain onset.
.S	One-half area surveyed, including the following sub-areas: Ibilibishi, Mitanda, Igokelo, Mbela, Mwambola, Itale and Budutu. Site survey Water use pattern Prevalence in users	Survey Nange, Northern part Masawe and Mitindo, i.e., survey now complete in proposed reduced area for project.	No third quarter report.	No fourth quarter report.
REA WE		Clinical examination mobility, habitat		
JNGWI				Results presented in yearly report. WHEN (?) was data taken on prevalence
			September--start population and prevalence surveys. Note. Monitor group (2 to 9 year olds). November 1968 t January 1969--first urine s	

	Qtr. 1: Jan. - Mar.	Qtr. 2: Apr. - June	Qtr. 3: July - Sept.	Qtr. 4: Oct. - Dec.
T 1 MONITOR 1ASAWE)	Sometime sine second quarter 1968 they performed snail density vs. season and habitat studies and incidence (2 to 13 years)		Continue habitat surveys Further urine tests (2 to 13 year olds)	
SUNGWI .CT	Continue and complete in March the population and prevalence surveys. Note: Sector V added and surveyed in 1970.			
)/ .NGA)THERAPY . AREA		Population and prevalence survey started and completed in April. Clinical survey--May I think the chemotherapy trial occurred in late May--not specifically stated.	Habitat and water use survey June and July (previously done also in October - November 1967). Follow up urine sample (after 3 months) end August.	
I & II DESIGNA-)			Habitat resurvey.	
. GROUP 9 YEAR			Second urine sample September to October.	
CTORS				Modification of sector plans Start prevalence and egg survey in a monitor group (2 to 14 years)

	Qtr. 1: Jan. - Mar.	Qtr. 2: Apr. - June	Qtr. 3: July - Sept.	Qtr. 4: Oct. - Dec.
. V	Sector V. Habitat, prevalence and census surveys Mobility study--Van Etten		REPORT MISSING	
.S I-IV		First mollusciciding--blanket treatment 7 May to 23 June.	Second mollusciciding treatment--August-September.	Post chemotherapy follow-up urine analysis--previous egg count. (was everyone surveyed? When was survey done? December?
.S II &			Chemotherapy--July 13 to August 3. Urine sampled. (Was urine before or after chemotherapy? Which data do we have?)	
.S I-V				Population census I, IV, V then II & III. Initiated in August 1970; completed toward end of year.
)O- IANG MOTHERAPY AL		12-month follow-up. Urine collected June. Treat positives		
JR GROUP) 9 YEARS				Prevalence/Incidence survey

	Qtr. 1: Jan. - Mar.	Qtr. 2: Apr. - June	Qtr. 3: July - Sept.	Qtr. 4: Oct. - Dec.
ORS I-V	Third mollusciciding cycle 13 January to 5 March	Fourth mollusciciding cycle 17 May to 16 June	Fifth mollusciciding cycle 16 August to 3 September	
NDO/ AMANG LMOTHERAPY		Second annual census and urine exame--May 1971		
OR II				Migration study October 1971 - January 1972
TOR GROUP TO 9 YEAR DS				Prevalence/incidence November
ORS I-IV	Sixth mollusciciding cycle February and March	Seventh mollusciciding cycle June 12 - July 18		
OR II	Finish population movement study October 1971			
NDO/ AMANG		Prevalence/incidence surveyed. All positives again treated.		
ORS I-V			Prevalence/incidence/egg output/census of Misungwi begun in August--completed in November	Further observation on mobility, socio-economic conditions and water use completed--area unspecified.

Because the model predictions were made at 2 year intervals, the corrections for mollusciciding were made in two parts. The first fractional reduction in habitat volume equaled the percent of habitats with snails (pre-cycle 3) divided by the percent of habitats with snails (pre-cycle 1) and we corrected for molluscicides by multiplying this fraction times the original volume. The second mollusciciding application was simulated by multiplying this reduced volume, by the precycle 7/precycle 3 fractional reduction. In Table 1, we give the fraction for reduction of snail habitat that we estimated for each habitat type from the Tanzania project reports, It should be pointed out that this is the fraction of habitats with snails for those habitats treated, not all the habitats. The ideal estimate of habitats for each year would be habitats treated with snails but still containing snails plus habitats not treated with snails. We did not use this value because we could not separate the habitats treated and not treated with the data we had available. Since all of the habitats we used were considered high transmission potential sites, it is likely they were treated. We thus believe we may be only slightly underestimating snail habitat volume for use in the model.