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ABSTRACT

Strategies for Bilharzia Control in Puerto Rico

Because of the relatively high costs of current methods for schistosomiasis control a cost-effectiveness model was developed to determine the optimum strategies and combination of methods, using Puerto Rico as a case study. The control methods evaluated were chemotherapy, snail control and interruption of water contact by provision of safe water. The parameter used to measure effectiveness of the control effort was the calculated decrease in number of adult schistosome worms in the endemic area multiplied by the number of years over which these worms were eliminated. This parameter, worm-years, is probably proportional to the amount of disease in an individual. The analysis of four strategies for the endemic zone of Puerto Rico showed that an annual budget of US $1,500 000 would best be spent primarily on chemotherapy, with secondary allocations for snail control and water supply. Emphasis on chemotherapy would be much more cost-effective than the present strategy in Puerto Rico which is based on snail control.

ACKNOWLEDGMENTS

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INTRODUCTION

I. Simple ways are needed to assist in choosing between alternate strategies of bilharzia control which include various combinations of control methods. Most of the field studies conducted on bilharzia control have evaluated the cost and effectiveness of one control method under a single prescribed level of treatment. It has thus been satisfactorily established that several methods are effective and their costs have been determined. Unfortunately the costs are generally so high that one cannot effort to apply the methods to every snail habitat or to every infected person in an endemic area. Consequently there is a need to evaluate the cost and effectiveness of judicious combinations of these methods at degrees or levels below complete treatment of the endemic zone. For example if it is too expensive to give oxamniquine, the new single-dose drug to all infected people in an endemic area, the cost-effectiveness should be evaluated for treating only infected children or only infected persons with high egg excretion rates. Another possibility is to evaluate the cost-effectiveness of mollusciciding 75% of the snail habitats and giving chemotherapy to the 25% most heavily infected people, compared with mollusciciding 25% of the snail habitats and treating the 75% most heavily infected persons.

Before attempting field studies to compare various levels and combinations of treatments, some simple theoretical analyses, which are inexpensive to conduct, should be made to minimize the amount of expensive and long range field studies required. This report presents the necessary theoretical analyses for Puerto Rico as a basis for planning such operational field studies.

The methodology is simple; calculations can be performed with a small hand calculator and mathematical procedures involved are limited to the basic operations: addition, substraction, multiplication and division. The amount of data involved in a single case study is small and can all be recorded on one large page from a bookkeeping ledger. A computer was not needed for these studies, thus they can easily be done by most technical personal in the headquarters of a bilharzia control program.

The methods of control evaluated by this theoretical approach were the drug oxamniquine, snail control by ditching and bayluscide and provision of water supply with adequate health education to interrupt water contact.

The parameter used to measure effectiveness of control was the calculated decrease in adult schistosome worms in the endemic area, multiplied by the number of years over which these worms were eliminated. To be more precise, effectiveness in a theoretical community was calculated in terms of the reduction in area under the worm population curve during the period after initiation of control, assuming a stable, equilibrium worm population at the start of control (Figure 1).

While somewhat arbitrary the use of "number of worm-years prevented" was an improvement over the use of the number of infections prevented in persons since it included a measure of the intensity of the infections. Recent unpublished communications from E. Paulini indicated that this parameter was proportional to the severity of disease, thus its use to measure effectiveness is probably a rough quantitative measure of the amount of disease prevented. Worm-years of infection is also probably proportional to the number of schistosomes eggs embedded in an infected person's tissues, thus proportional to the damage caused by the infection.

NUMBER OF SCHISTOSOME WORMS IN A COMMUNITY AFTER INITIATION OF CONTROL

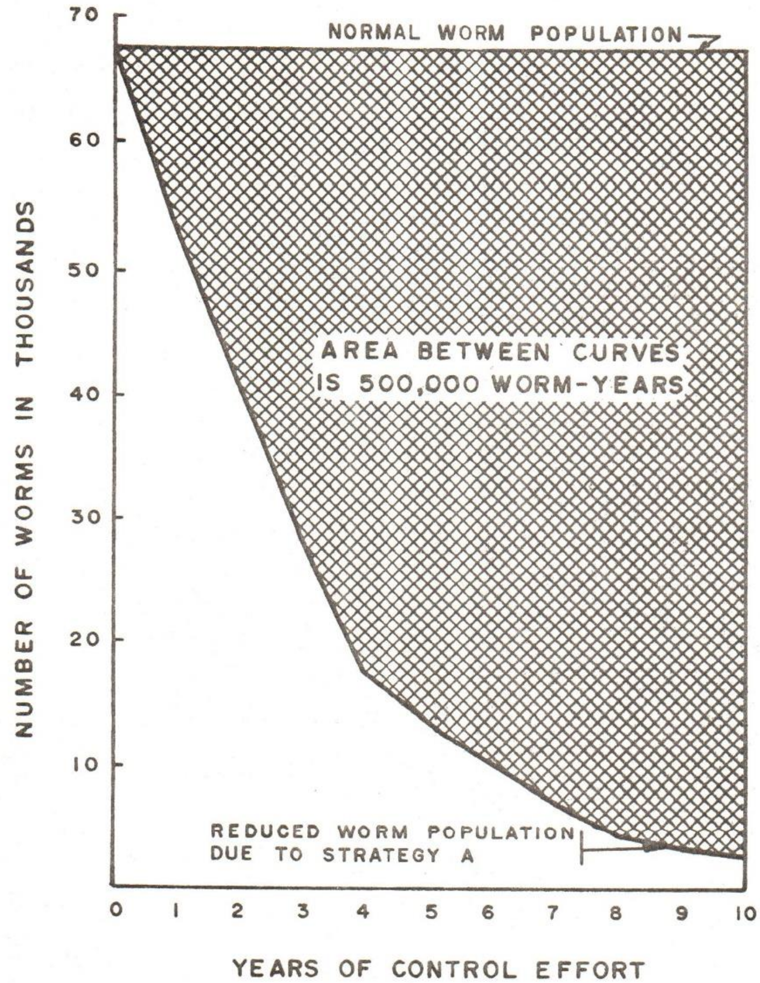


FIGURE 1

II. METHODS FOR CALCULATING NUMBER OF SCHISTOSOME WORMS

A simple calculation scheme was developed to estimate the number of schistosome worms. For determining effectiveness of the control methods it was necessary to calculate the schistosome worm population in the endemic area, year by year, after control was started. Available mathematical models were too complicated for this purpose so a computation scheme was used in which worm deaths were substracted from the existing worm population, and new worms were added to the population as a function of transmission. The assumptions used in the calculation scheme were:

1. The annual death rate of the worms is 10% corresponding to a half life of 5 to 6 years.
2. Super-infection does occur in snails, thus reduction in miracidial loads on the snails causes a proportional reduction in cercarial population and thus in the number of new worms.
3. The egg-excretion rate of infected people is proportional to their worm load at a rate of 2 eggs per gram of feces for each worm pair. This somewhat arbitrary figure can be varied from 1 to 10 without affecting the comparative effectiveness of the control strategies evaluated.
4. Worm populations are strongly clumped in people so single-sex infections are neglected.
5. The normal rate of acquiring new worms is equal to the death rate of worms in a stable transmission area. Reductions in contact of the human population with water cause proportional reductions in acquisition of new worms.

Based on the above assumption, the following rationale was used in calculating the yearly changes in the worm population. The reduction in worms was due to natural deaths at the rate of 10% per year, and deaths due to drugs at the specified mortality rate of the drugs, assuming a clumped distribution of worms in people. Worm deaths due to deaths of infected persons were included in the 10% death rate.

Increases in the number of worms were due to transmission which ocurred only in areas outside of a designated snail control zone. The pre-control transmission rate was equal to the pre-control death rate of the worms (10%), assuming a stable worm population. During control efforts the original transmission rate was reduced as a result of the improved water supply by 0.9, due to reduction in water contact and by the proportion of people supplied with piped water. As the total worm population decreased, the transmission rate also decreased in direct proportion, due to lowered miracidial and cercarial populations.

The number of worms killed by drugs was E x W where E was the drug efficiency (proportional reduction in worm population in treated community) and W was the number of worms in the treated people. The W was calculated from the number of infected people given the drug, assuming the clumped distribution of worms. The initial clumped worm burden was assumed to exist in people until the entire population was treated, then a new uniform worm distribution was calculated for subsequent cycles of treatment. These calculations were carried out separately for the zone with snail control and for the zone without it.

The initial worm population in the endemic zone of Puerto Rico was calculated from data supplied by the USPHS-CDC from their study in Boqueron which indicated a mean egg-excretion rate of 6 eggs per gram in stools of infected persons (CDC Annual Report 1975 page 8). It was arbitrarily assumed that this corresponds to a mean worm load of 3 worm pairs per infected persons, an equivalent of 1 egg per gram per worm. This assumption agrees with autopsy data from Brazil (Cheever, 1968). Since 189,000 infected people thus harbored 6 worms each, the number of schistosome worms in Puerto Rico before starting the control program was 1,134,000, and it was assumed that 75% (142,000 people) were in the endemic area (Figure 2). More recent estimates give lower numbers of infected people in Puerto Rico but the example reported here was not changed since the conclusions are not sensitive to small changes in population sizes.

POSITIVITY FROM SKIN TEST SURVEY FOR SCHISTOSOMIASIS IN PUERTO RICO, 1976[4]

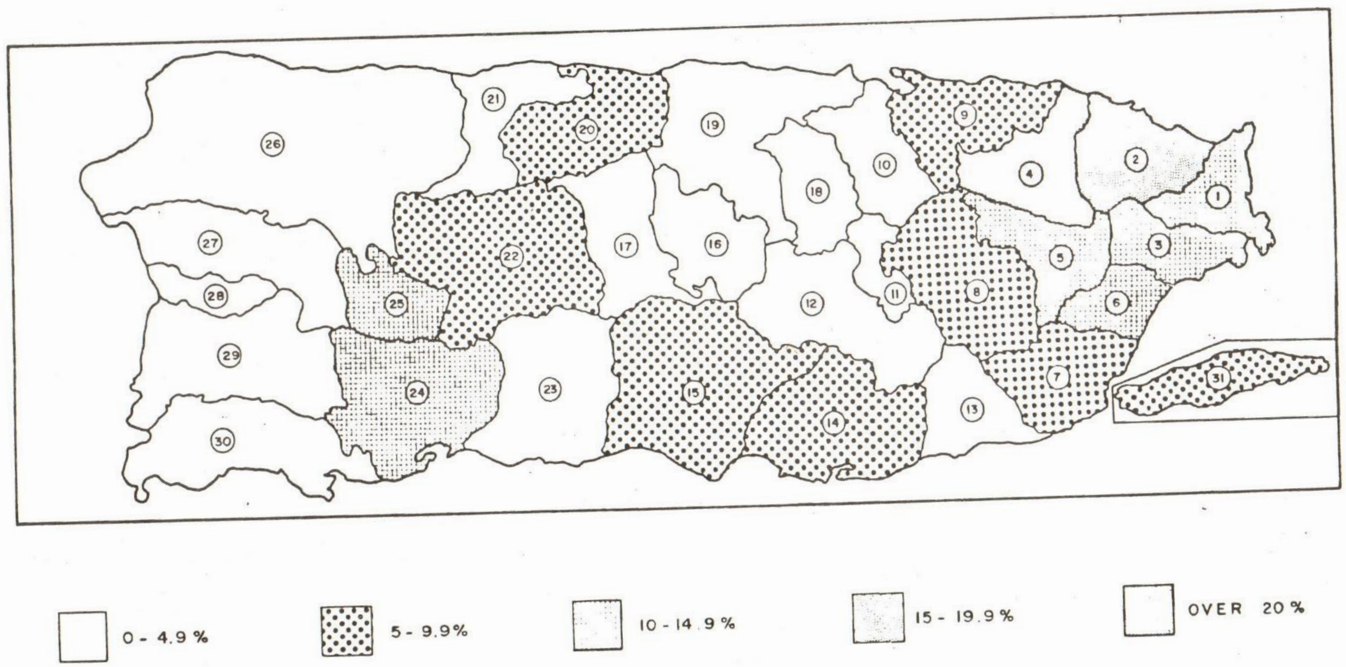


Figure 2

III. REGIMEN FOR APPLICATION OF VARIOUS CONTROL METHODS

The control methods assumed in this analysis are well known but the concept of reduced levels or degrees of control is somewhat new and is detailed herein. Snail control was assumed to be based on the technique currently used in Puerto Rico of ditching and drainage to minimize the amount of snail habitat then application of Bayluscide to the remaining habitats at a level of treatment adequate to interrupt transmission, and use of biological control afterwards, in those habitats where it is efficient. Although reduced levels of treatment were not considered for snail control, in some cases the budget restraints required that only a portion of the endemic area could be placed under snail control. The average amount of snail habitat in the endemic area in Puerto Rico is about 700 cubic meters per square kilometer and the annual rainfall is about 2 meters in the endemic zone (Figure 3). At a revised 1976 cost of US $44 per 100 cubic meters, $100,000 per year would be adequate to control only 325 square kilometers of endemic area (Table 1). From these figures reductions in budgets for snail control were calculated in terms of reduced areas in which snails were kept at minimal levels.

The chemotherapy analyzed was based on the use of oxamniquine at somewhat arbitrary drug prices, since the market price is not yet established. The strategy of selective treatment was evaluated wherein a quantitative stool exam is made on the entire population and only the persons with the heaviest infections are treated. Diagnosis cost US $1 per person in 1976 prices and treatment was assumed to cost US $10 per person treated. An effectiveness of 90% was assumed for oxamniquine treatment meaning than 90% of the worms were killed in a population, if every person was treated.

Since the majority of schistosome worms in Puerto Rico appear to be found in a small proportion of the infected people selective chemotherapy should be quite cost-effective (Figure 4). The same clumping of worms has been demonstrated for other endemic areas. (Lehman et. al., 1976). Although other possible approaches to reduced chemotherapy have been suggested such as reduced dosages or treatment of certain age groups, only the approach of treating the most heavily infected people was analyzed herein. The proportion of infected people to be treated depended on budget constraints. A budget ratio of 2:1 for expenditures for diagnosis: treatment was followed initially in these analyses, and as the prevalence decreased, excess funds occurrđd in the drug treatment budget. These excess funds were then diverted to the diagnosis budget, keeping the total program budget for chemotherapy constant.

Water supply is quite expensive and for practical reasons this analysis assumed an even pace of construction the first few years, reaching a stable number of persons served when the operation and maintenance costs consumed the entire annual budget. Cost figures for water supply were taken from annual reports of the aqueduct and sewer authority which serves both rural and urban populations(Table 2). Since its creation in 1945 the Puerto Rico Aqueduct and Sewer Authority has constructed potable water systems which cost $450 million dollars and which serve 2.84 million people as of 1976 (Annual Report 1977, ASA). This includes all costs of a system which gives chemical treatment, filtration, chlorination and fluoridation to water supplying all urban areas, and partial treatment to water serving many rural areas. The construction cost of $160 per capita is thus much higher than necessary to simply prevent bilharzia, which can be accomplished by avoiding the use of contaminated surface water. Additional treatment gives protection against typhoid and diarrheal diseases as well.

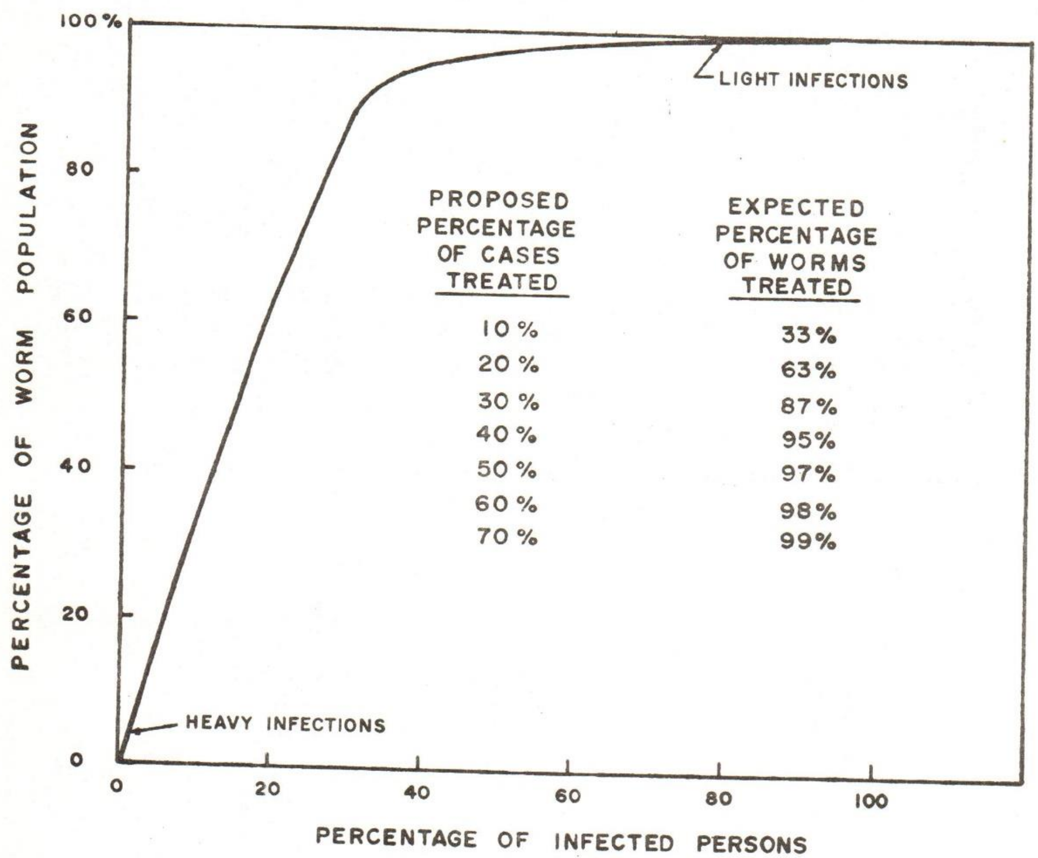
TABLE 2

COSTS OF CONSTRUCTION, OPERATION AND MAINTENANCE FOR PUERTO RICO AQUEDUCT AND SEWER AUTHORITY AS OF JUNE 30, 1977, FROM STATISTICAL REPORT OF ASA, 1977.

ITEM	Water Supply	Sewage Disposal	Common Facilities
Construction cost of facilities in service	$438,269,867	$191,714,540	$24,571,536
Annual Operation Costs	13,468,943	2,609,440	
Annual Maintenance Costs	8,543,950	4,876,470	
Persons Served	2,839,474	1,494,287	

FIGURE 4

DISTRIBUTION OF SCHISTOSOME WORM POPULATION AMONG INFECTED PEOPLE FROM BOQUERÓN, PUERTO RICO, 1972 CALCULATED FROM DATA SUPPLIED BY E. RUIZ-TIBEN, SAN JUAN LABORATORIES, USPHS- CDC.



The Rural Aqueduct program in Puerto Rico was budgeted separately and more closely approximates the type of system which would be sufficient to eliminate previous dependece on polluted surface waters. Construction costs by 1950 averaged $14 per capita, by 1960 they were $30 per capita and by 1966 a total of $33 million had been invested to serve 856,000 people a mean construction cost of $39 per person (Guzmán, 1966). The rise in cost over the 20 years reported was due to inflation and also because the easiest systems were constructed first, leaving difficult systems serving only a few people to be constructed during the latter years. Even this lower construction cost-estimated $50 per capita by 1976 - can only be partially charged against bilharzia control.

Operation and maintenance costs for 1976 were $22 million for the 2.84 million people served or $8 per capita per year (Annual Report ASA 1977). Again this cost was for operating a fully developed modern water supply system far beyond the needs for bilharzia control. The overall water consumption figure for both urban and rural systems was 47 cubic meters per family per month by 1976, or 330 liters per capita per day (Statistical Report by the Executive Director, July 1977 ASA). This is much greater than the amount required for effective bilharzia control in St. Lucia which was about 50 liters per person (Unrau, 1975). Thus less than 5/33 of the costs should be charged to bilharzia control, about 15%.

Since the provision of piped water has many benefits in addition to prevention of schistosomiasis, only part of the costs were attributed to the control program. Thus the construction cost used in these analyses was US $10 per capita and operation and maintenance cost was $1 per capita per year. The necessary amount of health education was assumed to be included in the annual $1 per capita cost.

At this level of expenditures it was assumed that the water systems were highly effective and reduced 90% of the water contact and thus 90% of transmission. Sanitary disposal of excreta by construction of latrines or septic tanks was not evaluated here since it appears to be relatively ineffective (Bhajan et al, 1978).

The strategies evaluated included 4 different budget schedules wherein all 3 control methods were used simultaneously, but with 4 different strategies compared, concentrating 80% of the money on each method in turn, and also dividing the money equally between the three methods (Table 3). It follows then that the endemic zone was divided into 2 parts, one with snail control and one without. In the area with snail control transmission was completely interrupted but in the area without it, transmission was only decreased by provision of water supply in proportion to the number of people served and the 90% reduction in their water contact.

TABLE 3. DISTRIBUTION OF FUNDS FOR VARIOUS STRATEGIES OF CONTROL.

Strategy Emphasis	Schedule	Chemotherapy Budget	Snail Control Budget	Water Supply Budget
Drugs	A	80%	10%	10%
Snails	B	10%	80%	10%
Water	C	10%	10%	80%
Uniform	D	33.3%	33.3%	33.4%

EVALUATION OF SEVERAL STRATEGIES FOR PUERTO RICO

A comparison was made of several alternate strategies for bilharzia control in Puerto Rico with an annual budget of US $1 per capita in the endemic zone 1976 prices, a total of $1,500,000 per year. Funds were distributed among the three control methods, either emphasizing chemotherapy (Strategy A), snail control (Strategy B), or water supply with health education (Strategy C), but always including all 3 methods to some degree. Comparisons were also made for a balanced strategy distributing funds equally among the three methods.(Strategy D).

An estimate of bilharzia prevalence island-wide was made from available data. The prevalence of infection in 1969, for fifth grade school children, was 14% by skin-test, and the skin-test prevalence in this age-group corresponds closely to prevalence determined by five fold fecal exam (Negrón et. al, in press). It has also been estimated that the prevalence rate among fifth-graders was approximately twice the prevalence among all ages, during these years. Thus the number of infected persons in Puerto Rico was estimated at 0.07 x 2,700.000 or 189.000 in 1969, for the purposes of this exercise.

It was arbitrarily assumed that about 75% of the infected persons lived in the endemic municipalities, in an area of 1,343 square kilometers and a total population of 1.5 million. Thus the mean prevalence rate of egg-passers in the endemic zone was 9.4% for 1969. The distribution of egg-loads or worm loads among these infected people was assumed to follow the pattern in the endemic community of Boqueron in Las Piedras (Figure 4). Obviously all of these numbers have changed by 1976 but unless they have changed by an order of magnitude, the conclusions of this comparative analysis will not be affected significantly.

The following scenarios were used in visualizing the geographical overlapping of the three control methods. Chemotherapy would be organized to cover the entire endemic zone in cycles whose period was inversely proportional to the chemotherapy budget. For a total program budget of $1 per capita or $1,500,000 dollars and allocating 10% for chemotherapy with a ratio of expenditures of 2:1 for diagnosis: treatment, this allows for $100,000 per year for diagnosis and $50,000 for treatment (Table 4). Thus 100,000 people would be examined each year at US $1 per capita and 9,400 would be found positive. At a cost of $10 per person treated, only 5,000 or 53% would be treated. The following year a new group of 100,000 would be examined, and the 53% most heavily infected of that group would be treated. This procedure would reach 97% of the worms in the population of 9,400 infected people diagnosed each year and would cover the entire population in 15 years.

At $1 per capita and allocating 80% of the budget for chemotherapy, $800,000 would be available for diagnosis, thus the entire population would be examined every 2 years. Similarly with 33% of the budget on chemotherap: $333,000 would be available for diagnosis, requiring 5 years to complete a treatment cycle throughout the endemic zone.

Snail control costs at $420 per square kilometer would require $564 000 per year to completely control the endemic zone. For 10% emphasis on molluscicides only $150,000 would be available, thus there would be snail control in 27% of the endemic zone (400,000 people). For 80% emphasis on snail control $1,200,000 would be available, more than necessary to cover the endemic zone. In this case the excess funds would be diverted to the chemotherapy budget ($636,000), allowing a total of $786,000 for chemotherapy and $564,000 for snail control. For the

TABLE 4. FIRST YEAR BUDGET ALLOCATION FOR SCHISTOSOMIASIS CONTROL IN PUERTO RICO WITH A TOTAL ANNUAL BUDGET OF US $1 PER PERSON IN THE ENDEMIC ZONE, OR US $1,500,000, 1976 PRICES (STRATEGY 1).

	Drugs			
Strategy	Diagnosis	Treatment	Snail	Water
Drugs - 1A	$800,000	$400,000	$150,000	$150,000
Snails- 1B	524,000	262,000	564,000	150,000
Water - 1C	100,000	50,000	150,000	1,200,000
Uniform - 1D	333,000	167,000	500,000	500,000

balanced strategy about $500,000 would be available for snail control, just enough to cover the endemic zone.

In Strategy B when the surplus snail control funds were diverted to chemotherapy, a total of $524,000 would be available each year for diagnosis, examining the entire population in 3 years. According to this budget distribution system and allocating $1 for each person in the endemic area ($1,500,000) the initial budget distribution was calculated (Table 4). From this basic distribution, slight adjustments were made for cases where the budget allocated to a certain method exceeded the amount needed for that method (Tables 4 and 5).

For the water supply program, construction would be evenly distributed throughout the endemic zone outside of the snail control area. When the entire endemic zone was covered by snail control, water supply had very little noticeable effect. This occurred for Strategies B and D.

The water supply program would include both construction and the annual cost of operation, maintenance and health education. The first year all the funds would be used for construction but as more units were added the operations cost would increase until all funds were used for operation.

The eventual, stable number of persons supplied with piped water was calculated by assuming all funds were used for operations maintenance and health education, for each of the strategies (Table 5). In 1970 only 10% of the population in Puerto Rico did not have piped water, thus the total population to be served in the endemic zone (if we ignore changes occurring from 1970 to 1976) was 150,000. Reduction in water contact due to this water supply program is thus the fraction of this 150,000 which is supplied with piped water (Table 5).

TABLE 5 REDUCTION IN WATER CONTACT DUE TO PROVISION OF PIPED WATER SUPPLY. ASSUMED CONSTRUCTION COSTS WERE US $10 PER CAPITA WHILE OPERATION, MAINTENANCE AND HEALTH EDUCATION COSTS WERE US $1 PER CAPITA, 1976 PRICES

	YEAR#1	YEAR# 2	YEAR# 3	YEAR#4	YEAR# 5
STRATEGIES A and B	TOTAL	BUDGET	= 10 %	= $150,000	
Existing Population Served	0	15,000	28,500	40,700	51,600
Operating Budget	0	$ 15,000	$ 28,500	$ 40,700	$ 51,600
Construction Budget	$150,000	135,000	121,500	109,300	98,400
New Population Served	15,000	13,500	12,200	10,900	9,800
Total Population Served	15,000	28,500	40,700	51,600	61,300
Proportion of 150,000 Served	0	0.10	0.19	0.27	0.34
STRATEGY C	TOTAL	BUDGET	= 80 %	= $1,200,000	
Existing Population Served	0	120,000	150,000	150,000	150,000
Operating Budget	0	$120,000	$150,000	$150,000	$150,000
Construction Budget	$1,200,000	300,000	0		
New Population Served	120,000	30,000	0		
Total Population Served	120,000	150,000	150,000		
Proportion of 150,000 Served	0	0.80	1.00	1.00	
STRATEGY D	TOTAL	BUDGET	= 33.4 %	= $ 500,000	
Existing Population Served	0	50,000	95,000	135,000	150,000
Operating Budget	0	$ 50,000	$ 95,000	$135,000	$150,000
Construction Budget	$500,000	$450,000	$405,000	$365,000	0
New Population Served	50,000	45,000	40,000	15,000	0
Total Population Served	50,000	95,000	135,000	150,000	150,000
Proportion of 150,000 Served	0	0.33	0.63	0.90	1.00

TABLE 6. SAMPLE CALCULATIONS FOR MODEL EMPHASING SNAIL CONTROL DESIGNATED AS STRATEGY IB

Snail control budget = $564,000 covers entire endemic zone, thus no new infections after first year.*

Water supply budget = $150,000

Chemotherapy: Examination budget = $524,000

Treatment budget = $262,000

	YEAR 1	YEAR 2	YEAR 3	YEAR 4
I.- NUMBER OF WORM DEATHS DUE TO DRUG PROGRAM				
Prevalence in examined pop.	0.094			
People examined	524,000	524,000	524,000	524,000
Cumulative people examined	524,000	1,048,000	1,500,000	
Infected people located	49,000			
Mean worm load in infected people	6.0			
Worms located	296,000			
People treated	26,000			
Prop. inf. people/treated people	0.53			
Prop. worms treated	0.97			
Worms treated	287,000			
Worms killed by drug (90%)	258.000	258,000	258,000	258,000
II.- SUMMARY OF WORM POPULATION				
New worms acquired (10%)x	85,000	*0	0	
Natural deaths of worms	85,000	59,000	28,000	
Deaths of worms from drugs	258,000	258,000	258,000	
Total worms (850,000 start)	592,000	280,000	100,000**	(0)

TABLE 6

	YEAR 1	YEAR 2	YEAR 3	YEAR 4
III - WATER SUPPLY				
(Ignore)				
IV - PREVALENCE RATE				
Initial infected persons	141.000	118,000	95,000	72,000
Number persons treated	26,000	26,000	26,000	25,000
Number cured	23,000	23,000	23,000	22,000

***Worms treated but not killed (30,000 worms left each year).

A second set of strategies was evaluated, based on an annual budget of $750,000 which was the actual 1976 expenditure of the Health Department on schistosomiasis control. This represents an annual expense of $0.50 per person in the endemic zone. Funds were again allocated according to four possible alternatives, emphasizing either drugs, snail control, or water supply or else a balanced division of the funds between the three methods (Table 7).

Spending $1 per capita annually the strategy emphasizing the use of drugs was clearly more effective than the other three strategies (Figure 5). Preliminary calculations showed that this was true for many other endemic areas as well, such as St. Lucia, Brazil, Egypt, and Tanzania. A second set of strategies utilizing the smaller annual budget also demonstrated the advantage of emphasizing chemotherapy, and snail control again ranked second (Figure 6). A balanced approach was the least cost-effective of the four strategies evaluated.

A more precise evaluation of cost-effectiveness was made by calculating the program cost per reduction in worm-years during the first four years of control and dividing by the total four-year budget, again demonstrating the ranking of drugs, snail control, water supply and a balanced program, in that order (Table 8). Preliminary calculations for other endemic areas showed that the cost-effectiveness increased with increased worm burden as one would expect. Thus priority for international programs should be given to areas with high worm-burdens, such as northeastern Brazil or the Nile River Vally.

A reduced budget of $0.50 per person was evaluated for Puerto Rico and no advantage was indicated by the cost-effectiveness analysis, in fact it was more cost-effecive to use the higher budget (Table 8).

TABLE 7. FIRST YEAR BUDGET ALLOCATION FOR SCHISTOSOMIASIS CONTROL IN PUERTO RICO WITH A TOTAL ANNUAL BUDGET OF US $0.50 PER PERSON IN THE ENDEMIC ZONE, OR $750,000 PER YEAR, 1976 PRICES (STRATEGY 2).

Methods of Emphasis	Drugs		Snails	Water
	Diagnosis	Treatment		
Drugs - 2A	$ 400,000	$ 200,000	$ 75,000	$ 75,000
Snails - 2B	74,000	37,000	564,000	75,000
Water - 2C	50,000	25,000	75,000	600,000
Uniform - 2D	167,000	83,000	250,000	250,000

FIGURE 5

PREDICTED EFFECTIVENESS OF SCHISTOSOMIASIS CONTROL IN PUERTO RICO WITH AN ANNUAL BUDGET OF $ 1,500,000

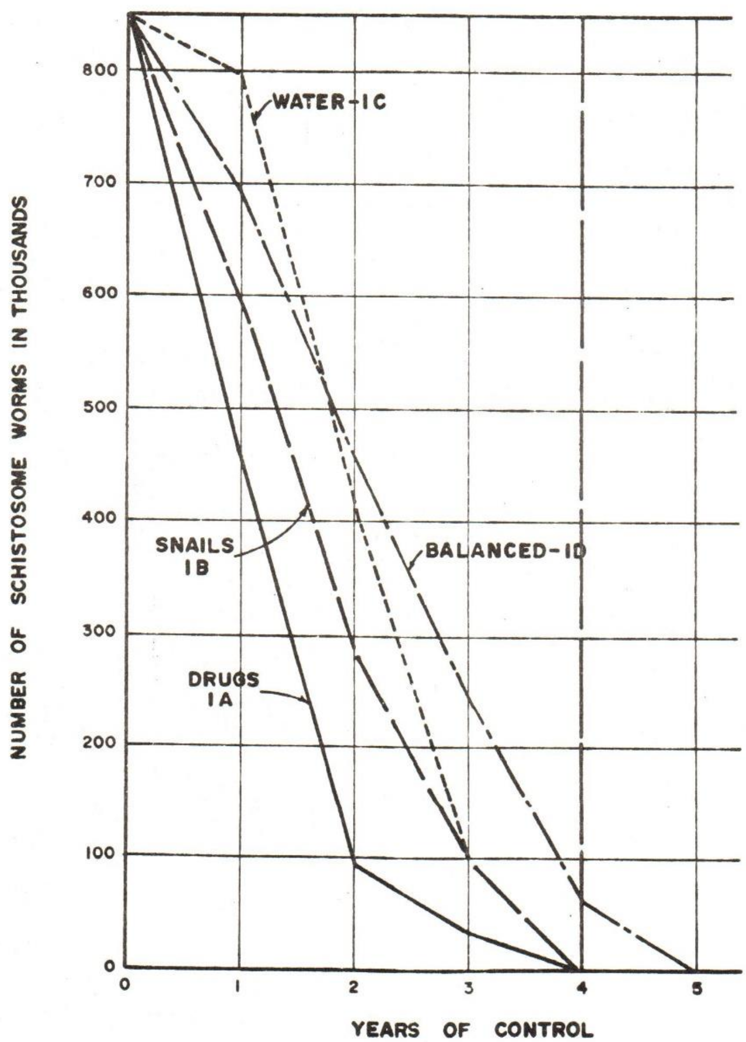


FIGURE 6

PREDICTED EFFECTIVENESS OF SCHISTOSOMIASIS CONTROL IN PUERTO RICO WITH AN ANNUAL BUDGET OF $750,000

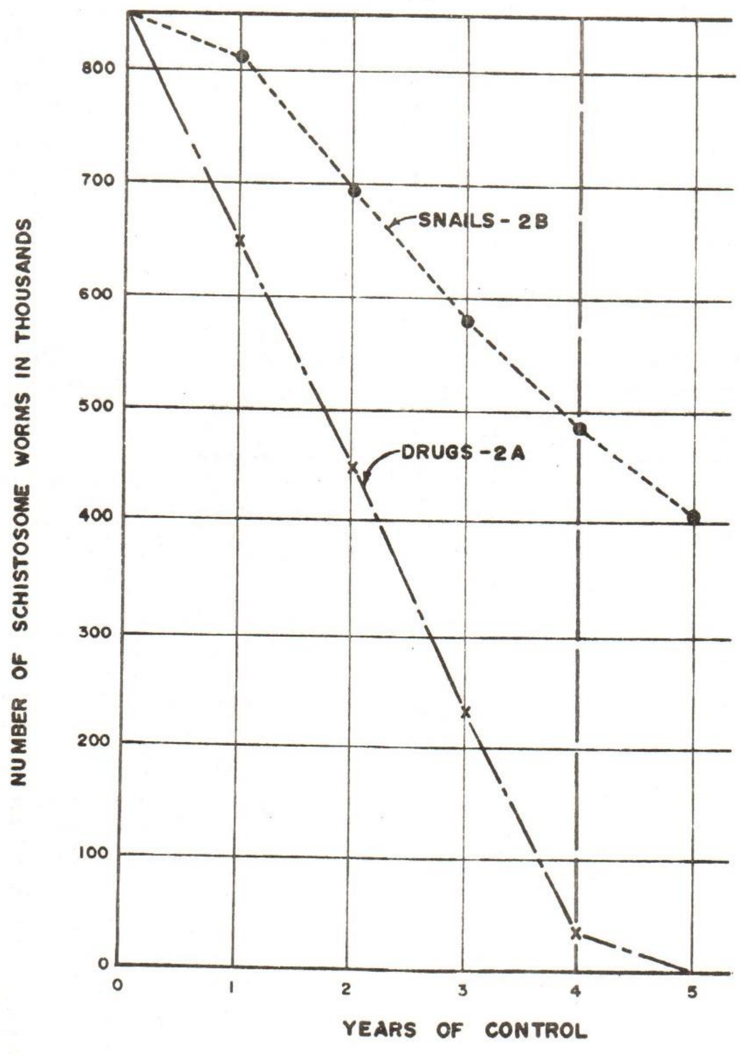


TABLE 8. COMPARISON OF COST-EFFECTIVENESS FOR SEVERAL STRATEGIES OF SCHISTOSOMIASIS CONTROL IN PUERTO RICO, 1976 COSTS.

Control Strategy Emphasis	Effectiveness in Million Worm Years Prevented	Cost per Worm-Years Prevented 1976 US $ per Worm-Year
Total Budget for 4 years $6-million		
Drugs - 1A	2.38	$ 2.52
Snails - 1B	1.97	3.05
Water - 1C	1.64	3.66
Balanced - 1D	1.53	3.93
Total Budget for 4 years- $3 million		
Drugs - 2A	1.60	3.75
Snails - 2B	0.64	4.69

CONCLUSIONS

A comparison of several possible strategies for bilharzia control in Puerto Rico showed that emphasis on the new drug oxamniquine would be much more cost-effective than continued efforts with the present strategy emphasising snail control. The analysis also indicated that an intensive program of a few years duration would be a better use of funds than a long-term program of low intensity.

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