Evaluation of a programme for control of *Schistosoma haematobium* infection in Yemen

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تقييم برنامج ممتد لمكافحة عدوى البلهارسيا الدموية في منطقة يتوطّن بها هذا المرض في اليمن

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الخلاصة: أُجريت دراسة تَدَخُّلية في «خامر»، شمالي صنعاء، لمكافحة داء البلهارسيات البولي، باستخدام المعالجة الكيميائية والتثقيف الصحي. كما تم أيضاً في هذه الدراسة تقييم صدقية ومردوديَّة الأشرطة الكاشفة، بوصفها أداة تشخيص سريعة لتحرِّي الإصابة بعدوى البلهارسيا الدموية، إضافةً إلى البيلة الدموية المرئيَّة بالنظر. ولقد انخفض معدل انتشار البلهارسيا الدموية من 58.9 إلى 5.8٪ بعد مرور 14 شهراً من بدء هذه الدراسة التَّدَخُّلية، كما انخفض أيضاً معدل تواتر حدوث العدوى الثقيلة الوطأة من 40.0٪ إلى 18.9٪. كذلك، نتج عن جلسات التوعية والتثقيف الصحي انخفاض كبير في تكرار التَّماس مع المصادر المائية، وامتثال أكبر للتدابير الوقائية. وقد اتضح أن أسلوب المعالجة الكيميائية الجموعي، بالإضافة إلى جلسات التوعية والتثقيف الصحي، يُعَدُّ طريقة مجدية وفعَّالة لخفض الإصابة بعدوى البلهارسيا الدموية في اليمن. ويمكن أن يكون استخدام الأشرطة الكاشفة والبيلة الدموية المرئيَّة بالنظر، وسيلة فعَّالة لقاء التكلفة، في المناطق النائية، التي تكون إمكانية الوصول إلى الخدمات الصحية فيها محدودة.

ABSTRACT An intervention study was conducted in Khamir, north of Sana'a, for control of urinary schistosomiasis using chemotherapy and health education. The validity and cost–effectiveness of reagent strips as a rapid diagnostic tool to screen for *Schistosoma haematobium* infection was also assessed along with visible haematuria. Prevalence of *S. haematobium* infection 14 months post-intervention fell from 58.9% to 5.8% and frequency of heavy infection from 40.0% to 18.9%. Health education sessions resulted in significant decrease in the frequency of contact with water sources and greater adherence to preventive measures. Mass chemotherapy plus health education is a feasible and effective method for reducing *S. haematobium* infection in Yemen. Reagent strips and visible haematuria could be cost-effective in remote areas with limited access to health services.

Évaluation d'un programme de lutte contre l'infestation à *Schistosoma haematobium* au Yémen

RÉSUMÉ Une étude d'intervention a été réalisée à Khamir, au nord de Sanaa, pour la lutte contre la schistosomiase urinaire au moyen de la chimiothérapie et par l'éducation sanitaire. La validité et le rapport coût-efficacité des bandelettes réactives comme outil de diagnostic rapide pour la recherche d'une infestation à *Schistosoma haematobium* ont également été évalués parallèlement à l'hématurie visible. La prévalence de l'infestation à *S. haematobium* 14 mois après l'intervention a chuté de 58,9 % à 5,8 % et la fréquence de l'infestation massive a reculé, passant de 40,0 % à 18,9 %. Les sessions d'éducation sanitaire ont entraîné une diminution significative de la fréquence du contact avec les sources d'eau et un meilleur respect des mesures de prévention. La chimiothérapie de masse associée à l'éducation sanitaire constitue une méthode faisable et efficace pour réduire l'infestation à *S. haematobium* au Yémen. Les bandelettes réactives et l'hématurie visible pourraient être d'un bon rapport coût-efficacité dans les zones reculées où l'accès aux services de santé est limité.

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Introduction

Schistosomiasis is the second most prevalent tropical disease in Yemen after malaria and is one of the most important public health problems. With the unification of the country, total population is now 20 million, of which 2–3 million are estimated to be infected [*1–4*]. Environmental factors and the expansion of agricultural facilities, with the associated improvement in irrigation systems and construction of dams, have generated the optimal environment for fresh-water snails, the intermediate host, resulting in an increase in the prevalence of schistosomiasis (*1–4*). Yemen has so far received little attention from international health organizations even though millions of its inhabitants are at risk.

The economy of the country depends mainly on agriculture, most of the population being involved directly or indirectly in this field. During the past few years, many new agricultural projects have been established and many of the previous ones extended, so the irrigation system is extensive. In some places these irrigation projects serve as a source of drinking water for humans. Agricultural workers are at high risk of acquiring schistosomal infection and schistosomal disease because of their daily work in the fields and a continuing contact with schistosome-infected water. The health and labour of these groups should be of paramount importance since increasing food production to meet the requirements of a rapidly increasing population is a major issue for the developing world, particularly Yemen [*5–8*].

High infection rates for urinary schistosomiasis were found in the years 1995, 1998 and 1999. An evaluation of the results of control efforts made in Yemen over the past 10 years shows a remarkable success in reducing the scale of the disease. Infection rates have fallen in Hajah, Sana'a and Marib provinces. [*5,8*]. There have been no previous reports on endemicity of schistosomiasis or other intestinal parasites in Khamir, or on integrated methods for schistosomiasis control in the country.

This study was therefore conducted with the aim of evaluating the impact of integrated surveillance and control methods on the burden of schistosomiasis in the north of Sana'a governorate. A further aim was to assess the validity and its cost-effectiveness of using visible haematuria (macroscopic haematuria) and reagent strip tests (microscopic haematuria) as screening tools for *Schistosoma haematobium* infection.

School enrolment rates in Yemen are relatively low, especially in females, in whom enrolment is below 30% [*9*]. To overcome this deficiency, non-enrolled as well as enrolled children (both pre-school and school-age) were targeted in addition to the community. It is envisaged that implementation of integrated methods for surveillance and control of schistosomiasis would assist in the development of an effective, school-based control programme sensitive to local social and cultural conditions. The study will also offer the opportunity to assess the validity of detecting urinary schistosomiasis in Yemen.

Methods

This was an intervention study targeting the community and schoolchildren in Khamir, located 90 km north of Sana'a. This is an agricultural area, depending on rain and groundwater for irrigation and domestic use.

Baseline survey

The community and school baseline surveys were conducted in October 1999. A

list of the houses in the study area (1000) was prepared and a random sample of 100 houses (863 individuals) was selected. Each individual was interviewed by a member of the intervention project team using a questionnaire. A urine sample was collected from each participant for examination. There were no refusals to participate.

The items on the questionnaire included demographic data; medical history, including schistosomiasis infection and treatment, whether participants passed blood in the urine and the results of any laboratory tests; and information on sources of water, use of water and whether they used any preventive measures. Parents supplied information for babies and young children. Urine samples were tested in the field by members of the project team.

A sample of 20% of schoolchildren (287 children), randomly selected from the 14 schools of the area was included in the study. These children were interviewed using the same questionnaire, and urine samples were collected for examination in the same way as for the community survey.

Intervention

The schistosomiasis control methods consisted of chemotherapy for *S. haematobium* and health education. Mass treatment was administered in October 1999; a total of 8540 individuals were treated with a single dose of praziquantel, 40 mg/kg body weight. These were schoolchildren, non-enrolled school-age children, and preschool children together with their parents and other community members.

Health education intervention sessions were given during the period September 1999–December 2001. Schoolteachers from all 14 schools in the district participated in a 2-day seminar. The teachers were educated about the disease and briefed about the study. They were also given detailed information regarding methods of health education for different groups, chemotherapy for schistosomiasis and dosage and record keeping. One teacher from each school was appointed as coordinator for the control activities in his/her school.

The teachers gave weekly health education classes in schools in which posters were distributed. Health education sessions were also held in schools for non-enrolled children and pre-school children along with their parents. Other classes were given in khat sessions and Friday prayer sessions.

Community evaluation survey (14 months post intervention)

The houses in the study area (1000) were listed and a sample of 100 houses (913 individuals) was randomly selected. The evaluation was performed via questionnaire and urine analysis. The same questionnaire was used with the following items added:

- Have you attended mass chemotherapy?
- Have you attended a health education session?
- How did you hear about the control programme?

School evaluation survey (14 months post intervention)

A post-intervention evaluation via questionnaire and urine analysis was done on 20% of all schoolchildren in the area, 323 schoolchildren. The questionnaire was the same as that for the community evaluation survey.

Validation of reagent strips

The reagent strips were compared to microscopic urine examination to determine their validity as rapid diagnostic tools for *S. haematobium*. Urine was examined immediately in the field using the Nucleopore® filtration technique. The reagent strips used

in this study were Hemastix (Bayer Diagnostics, Fernwald, Germany) and Combur 9 strips (Roche Diagnostics, Mannheim, Germany) [*14*].

Results

Community survey

Prevalence of *S. haematobium* infection before the intervention measures and 14 months after intervention is shown in Table 1. Overall prevalence was 58.9% pre-intervention, falling to 5.8% in the post-intervention survey, a significant reduction. The prevalence of infection was 55.2% among people 16–39 years old, compared to 42.9% in older individuals.

The majority of infections overall (60.0%) pre-intervention were light (< 50 eggs/10 mL urine). The frequency of light infection in children ≤ 15 years was significantly higher than heavy infection. In contrast, the frequency of heavy infection was significantly higher than light infection in the older age groups (Table 2).

There was no significant difference between males and females, or between literate and illiterate individuals regarding the prevalence or intensity of infection (Tables 1 and 2).

There was a significant decrease in the in the prevalence of infection 14 months post-intervention. The overall prevalence dropped to 5.8%, ranging from 4.9% among children 6–15 years old to 7.8% among those aged 16–39 years. Furthermore, the majority of infections post-intervention were light infections (81.1%), regardless of age or sex (Tables 1 and 2).

Community evaluation survey

Prevalence of infection in participants who were literate was 60.0%; this decreased to

Table 1 **Prevalence of *Schistosoma haematobium* infection before and 14 months after intervention for inhabitants of 100 households (community-based study)**

Age (years)	Pre-intervention			Post-intervention		
	Males %	Females %	Total %	Males %	Females %	Total %
< 6	50.5	46.2	48.3	6.5	5.3	5.9
6–15	69.2	65.7	67.6	5.0	4.8	4.9
Enrolled[a]	63.6	56.6	61.3	4.2	3.7	4.1
Non-enrolled	71.3	67.2	69.3	5.3	5.0	5.2
16–39	56.4	53.7	55.2	8.8	6.8	7.8
Literate	52.9	50.0	52.4	4.3	0	3.8
Illiterate	57.4	54.0	55.6	10.5	7.1	8.7
≥ 40	48.6	36.4	42.9	6.7	6.7	6.7
Literate	33.3	–[b]	33.3	0	–[b]	0
Illiterate	50.0	36.4	43.3	7.1	6.7	6.9
Total	61.2	56.3	58.9	6.1	5.4	5.8
Literate	60.5	54.8	60.0	4.1	3.3	3.9
Illiterate	61.4	56.4	58.8	6.6	5.6	6.1

[a] *Enrolled in school.*
[b] *Individuals were not available or not examined.*

Table 2 **Prevalence of *Schistosoma haematobium* infection classed as heavy infection (> 50 eggs/10 mL urine) before and 14 months after intervention for inhabitants of 100 households (community-based study)**

Age (years)	Pre-intervention			Post-intervention		
	Males %	Females %	Total %	Males %	Females %	Total %
< 6	21.6	26.5	24.0	14.3	16.7	15.4
6–15	37.3	36.4	36.9	15.4	20.0	17.4
Enrolled[a]	40.5	40.0	40.4	0	0	0
Non-enrolled	36.3	35.9	36.1	20.0	22.2	21.1
16–39	65.9	63.9	65.0	28.6	20.0	25.0
Literate	44.4	50.0	45.5	0	0	0
Illiterate	71.4	64.7	68.1	33.3	20.0	27.3
≥ 40	55.6	58.3	56.7	0	50.0	20.0
Literate	100[b]	None	100	0	None	0
Illiterate	52.9	58.3	55.2	0	50.0	20.0
Total	40.1	39.7	40.0	16.7	21.7	18.9
Literate	42.3	41.2	42.0	0	0	0
Illiterate	39.6	39.6	39.6	16.7	21.7	18.9

[a]*Enrolled in school.*
[b]*One person.*

3.9% post-intervention. Heavy infection decreased from 42.0% of those infected to 0%. Similarly, for participants who were illiterate, prevalence of infection decreased from 58.8% to 6.1% and the rate of heavy infection decreased from 39.6% to 20.8% (Tables 1 and 2).

School evaluation survey

Prevalence and intensity of infection also decreased markedly in the school-based evaluation survey. Overall prevalence was 66.9% pre-intervention and fell to 4.3% 14 months post-intervention (Tables 3 and 4).

Table 3 **Prevalence of *Schistosoma haematobium* infection before and 14 months after intervention for 20% of schoolchildren (school-based study)**

Age (years)	Pre-intervention			Post-intervention		
	Males %	Females %	Total %	Males %	Females %	Total %
6–15	71.5	62.5	69.9	5.3	3.6	4.9
≥ 16	56.1	50.0	55.7	2.9	0	2.6
Total	67.9	61.4	66.9	4.6	3.2	4.3

Table 4 **Prevalence of *Schistosoma haematobium* infection classed as heavy infection (> 50 eggs/10 mL urine) before and 14 months after intervention for 20% of schoolchildren (school-based study)**

Age (years)	Pre-intervention			Post-intervention		
	Males %	Females %	Total %	Males %	Females %	Total %
6–15	39.1	22.0	38.0	20.0	0	16.7
≥ 16	37.5	50.0	38.2	0	0	0
Total	38.8	33.3	38.0	16.7	0	14.3

Impact of health education

The frequency of contact with water sources significantly decreased in the community and the school surveys (Table 5). Similarly, adherence to preventive measures rose from almost 0% to well over 80% in both surveys.

Table 5 **Effect of education measures for schistosomiasis control (community-based study and school-based study)**

Variable	Pre-intervention (%)	Post-intervention (%)
Contact with water sources		
Community	95.0	9.0
Schoolchildren	98.0	3.6
Application of preventive measures		
Community	0.9	97.0
Schoolchildren	0	88.0
Blood seen in urine		
Community	55.0	2.3
Schoolchildren	60.0	1.2
Had chemotherapy		
Community	NA	95.0
Schoolchildren	NA	97.3
Attended health education sessions		
Community	NA	98.6
Schoolchildren	NA	99.4
[a]*Heard about the programme through:*		
mobile team of the programme	NA	90.0
school sessions	NA	25.3
community leaders	NA	88.1

NA = not applicable.

[a]*Community and schoolchildren combined.*

Almost all the people interviewed had been treated and had attended health education sessions (≥ 95%). Most reported that they knew about the programme from the mobile team of the intervention programme or from leaders of the community; a smaller number reported school sessions as being the source of information (Table 5).

Validation and cost–effectiveness of reagent strips

Compared to parasitological examination of urine, the reagent strips recorded low sensitivity, low specificity, limited positive predictive value and low negative predictive value in both surveys (Tables 6 and 7).

Compared to detection of eggs, using strips as the screening method greatly reduced the cost of the control programme in the study area, which is a remote area with limited facilities (Table 8).

Discussion

Carefully targeted and infrequent delivery of mass chemotherapy offers a cheap and effective tool for control of schistosomiasis at low cost [*10–12*]. For a number of reasons schoolchildren have been the favoured target group in chemotherapy programmes for schistosomiasis. They are easy to approach with health education programmes, they usually carry most of the burden of infection in the community and they are easy to reach physically for chemotherapy. Moreover, schoolchildren represent the future of developing countries. Investment in their health will have a bearing on educational performance and their future contribution to development. Schools also offer an infrastructure for control programmes in areas where infrastructure of health institutions is deficient.

Using strips as the screening methods has greatly reduced the cost of control programmes elsewhere [*13*]. Yet, we need to assess their practicability and validity in Khamir; the findings of previous reports indicate that the validity of these screening methods has varied in different settings [*14,15*].

Lu-Guang et al. studied the effect of selected chemotherapy combined with health education to control schistosomiasis in marshland of the Yangtze River in China. The prevalence of schistosomiasis decreased by 82% [*16*]. In the present study, overall prevalence fell by 90.2% to 5.8%.

Mass chemotherapy was found to be a feasible and efficacious approach for schistosomiasis control in a study done in Upper

Table 6 **Validation of reagent strips in Khamir, October 1999, community-based study**

Eggs	Strip		Total
	No. +ve	No. –ve	
Present	252 (A)	96 (B)	348
Absent	194 (C)	129 (D)	323
Total	446	225	671

Sensitivity = A/(A + C) = 252/446 = 56.5%.
Specificity = D/(B + D) = 129/225 = 57.3 %.
Positive predictive value = A/(A + B) = 252/384 = 72.2%.
Negative predictive value = D/(C + D) 129/ 323 = 39.9 %.

Table 7 **Validation of reagent strips in Khamir, October 1999, school-based study**

Eggs	Strips		Total
	No. +ve	No. –ve	
Present	86 (A)	40 (B)	126
Absent	65 (C)	45 (D)	110
Total	151	85	236

Sensitivity = A/(A + C) = 86/151 = 57.0%.
Specificity = D/(B + D) = 45/85 = 52.9 %.
Positive predictive value = A/(A + B) = 86/126 = 68.3%.
Negative predictive value = D/(C + D) = 45/110 = 40.9%.

Table 8 **Comparison of total cost of treatment using screening reagent strips (visible haematuria) and the urine filtration method (detection of eggs) for identification of infection in urban and rural areas**

Variable	Cost (US$)			
	Urine filtration		Strips	
	Urban	Rural	Urban	Rural
Screening per person	0.48	4.26	0.85	2.02
Treatment per person	1.85			
Total	2.33	6.11	2.70	3.87
Screening per case detected (infected)	0.92	8.21	1.28	3.04
Treatment per infected person treated	1.00		1.25	
Total	1.92	9.21	2.53	4.29

Egypt. Baseline prevalence was reduced by 83.6%, from 23.1% to 3.8% [*17*]. In Mali, where mass chemotherapy with praziquantel was used to control *S. haematobium* in an area of 87 villages, overall prevalence was reduced from 68.8% to 39.4% [*18*].

An analysis of cost-effectiveness of *S. haematobium* control by chemotherapy confirmed the cost advantage of school-age targeting over vertical programmes, but emphasized the importance of school attendance in selecting community-based over population-based approaches [*19*]. The rate of school enrolment and absenteeism from schools seem to be crucial factors in the effectiveness of school-based programmes [*20*]. In a school-based schistosomiasis control programme in Egypt it was reported that 80% of infected girls were not treated because they were not enrolled in schools [*21*]. After studying the impact of school-based mass chemotherapy on helminth egg production in a community in Kenya, Olsen concluded that school-based chemotherapy misses a significant proportion of transmission of schistosomiasis and intestinal helminths maintained by pre-school children, non-enrolled school-age children and adults [*22*]. In another school-based programme to control schistosomiasis and intestinal parasites in Kenya, it was noted that in some schools the prevalence of haematuria was not affected, or actually increased, after the first year of intervention due to enrolment of untreated children after mass treatment was given [*23*]. Thus, the outcomes of school-based programmes seem to be easily influenced by the pool of untreated children outside the school.

Reagent strips and visible haematuria could be cost-effective screening methods for the disease only if employed in remote areas with limited accessibility to health services and limited availability of facilities, such as the study area.

Savioli and Mott found the development of a simplified, indirect approach to the diagnosis of *S. haematobium* in Tanzania (based on a combination of observation of grossly bloody urine specimens, reagent strips for measuring haematuria, and treatment with praziquantel) reduced costs of schistosomiasis control compared with the more accurate but time-consuming parasitological methods [*24*]. Chen-Hong et al. found that the rate of infection of

residents in a community was the determining factor for the cost-effectiveness of mass chemotherapy schemes [*25*]. Taylor et al. found that microhaematuria could be valuable in the diagnosis of *S. haematobium* in national control programmes and could replace parasitological examination as long as sensitivity and specificity continued to be evaluated [*26*].

The results of this study indicate that an integrated community and school-based programme combining chemotherapy and health education can be effective for control of *S. haematobium* infection in endemic areas. Reagent strips and visible haematuria could be used for screening for the disease in remote areas where there is limited access to health services. There was a significant impact on prevalence. The relative contribution of heavy infection among positive individuals was reduced and there was a change in the behaviour of the community, manifested by adopting preventive measures against the disease.

Recommendations

- Mass chemotherapy should be considered for high prevalence areas.
- Personnel involved in schistosomiasis control activities should be adequately trained to ensure quality of services. An appropriate surveillance system should be in place so that data are carefully recorded in the field and reported. Data analysis should be done at all levels to guide control operations and proper feedback of data ensured.
- Since school enrolment rates are relatively low in Yemen, especially in females, to be effective, any control programme must target non-enrolled as well as enrolled children.
- Health education is an important component of schistosomiasis control. The development of human resources and materials for health education must be ensured to decrease in the frequency of contact with water sources and encourage adherence to preventive measures.
- A national control programme must target both the community and schoolchildren to obtain the best possible sustainable results and community participation should be incorporated into the activities of the national schistosomiasis control programme.
- Primary health care staff should be trained in communication skills in order to conduct health education programmes at community level.
- Support from nongovernmental organizations should be sought for schistosomiasis control activities, including chemotherapy, training, health education, sanitation and water supply.

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