# REPORT OF THE WHO INFORMAL CONSULTATION
# ON SCHISTOSOMIASIS IN LOW TRANSMISSION AREAS:
# CONTROL STRATEGIES AND CRITERIA FOR ELIMINATION

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Strategy Development and Monitoring for Parasitic Diseases and Vector Control
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## List of participants

Professor El Mutamad El Amin, Bilharzia Department, Health Service - Gizan Province, Ministry of Health, P.O. Box 120, Gizan, Saudi Arabia - email: mutamadamin@hotmail.com

Dr Quentin Bickle, Department of Medical Parasitology, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, United Kingdom - email: Quentin.Bickle@lshtm.ac.uk

Dr I. Cesari, Laboratorio de Inmunoparasitología, Centro de Microbiología y Biología Celular, Instituto Venezolano de Investigaciones, Apdo. 21827, Caracas 1020A, Venezuela - email: icesari@pasteur.ivic.ve

Professor J.Y Chai, Department of Parasitology, Seoul National University, College of Medecine, Seoul 110-799, Korea - email: cjy@plaza.snu.ac.kr

Dr Minggang Chen, Chief, Department of Scientific Information, Institute of Parasitic Diseases, Chinese Academy of Preventive Medecine, 207, Rui Jin Er Lu, Shanghai 200025, China -email: mgchen@fudan.ac.cn

Professor A. Deelder, Laboratory of Parasitology, Medical Faculty, University of Leiden, P.O. Box 9605, 2300 RC Leiden, Netherlands - email: parasito@rullf2.medfac.leidenuniv.nl

Dr Alan Fenwick, Resident Project Manager, Medical Service Corporation International, Schistosomiasis Research Project, Ministry of Health (VACSERA) (E-RDC), USAID Project No. 263-0140.2, 51, Wezarat El Zeraa St., Agouza, Giza, Egypt - email: afenwick@menanet.net

Dr George V. Hillyer, Chancellor, University of Puerto Rico, Rio Piedras Campus, P.O. Box 23300, San Juan, PR 00931-3300, United States of America - email: g_hillyer@rcmaca.upr.clu.edu

Dr Jaouad Mahjour, Directeur de l'Epidémiologie et de Lutte contre les Maladies, Ministère de la Santé, 14, rue Alkalsadi, Agdal, Rabat, Morocco - email :jmahjour@sante.gov.ma

Professor J. Massoud, Department of Medical Parasitology, School of Public Health, P.O. Box 6446, Teheran 14155, Islamic Republic of Iran

Dr Hiroshi Ohmae, Department of Parasitology, Institute of Basic Medical
Sciences, University of Tsukuba, Tsukuba City, Ibaraki-ken 305-8575, Japan

Dr J.P. Pointier, Laboratoire de Biologie Marine et Malacologie, Ecole
Pratique des Hautes Etudes, UMR 5555 du CNRS, Centre de Biologie et
d'Ecologie, Tropicale et Méditerranéenne, 52, av. de Villeneuve, 66860
Perpignan, Cedex, France - email: pointier@univ-perp.fr

Dr L. Rey, Departamento de Medicina Tropical, IOC/FIOCRUZ, Av. Brasil
4365, 21045-900 Manguinhos, Rio de Janeiro, Brazil -
email: dandrea@gene.dbbm.fiocruz.br

Dr Joachim Richter, Specialist, Medizinische Einrichtungen, Heinrich-
Heine-Universität, Medizinische Klinik und Polyklinik, Klinik für
Gastroenterologie, Hepatologie und Infektionsmedizin, Moorenstr. 5, 40225
Düsseldorf, Germany - email: richter1@uni-duesseldorf.de

Dr D. Rollinson, Biomedical Sciences, Department of Zoology, The Natural
History Museum, Cromwell Road, London SW7 5BD, United Kingdom -
email: D.Rollinson@nhm.ac.uk

Dr Ronaldo Santos do Amaral, Gerente Técnico, Programa de Controle da
Esquistossomose, CCDTV/DEOPE/FNS, Ministério da Saúde, Fundaçao
Nacional de Saúde, Setor de Autarquias Sul, Quadra 4 - Bloco N - Sala 715,
CEP: 79.958-902 - Brasilia-DF, Brazil -
email: amaral@nettur.com.br / ramaral@fns.gov.br

Dr. Maged Al Sherbiny, Director, Egyptian Reference Diagnostic
Laboratory, VACSERA, 51 Wezaret El Zeraa Street, Agouza, Cairo, Egypt -
email: maged123@intouch.com

Professor Peter G. Smith, Head of Infectious and Tropical Diseases, London
School of Hygiene and Tropical Medicine, Keppel Street, London WC1E
7HT, United Kingdom - email: psmith@lstm.ac.uk

Dr Vaughan R. Southgate, Head, Taxonomy Unit, British Museum (Natural
History), Cromwell Road, South Kensington, London SW7 5BD, United
Kingdom - email: V.Southgate@nhm.ac.uk

Professor Martin G. Taylor, Department of Medical Parasitology, London
School of Hygiene and Tropical Medicine, Keppel Street, London WC1E
7HT, United Kingdom - email: Martin.Taylor@lshtm.ac.uk

Dr V.C.T. Tsang, Division of Parasitic Diseases, Centers for Diseases Control and Prevention, 4770 Buford Highway, N.E., Atlanta, GA 30341, United States of America - email: vct1@cdc.gov

Moriyasu Tsuji, M.D, Ph.D, Department of Infectious Diseases, Division of Tropical Diseases and Parasitology, Kyorin University School of Medicine, 6-20-2 Shinkawa, Mitaka, Tokyo 181-8611, Japan - e-mail: tsujimys@kyorin-u.ac.jp

**WHO Secretariat**

Dr L. Chitsulo, CPE/PVC - email: chitsulol@who.int
Dr D. Engels, CPE/PVC - email: engelsd@who.int
Dr L. Savioli, CPE/PVC - email: saviolil@who.int
Dr N. Zagaria, CPE/CEE - email: zagarian@who.int

## Objectives and context of the meeting

While schistosomiasis remains a major public health problem in terms of numbers at risk and those infected, control has been successful in a number of endemic countries. Japan has succeeded in completely eliminating the disease. In a number of other countries, major efforts in schistosomiasis control have been sustained for years, and elimination is now regarded as a feasible option.

A WHO Informal Consultation on schistosomiasis control, held in Geneva from 2-4 December 1998, has clearly identified the current duality in the status of schistosomiasis control between countries in which there is limited or no control (mainly sub-Saharan Africa), and most countries in Asia, the Middle East, and Southern and Central America, where large-scale control programmes are ongoing, or schistosomiasis is nearly or already eliminated. In the highly endemic countries, the 1984 WHO Expert Committee's recommendation to implement a strategy of morbidity control continues to be valid. The report of the WHO Informal Consultation on schistosomiasis control, held in Geneva from 2-4 December 1998 gives clear and updated recommendations as to how this strategy can be implemented in a sustainable way in situations where funds are scarce and national health authorities have to deal with many other, more visible health problems.

The object of this Informal Consultation on schistosomiasis in low transmission areas, are the countries where the implementation of the WHO recommended strategy has been successful, and morbidity control has now been achieved. Prevalence of infection and transmission are at a low level in most of these countries. This is particularly true in semi-arid areas and small island nations. In these cases, elimination of the disease can be contemplated.

There is therefore a need to review the situation in low transmission areas to understand why and how control has been successful. There may be a need to change the emphasis in control from morbidity control to transmission control, in order to eventually achieve the elimination of schistosomiasis infection. Also, the understanding of the elements which made schistosomiasis control successful in some countries or areas will provide a basis for providing technical assistance and guidance to other, less advanced countries or areas. Countries where transmission has ceased should no longer be considered endemic. There is therefore also a need to devise criteria that can be used by countries wishing to declare that elimination has been achieved on their territory.

This Informal Consultation on "Schistosomiasis in Low Transmission Areas: Control Strategies and Criteria for Elimination", will provide a platform for discussing control strategies in low transmission areas and arrive at a consensus on criteria for elimination. Experts on schistosomiasis control, diagnosis and epidemiology, have been brought together for this purpose. The conclusions of this Informal Consultation will provide valuable additional information for the next meeting of the WHO Expert Committee on the Control of Schistosomiasis and Soil-transmitted Helminths, to be held in 2001.

## Orientation and goals of the meeting

The fact that the overall number of people with schistosomiasis has not changed substantially over the past fifty years masks the tremendous achievements which have been made by many countries in the reduction of the public health importance of the disease. It is estimated that 200 million people are infected with schistosomiasis and 600 million are at risk of infection in more than 76 countries. Many of those with schistosomiasis are in sub-Saharan Africa. In this region, few countries have undertaken successful control programmes because of the limitation of resources. Schistosomiasis has also spread in Africa because of water resource development schemes, population increase and movement. Intestinal schistosomiasis has been introduced to the lower Senegal River basin by the building of the Diama Dam and is on the increase in other parts of the basin in association with water-resource schemes. This infection has also been introduced to Somalia and Djibouti due to population movements. It is now appreciated that morbidity due to schistosomiasis is higher in sub-Saharan Africa than previously recognized.

Notwithstanding the situation in sub-Saharan Africa, over the past twenty years, schistosomiasis control has been successful in other geographical regions. There have been no new cases of schistosomiasis in Japan since 1977 and no infected snails since 1976. Transmission of schistosomiasis has also been interrupted in Tunisia since 1984. There has been a significant reduction in the number of endemic counties and provinces in China, such that less than 2 million people are thought to be infected today. Schistosomiasis prevalence and morbidity have also been greatly reduced in the Middle East and on many islands. The prevalence of schistosomiasis in Mauritius, and Puerto Rico is now very low, to an extent that transmission may have been interrupted. In Puerto Rico it is now difficult to find vector snails. Transmission to humans is almost non-existent on the other Caribbean islands, the only exception being the Dominican Republic.

The fact that schistosomiasis control has been successful suggests that it may be time to revise the list of endemic countries. There are 76 countries considered endemic for schistosomiasis with the introduction of intestinal schistosomiasis in Djibouti and the separation of Eritrea from Ethiopia. As there have been no recent documented autochthonous cases of schistosomiasis in Thailand and Turkey, there is a question as to whether these countries should be considered endemic. Turkey appears on the list of endemic countries based on the presence of vector snails and extensive water

resource developments in areas bordering the endemic area in Syria. The presence of intermediate hosts of a particular infection does not in itself make the disease endemic. It is actual transmission of the infection that renders it endemic. Japan, Montserrat, Puerto Rico and St Lucia, among others, are countries where transmission appears to have been interrupted. They should not be considered endemic for schistosomiasis anymore. However, before formerly endemic countries can be certified as free of schistosomiasis, there needs to be internationally agreed criteria. It is expected that this meeting will initiate the process for defining such criteria.

One major reason for the success of schistosomiasis control was the development of safe, single-dose oral drugs such as oxamniquine and praziquantel. These drugs made it possible to use chemotherapy on a much wider scale. Thus the strategy for control shifted from stopping transmission to targeting the adult parasites in the definitive hosts. While the strategy for morbidity control, through chemotherapy, has been adopted in most control programmes, a combination of operational components have been used in the most successful ones. Thus in many programmes, health education and different types of snail control have also been part of the programme.

The success of morbidity control has led to several countries currently being in a transition phase from high morbidity and high transmission to low morbidity and low transmission. These countries include Brazil, China, Laos, Morocco, and Saudi Arabia. There is therefore now a need to discuss the possible strategies and operational components to consolidate control and pursue elimination. In several countries with low transmission the use of widespread chemotherapy may no longer be justified. There needs to be a shift towards transmission control through the provision of water and sanitation, environmental modification and where feasible, snail control.

The strategy for morbidity control was feasible because chemotherapy could be targeted to those with heavy infections who could be easily detected by field applicable parasitological methods. With the transition to lower morbidity, there is a need for more sensitive diagnostic techniques to detect those infected in areas with ongoing transmission. While immunodiagnostic tests showed promise in the laboratory, they have been rarely used in control programmes. Only in China and Venezuela have immunological tests been used as a primary screening method, with confirmation by parasitological tests. In Puerto Rico, immunodiagnosis was used to evaluate the endemic situation island-wide. There is need for more discussion and research to establish whether sensitive diagnostic methods are

available and suitable for widespread use in low transmission areas. There is also a need to standardize clinical case definitions and diagnostic criteria in low transmission areas.

A major objective of this meeting is also to determine the criteria for designating countries as having eliminated schistosomiasis. Another objective is to suggest guidelines as to when to change operational elements and strategies for control when schistosomiasis morbidity has been reduced to a low level. There is also the need to give recommendations on the best means for diagnosis in low transmission areas when parasitological methods are no longer sufficiently sensitive and the need for recommendations on clear clinical case definitions in low transmission areas. Recommendations on these issues will provide guidance to the many countries succeeding with schistosomiasis control and provide a road map for those contemplating national schistosomiasis control programmes. Not only is schistosomiasis control feasible; in some situations elimination can be contemplated.

## Executive summary

From 10-13 April 2000 more than 30 international experts and representatives from countries where successful control of schistosomiasis has been achieved met at the London School of Hygiene and Tropical Medicine, in an Informal Consultation on "Schistosomiasis in Low Transmission Areas: Control Strategies and Criteria for Elimination".

It has been demonstrated, in the reports from all represented countries or islands (Brazil, China, the Dominican Republic, Egypt, Guadeloupe, Iran, Japan, Martinique, Morocco, Puerto Rico, Tunisia, Saudi Arabia, St Lucia, and Venezuela) that sustained control efforts based on regular chemotherapy have achieved significant reductions in morbidity and mortality. When disease is no longer a public health issue, new objectives may need to be defined in terms of possible elimination. In turn this leads to new approaches and algorithms defined according to local situations.

Where *elimination* is aimed for, case detection may be a problem, as the commonly used clinical and parasitologic diagnostic procedures may lack sensitivity in these instances. The group advised that these methods be reinforced by more sensitive diagnostic techniques. Algorithms must change to incorporate more sensitive high throughput and inexpensive modern technologies. A rapid inventory was made of the major antibody and antigen assays for the diagnosis of schistosomiasis. Recommendations were agreed on the way these tests could be used in low transmission areas, and their further development into field applicable formats was encouraged.

As the parasite reservoir decreases, focusing on sustainable transmission control using hygiene and sanitation improvements and environmental snail control should become the major consideration. These will consolidate the improvements to health already achieved as well as decreasing the risk of resurgence of schistosomiasis.

Globally, three different situations were identified in the countries and areas in which deliberate efforts at schistosomiasis control have led to a reduction to low endemicity: (i) transmission is still present; (ii) currently low transmission, but with a significant risk of re-emergence due to population movements and/or environmental change; and (iii) low or zero risk of re-emergence. It was however recognized that each country has a unique situation which must be taken into consideration on a case-by-case basis, and that where they occur, zoonotic reservoirs must be taken into consideration in control efforts.

In low transmission areas, more cost effective use of resources may be obtained by the central authorities delegating implementation of schistosomiasis control to the regional authorities. Thus more reliance on established health and education resources will be required, and transfer of expertise and training is essential. Integration with services dealing with hygiene and hygiene-related diseases will result in general health gains. An integrated approach with other diseases, particularly if combined with the incorporation of novel, more sensitive diagnostic tests for schistosomiasis may enhance motivation of the control personnel.

In situations where surveillance and preparedness are a major issue, it is also important that implementation is carried out through existing structures such as health services, complemented by surveys in populations at high risk. Planning and management should be flexible, so that operational decisions will be based on sound geographical knowledge of high-risk areas. An integrated approach with other diseases is also useful here for determining local integrated control and surveillance measures. The group strongly emphasized that surveillance should only be eased when the risk of resurgence has been demonstrated to have diminished. Snail survey data is essential to indicate the potential for resurgence. Operational research should be promoted to adapt control and surveillance to particular local conditions, and to allow for changing situations.

Schistosomiasis is currently not considered as a disease targeted for global eradication or elimination. WHO has therefore not established a standardized Certification Process, which would involve the setting up of an International Commission, and the definition of standardized criteria to certify that schistosomiasis is no longer endemic in a country or area. Indeed, the fact that asymptomatic cases are common, and that for certain schistosome species an animal reservoir exists would make the definition of criteria for elimination a complex issue.

Also, interruption of transmission may be reached in different ways: by the elimination of the parasite reservoir, by the elimination of the snail intermediate host (e.g. through the use of competitor snails), by an improvement in socio-ecomomic status and hygiene so that contamination and infective water contact does not occur any more, or by a combination of these scenarios. The issue is further complicated by the risk of re-introduction of the disease in an area where it was previously eliminated, particularly where water resource development and/or migration occurs.

A possible way for individual countries to demonstrate that schistosomiasis has been eliminated from their territory is to document that no new, locally contracted infections have been observed over an appropriate period of time. The observation period, during which no cases should be detected in order to confidently declare that transmission has been interrupted, depends very much on the risk of re-emergence or re-introduction in a particular context. The degree of certainty that no new cases were detected also depends very much on the performance of the surveillance system, in terms of sensitivity of the diagnostic method used, and the operational performance of the reporting system.

## "Elimination/Eradication": definition of terms, criteria and certification - the guinea worm example

WHO uses the following definitions for the terms "eradication" and "elimination":

**Disease eradication:** a permanent reduction to zero of the world-wide incidence of infection caused by a specific agent, as a result of deliberate efforts. Continued measures are no longer needed.

**Disease elimination:** a reduction to zero of the incidence of a specified disease in a defined geographic area, as a result of deliberate efforts. Continued intervention or surveillance measures are required.

Guinea worm, or dracunculiasis, has been identified as a disease targeted for eradication because of the facts that there is no asymptomatic carrier state of the disease, that the incubation period is relatively short (10-14 months), and that there is no known animal reservoir. As a result, the absence of locally contracted cases for a period of three years - in the presence of adequate case detection, can be accepted as a proof of the local interruption of transmission of the disease.

Adequate surveillance is the key to successful certification of elimination and/or eradication. In the case of guinea worm, as the clinical aspects of the disease are obvious, a village based, active surveillance system was set up in every endemic and formerly endemic village. A village health worker carries out the surveillance and reports the number of cases in his village on a monthly basis. Surveillance is considered to be adequate if 9 out of the 12 monthly reports are received in a year.

An International Commission for the Certification of Dracunculiasis Eradication (ICCDE) has defined strict criteria for the certification of elimination/eradication, with the aim of (i) ensuring international credibility for the expected future claim that the disease has been eliminated in a number of countries and, eventually, eradicated; (ii) having an established and consistent mechanism for judging the success of the elimination/eradication effort; and (iii) having a standard, effective procedure to identify and eliminate the disease in previously unknown foci of transmission.

The certification process comes in during the final phase of the elimination/eradication process. It starts when transmission no longer

occurs. It is done country by country, on the basis of individual country reports. International Certification Teams visit countries where a three-year period of interruption of transmission has been reported. Certification of Elimination in a country is granted by the International Commission for the Certification of Dracunculiasis Eradication (ICCDE), when an International Certification Team has successfully ascertained the validity of the country report. Eradication is eventually achieved when all formerly endemic countries are certified free of transmission.

## Country reports

### Brazil

Up to 1920, schistosomiasis (*S. mansoni* is the only species present) was limited to the North-Eastern region, where it is believed to have been introduced by African slaves brought in to work on the sugar cane plantations which were set up soon after the colonization in 1500. After 1920, the disease spread to other regions following the migratory movements stimulated by development, and new foci are still being detected up to the present day. The most recently discovered focus was detected in Rio Grande do Sul state in 1997. In 2000 it was estimated that 2.5 million people were infected out of a total of 25 million at risk and that 19 states, with a total area of 1 million km², were affected.

There are great variations in the endemic level between different regions, due to several factors: (i) the snail host distribution and species (the most important snail host is *Biomphalaria glabrata*, followed by *B. straminea* and *B. tenagophila*); (ii) the pattern of human water contact - water contact is highest in rural areas, where rivers and streams serve as playgrounds for children and work areas for adults; (iii) the lack of basic sanitation - this is worst in rural areas where many houses lack sewage systems and safe water.

Between 1956 and 1975 only 187,000 patients were treated, due to the toxicity of the available drugs, but then oxamniquine was introduced and, after extensive pilot trials, the government introduced the Special Schistosomiasis Control Programme (PECE) which ran from 1976-1997. This programme relied mainly on diagnosis and treatment, together with supportive mollusciciding and environmental sanitation. Resources were not adequate to cover all endemic areas but 11.3 million people were treated between 1976 and 1997, mass treatment being carried out where prevalence exceeded 20% and treatment being restricted to the parasitologically-positive

elsewhere. Overall prevalence fell from 23.3% in 1977 to 13.7% in 1978, and to 5.8% in 1989. In 1990, Bahia and Minas Gerais states were included for the first time, raising overall prevalence to 11.7% in 1993, which fell to 9.8% following treatment of infected patients. Now these states account for 70% of all cases in Brazil.

By 1996, the price of praziquantel on the world market had fallen to a much lower level than that of oxamniquine, so praziquantel was purchased from China (the cost of treating a child with praziquantel is now $1.25, versus $4.07 with oxamniquine). Pilot trials showed that in terms of efficacy and side effects, praziquantel performed similarly to oxamniquine and the two drugs are now being used side-by-side in the Schistosomiasis Control Programme (PCE), which is coordinated nationally by the Ministry of Health. For control purposes, the endemic areas are classified as: (i) endemic areas with *widespread* transmission; (ii) endemic areas with *focal* transmission; (iii) *schistosomiasis-free* areas (sub-classified as either *with/without the presence of susceptible snail host species*); (iv) `vulnerable` areas, which are currently free of the disease, but where settlement of infected people makes transmission likely, unless preventive measures are taken. In endemic areas, where the disease is *widely* dispersed, the aims of PCE are to: (i) reduce the numbers of serious cases and deaths due to schistosomiasis; (ii) reduce the prevalence of schistosomiasis to <25%; and (iii) prevent spread of the disease. Where the disease is only *focal,* the objective is to stop transmission. In *vulnerable* areas the objective is to prevent the introduction of the disease.

In endemic areas, stool surveys using the Kato-Katz method are carried out by mobile teams going from house to house every 2 years in all endemic municipalities, and every 4 years in all municipalities where prevalence of less than 5% were previously recorded. Areas are then stratified according to the following levels of prevalence as determined by faecal egg-count positivity: <5%; 5-<25%; 25-<50%; 50% and above. If prevalence is <25%, only egg-positive cases are treated; if prevalence is 25-<50%, there is treatment of egg-positive cases plus co-residents; if prevalence is 50% or above, there is mass treatment of people above 2 years of age and less than 70 years. In addition to this *active* case detection strategy, there is *passive* case detection by a health unit - each case and family members are investigated and followed up 90 and 180 days post-treatment. Treatment of children is with liquid oxamniquine (1x20 mg/kg) or praziquantel (1x60 mg/kg), and for adults oxamniquine capsules (1x15 mg/kg) or praziquantel tablets (1x50 mg/kg).

The PCE strategy also aims to incorporate other interventions – sanitary engineering, sanitary education, and snail control. *Sanitary engineering* involves the provision of piped water supplies and other improvements in the home (the provision of wells, water tanks, bathrooms, septic tanks, sinks, laundry areas). The aim is to carry this out in all localities, but giving priority to those with prevalence 25% or above. For the permanent elimination of snails, their breeding sites must be eliminated by the construction of canals, drains, and land fills. The policy is that this should be carried out in all localities, irrespective of prevalence level, and is the responsibility of municipal and local authorities. *Sanitary education* aims at changing the habits of at-risk populations. It includes lectures, meetings, and the distribution of educational materials and must accompany control activities in all localities, irrespective of the level of prevalence. *Snail control* uses niclosamide powder (75%, at 1 ppm) and should in general only be carried out in localities where prevalence is 25% or above, and where sanitary engineering works are not possible. However, even in localities with <5% prevalence, mollusciciding is used in areas of `focal` endemicity, if elimination of the focus seems to be feasible.

The current situation is that in 3 states (Piaui, Santa Catarina, and Distrito Federal), where transmission is focally distributed, the disease is under control and is no longer considered to be a significant public health problem. The remaining 16 affected states show a variety of endemic levels, with the worst-affected states being those in the north-east and south-east. There has been priority allocation of resources to the most-affected localities and a significant number of these now show low prevalence, after having been subjected to continuous control efforts.

Schistosomiasis specific mortality rates in Brazil:

| | Mortality rate (deaths per 100,000 inhabitants) | | | |
|---|---|---|---|---|
| Year | 0-14 yrs | 15-49 yrs | 50+ yrs | All ages |
| 1979 | 0.08 | 0.85 | 2.23 | 0.71 |
| 1997 | 0.01 | 0.25 | 1.64 | 0.31 |

Source: Programa Nacional de Controle da Esquistossomose, Brazil

Consequently, there has been a significant reduction in the overall morbidity and mortality due to schistosomiasis. The disease specific mortality rate fell by 54% between 1979 and 1997 (from 0.71 to 0.31 per 100,000) and similarly the number of hospitalised cases fell by 65% between 1988 and 1999 (from 3.14 to 1.10 per 10,000). However, a reduction in prevalence has not yet been achieved uniformly in all areas. Control is particularly difficult in localities where transmission of the disease is heavily

dependent on occupational exposure, such as in fishing and farming communities.

**The Caribbean (Dominican Republic, Guadeloupe, Martinique, Puerto Rico, Saint Lucia)**

*Schistosoma mansoni* was once a major public health problem in the Caribbean islands but, following many years of control efforts, transmission has stopped or been reduced to a very low level in many areas. Current variation in rates of transmission between the islands is influenced by differences in their epidemiology and ecology.

In the Dominican Republic, the most northern endemic country in the America's, prevalence rates of 7-24% were reported for the 1982-1987 period but current prevalence rates are not known. Limited resources have been made available to schistosomiasis control but transmission control may have been effected by competitive displacement of *Biomphalaria glabrata* from many areas as a result of the spread of the *Marisa cornuarietis* and the prolific *Tarebia granifera*.

In Guadeloupe sero-prevalence in the 1970's was around 25%. As part of an integrated control programme between 1978 and 1988, *Melanoides tuberculata* was introduced and spread at the expense of *B.glabrata* but transmission sites persisted at the borders of the forest where *Rattus rattus* are heavily infected with prevalence rates of 5-60%. Between 1983-1998, prevalence fell to less than 1% and schistosomiasis ceased to be regarded as a public health problem. In Basse Terre Island transmission is deemed "interrupted" but the persistence of parasite transmission in *R. rattus* poses a potential threat of human infection.

In 1977, when the prevalence of infection in Martinique was 12%, an integrated control programme was introduced. This included education, case detection and treatment, improved sanitation and biological control against *B. glabrata* using *M. tuberculata*. Between 1977-1996 human cases and snail host densities declined such that only residual cases are now detected (a typical post-transmission state). Any potential threat to tourists (a concern of the authorities) is further minimized as they typically do not visit previous transmission sites.

In Puerto Rico, an original two-step, island-wide, serologic survey was carried out for schistosomiasis in the mid 1990's. In the first study, almost 3,000 serum samples (opportunistic sample collection from blood

donors, all over 16 years old) from all 76 municipalities comprising the island were tested for the detection of antibodies to *S. mansoni* microsomal antigens by FAST-ELISA, and those positive were confirmed by Western immunoblot (EITB). Almost 50% of all positive samples were found in only 17 municipalities, with only 10% of the positives - mostly residents in these "hot spots" - being 16-25 years old. To further establish the prevalence in younger age groups, as a surrogate of recent disease incidence, anonymous samples from a school children dengue fever survey in these areas were used. Less than 10% of children below 10 years of age were found positive by FAST-ELISA, and less than 1% by confirmatory EITB. No children 1-5 years old were found positive by EITB. It was therefore concluded that there had been little transmission of *S. mansoni* in Puerto Rico during the first half of the 1990's.

In 1997, the prevalence by stool examination (MIF concentration technique) in the areas of previously highest transmission years was estimated to be only 0.6%. Infections were restricted to only 3 people out of 495, all over 36year old ("residual cases"). It was concluded that transmission had been "interrupted" owing to the observed displacement of *B.glabrata* by the reciprocal spread of *M. cornuarietis*. and *T. granifera*.

In Saint Lucia, the control programme introduced in 1965 led to the pre-existing prevalence rates of 22-57% in different areas falling to 4-14 % by 1981. *M. tuberculata* was introduced in 1978 and by 1993 was confirmed to have spread whilst *B. glabrata* had declined markedly. No parasitological data is available since 1981, but the scarcity of *B. glabrata* is taken to indicate that transmission is low or absent.

Throughout the Caribbean Islands, biological control with snail competitors of *B. glabrata* is regarded as having made a significant contribution to the declining prevalence of schistosomiasis. Such competitive displacement of *B. glabrata* depends on the ecological setting, being favoured in transmission sites such as permanent habitats such as watercress beds, streams and canals but not in temporary ponds or marshes.

**China**

In the mid-1950's *S. japonicum* was endemic in 12 provinces; more than 100 million people were at risk, and more than 10 million were infected. In 1955 the Central Committee of the Chinese Communist Party set up a national schistosomiasis control programme under the direct control of a "National Leading Group" with ministerial level representation in

Public Health, Agriculture, Water Conservancy, Light Industries, Chemical Industry, Finance, and Commerce. A nation-wide control network was created, down to the county level. By 1958, there were 197 prevention and treatment stations, 1200 specialized medical teams, and 42 new specialized institutions, with a total of 17,000 control staff recruited. Altogether an estimated 20 million people were involved in schistosomiasis control.

This "human sea" approach to schistosomiasis control was greatly facilitated by the collective approach in agriculture and by associated reforms such as the provision of free healthcare in 25,000 new health centers, the introduction of "barefoot doctors" etc.., which were implemented during the "Great Leap Forward" of 1956-1960. Of particular significance was the personal commitment of Chairman Mao Tse-tung, who in 1958 composed the poem "Farewell to the God of Plague" to mobilize the people in the effort to eliminate the disease.

A nation-wide survey was carried out to map the distribution of the disease and the snail intermediate hosts. Humans were examined by faecal examination (egg hatch test), by intradermal test, and clinically, and cattle were examined by the egg hatch test. By 1956, 60 million people had been examined. Population-scale chemotherapy of all diagnosed cases was started in 1955 and 5 million patients had been treated by 1961. The drug used was tartar emetic (antimony potassium tartrate), first as a 20-day course of intravenous injections to a total of 1.5g, and later as a 3-day course to a total of 0.7g. In the so-called "walking on two legs" approach, traditional Chinese medicines (TCM) were given prior to the antimony to relieve ascites and to 'strengthen' the patients. Cure rates reached 85% but drug reactions were frequent and severe. Mortality rates with the 'long' course were up to 0.4% (0.05% with the short course). Diagnosis and chemotherapy campaigns were carried out annually.

Considerable efforts were made to discover new drugs. This resulted in the trial of several nitrofuran compounds, but these were apparently too toxic for widespread use (many drugs of this class of compounds are potent mutagens and carcinogens). In the late 1970's praziquantel became available and this soon replaced the antimonialsand other non-antimony chemicals. All infected bovines were also treated, first with antimonials, later with amoscanate and praziquantel. Recently, the qinghaosu (TCM) derivatives artemether and artesunate were shown by Chinese scientists to be highly effective against immature *S. japonicum*, and therefore useful for the treatment of early infections and the prevention of disease.

Health education by slogans, posters, reading materials, slide-shows, and films was heavily emphasized. Two further key elements were used in the national strategy: methods to kill eggs in human and animal faeces before these were used as fertilizers on the fields; and snail control. Several strategies were employed to this latter purpose: environmental management such as the building of dykes and land reclamation to eliminate snail habitats, conversion of rice paddies into dry crops, mollusciciding using (initially) sodium pentachlorophenate and (later) niclosamide, killing of snails by hand-picking, burying by digging new irrigation ditches and filling in old ones, ploughing by machines followed by compacting earth.

Thus, for the first two decades, the National Control Programme activities involved annual case detection and treatment, snail control by habitat modification and mollusciciding, health education, and community participation. Since praziquantel became available in the early 1980's large-scale chemotherapy has become the mainstay of control, particularly because the remaining endemic areas are mostly in swamp/lake and mountain regions, where snail control is difficult. The aim is morbidity control by large-scale chemotherapy in both humans and bovines, health education, and focal snail control. In areas with a prevalence over 15% chemotherapy is offered to everyone with a history of infective water contact; in areas where prevalence is lower than this, only those with faecal eggs or serologically positive cases are treated.

Between 1989 and 1995, prevalence in humans was reduced by 52% and in bovines by 32%. Since its introduction, more than 30 million doses of praziquantel have been administered. Morbidity due to schistosomiasis has decreased very significantly. Very few advanced cases are seen today in the specialized "schistosomiasis hospitals". In the provinces of Hunan and Hubei, which harbour most of the remaining areas with considerable transmission, the incidence of acute cases in 1999 was less than 0.25 per 100,000 inhabitants. Outbreaks of acute cases during heavy flooding seasons have effectively been contained over the last 10 years.

Over the years, the following criteria were developed for certifying that, respectively, morbidity control, transmission control, and interruption of transmission have been achieved:

**morbidity control:** the prevalence rate by faecal examination in humans is <5%; the prevalence rate by faecal examination in domestic animals is <3%; no, or very few acute cases are found

**transmission control:** the prevalence rate by faecal examination in humans and animals is <1%; no acute cases are found, and no new infections are found in children under 12 years of age or in domestic animals under 2 years of age; a reduction of higher than 98% in areas of snail habitats has been reached

**interruption of transmission:** no new infections are found in man or in domestic animals for five successive years; the prevalence rates by faecal examination in residents or domestic animals are <0.2%; no snails are found after careful surveys for at least one year

**elimination:** no new infections in humans or animals, and no infected snails are detected for a further 5 years after having reached the criteria for interruption of transmission

The distribution of schistosomiasis in China in the 1950's
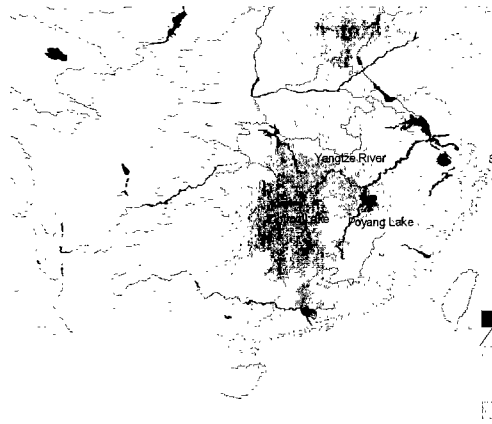


The distribution of schistosomiasis in China in 2000
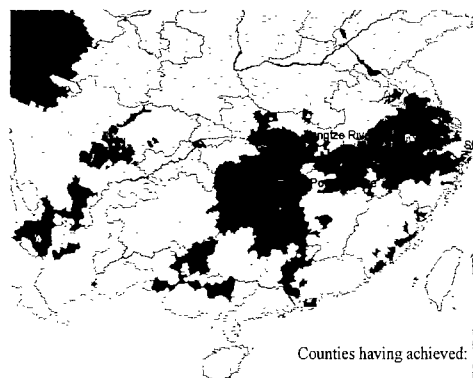


Source: Department of Diseases Control, Ministry of Health, P.R. China

Achievements in transmission control in China (1999)

| Province | Initial number of endemic counties | Number of counties having reached interruption of transmission | Number of counties having reached transmission control | Number of counties still considered as endemic |
|---|---|---|---|---|
| Shanghai | 9 | 9 | 0 | 0 |
| Jiangsu | 57 | 35 | 7 | 15 |
| Zhejiang | 54 | 54 | 0 | 0 |
| Guandong | 12 | 12 | 0 | 0 |
| Guangxi | 19 | 19 | 0 | 0 |
| Anhui | 41 | 14 | 13 | 14 |
| Fujian | 14 | 14 | 0 | 0 |
| Jiangxi | 37 | 19 | 7 | 11 |
| Hubei | 58 | 20 | 6 | 32 |
| Hunan | 29 | 7 | 1 | 21 |
| Sichuan | 62 | 25 | 20 | 17 |
| Yunnan | 17 | 10 | 2 | 5 |
| **Total** | **409** | **238** | **56** | **115** |

Source: Department of Diseases Control, Ministry of Health, P.R. China

Despite the fact that achievements in schistosomiasis control over the last 45 years are impressive, the population at risk is still 40 million and authorities in China are aware that elimination in the remaining areas with transmission requires further long-term commitment. The major remaining constraints in view of elimination are: the difficulty of snail control in swamp/lake and mountain regions, frequent population movements, poor access to mountain villages, and the presence of animal reservoirs of infection.

## Egypt

Since schistosomiasis has long been recognized as a major public health problem in Egypt, there has always been strong governmental commitment to achieving control. The National Schistosomiasis Control Programme is one of the world's biggest and its current objective are: (i) the control of morbidity by reduction of prevalence and intensity of infection; (ii) the protection of children and other high-risk groups; (iii) the protection

of newly reclaimed areas; and (iv) the prevention of the spread of *S. mansoni* to Upper Egypt.

The main components of the control strategy are: (i) selective population chemotherapy using PZQ at 40 mg/kg in a single oral dose; (ii) where appropriate, focal snail control with chemical molluscicides (niclosamide at 1-2 ppm), to reduce transmission; (iii) health education and community participation. About 30 TV spots and 8 radio messages are broadcast periodically throughout the year, children receive health education in schools, health workers visit villages; and (iv) environmental improvement. Clean water supplies are now available in most Egyptian villages, and sanitation is slowly improving. Covering of canals is being planned.

Between 1989 and 1996, about 2.5 million patients were diagnosed and treated free of charge every year and during this period over 20 million doses of praziquantel were administered. The Ministry of health annual reports showed that the overall prevalence of both *S. haematobium* and *S. mansoni* declined steadily, year by year. For *S. haematobium*, prevalence fell from 11.9% in 1988 to 5.0% in 1996, for *S. mansoni* from 16.4% to 11.9%. For *S. haematobium* in Middle and Upper Egypt prevalence between the years 1969 and 1983 had varied between 22.6% and 45.7% but by 1998 was down to between 2.3 and 7.3%. For *S. mansoni* in Lower Egypt, prevalence in the years 1986 to 1993 was between 15.8 and 46.6%, reducing to 4.4 – 11.0% by 1998. Two methods of active case detection were used: population-based, in which entire village populations were given faecal examinations; and case detection targeted at school children only. Cure rates for *S. haematobium* were >90% and for *S. mansoni* >80%. In *S. mansoni* patients all stages of the disease were treated successfully with praziquantel. After chemotherapy, hepatosplenomegaly was reduced in half the patients, and colonic polyposis also responded well. Treatment of *S. haematobium* cases led to reductions in proteinuria, haematuria, urinary iron loss and leucocyturia.

In any village with a prevalence of >20%, the surrounding canals were treated with the molluscicide niclosamide. Canals were also sprayed wherever infected snails were found. The first TV spots (12 short 2-minute messages) were shown regularly between 1988 and 1997, and beginning in 1997, 18 new TV and 8 radio messages received national exposure.

However, in 1996, the Ministry of Health and Population concluded that the population still faced an unacceptably high risk of schistosomiasis
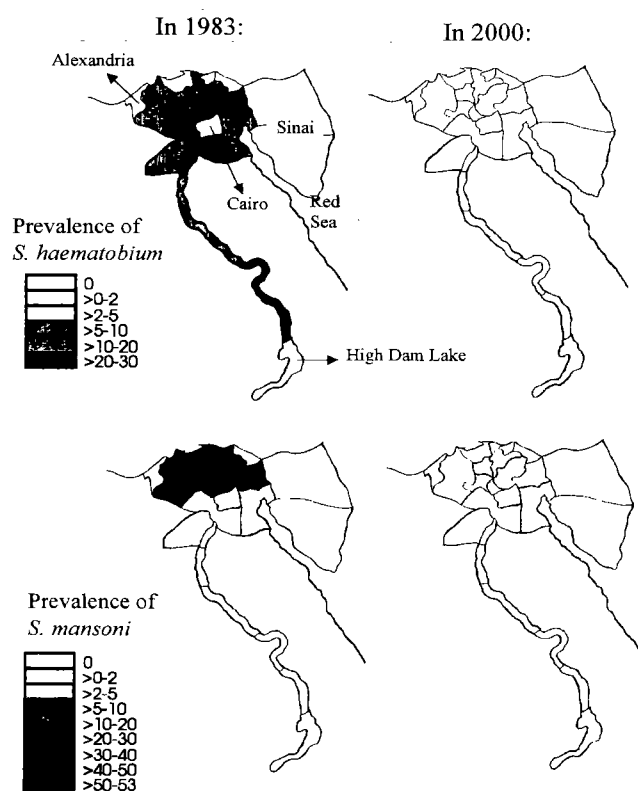
and therefore planned an attack phase using mass chemotherapy for all school children in rural Lower Egypt plus mass chemotherapy in all villages with a prevalence >20%. Prevalence was determined using sentinel surveys by stool examination and reagent strip examination of urine.

In April 1997, 4.3 million children were treated in 11 governorates. In December 1997, 2.7 million were re-treated in 5 governorates. In June 1997 mass chemotherapy was offered to the 2.9 million population of 535 villages. The following May (1998) 4.1 million school children were treated in 8 governorates. Three months later an overall reduction in prevalence of 50% was estimated by parasitological methods but prevalence in schools in 5 governorates was judged to be still unacceptably high. Therefore, a second round of school-based chemotherapy was carried out in October 1999, in which 3.8 million children were treated in 8 governorates and mass treatment was repeated in 208 villages with >20% prevalence at follow-up. In 1999, villages with a prevalence of >10% were offered mass chemotherapy: 230 villages were treated in May and 98 in October.

The current situation is that S. haematobium has virtually disappeared from the Nile Delta, and in Upper Egypt prevalence is below the target of 5%. S. mansoni persists in the Delta, but at a reduced prevalence and intensity. The future national strategy is likely to be a return to selective population chemotherapy, with mass chemotherapy and snail control being offered only to remaining "hotspot" villages.

In conclusion, schistosomiasis is now only a relatively minor health problem in Egypt, with an overall prevalence of <10%. It is hoped that the mass treatments which have been given to children will mean that these children will not suffer serious morbidity in later life, but vigilance is still needed to prevent a resurgence of infection.

The distribution of schistosomiasis in Egypt:



Prevalence of
S. haematobium

| | |
|---|---|
| | 0 |
| | >0-2 |
| | >2-5 |
| | >5-10 |
| | >10-20 |
| | >20-30 |

Prevalence of
S. mansoni

| | |
|---|---|
| | 0 |
| | >0-2 |
| | >2-5 |
| | >5-10 |
| | >10-20 |
| | >20-30 |
| | >30-40 |
| | >40-50 |
| | >50-53 |

Source: National Schistosomiasis Control Programme, Ministry of Health and Population,
Egypt

**Islamic Republic of Iran**

Kurzestan province in the south-west of Iran is where transmission of *S. haematobium* occurred in the past with approximately one third of the rural population being at risk of exposure, notably in the swampy areas of the region. As judged by examination of urine samples for eggs by filtration, the prevalence in 1970 was 8.3% (1822 positives) and the incidence monitored in schoolchildren below 15 years old was 3.5%. Control measures involving regular annual selective chemotherapy, mollusciciding,

environmental modification and improvements in sanitation were started in 1970.

Chemotherapy was based on selective treatment of positive cases following annual mass screening of the at risk population (those living near known snail-infested habitats). Initially niridazole was used and later replaced with metrifonate and then with praziquantel.

Standard latrines and safe water supplies were provided in each village and, where appropriate, swamps were drained and canals improved especially in areas where mollusciding alone was inadequate.

Control of the snail intermediate host, *Bulinus truncatus*, was carried out by biannual survey of the potential habitats such as ponds, borrow-pits, swamps and canals, and treatment of infested sites, initially with copper sulphate and later with niclosamide. Between 1970 and 1985 there was a steady decline in the proportion of infested habitats from 6.3% to 0.5 % positive. The original biannual treatment was later replaced by single annual treatment, and snail treatment was eventually stopped. In 1995, 1.7% of over 8000 habitats sampled still harboured snails, but in view of the successful interruption of transmission in Iran, habitat monitoring activities subsequently ceased.

Throughout the control period the human infection rate declined, falling to 1.3% after 5 years (1975) and to 0.03% by 1994. In 1999, only 4 cases were detected among 40,000 urine samples examined, and these were deemed to be residual cases. Transmission had apparently ceased before 1990 as no new infections were detected in schoolchildren <15yr from this date to the present.

Transmission is believed to have ceased in Iran as the indigenous source of human infection has disappeared. The above control and monitoring procedures have been suspended and there is reliance on clinical case detection to detect any resurgence of transmission. *Bulinus truncatus* is still present and reported to be increasing and so there is a potential for resurgence of transmission if the infection were reintroduced by immigration. Antibody or antigen detection tests should be valuable for the confirmation of clinical diagnosis in those individuals in whom eggs cannot be found.

**Japan**

There were originally 3 major endemic areas (Katayama District, Kofu Basin and Chikugo River Basin) and 3 minor unstable endemic areas (Tone River Basin, Obitsu District, and Numazu) in Japan. These habitats were mainly rice fields and river banks in wet and low-lying areas. The total endemic area was about 30,000 hectares and the total infected population was 8,000 in 1920 and 100,000 in 1961. Following Miyairi & Suzuki's 1913 discovery of the identity of the *Oncomelania* snail host, which completed the knowledge of the life cycle of *S. japonicum*, control measures included the cleaning of ditches, mollusciciding and land reclamation. All these self-reliance activities leading to elimination were enthusiastically carried out with the active involvement of farmers at the endemic sites. Their efforts were strongly supported by governmental officials at all levels.

There were several technical advances which underpinned control efforts. In 1909, caustic lime and calcium cyanamide were shown to be effective molluscicides. The molluscicide calcium cyanamide was introduced in the 1940's, but was replaced in 1948 by sodium pentachlorophenate, which was then used for many years. Because of its high toxicity to plants and fish, its use was discontinued in 1971. It was replaced by yuramin, phebrol, and niclosamide (which was first used in Puerto Rico in 1963). However, niclosamide was little used in Japan, because the extent of the *Oncomelania* habitats was already greatly reduced by the time it became available. Other snail control methods included the burning of rice straw in suspected snail habitats, or the use of flame throwers to kill snails.

Farmers were recommended to wear socks, garters, and gloves to prevent cercarial infection. Much later, in 1952, topical repellents such as benzyl benzoate and dimethyl phthalate were discovered to have some cercaria-repellent activity when applied to the skin.

In 1910 it was recommended that human excreta be appropriately stored to kill eggs before being used as a fertilizer. Between 1904 and 1910, cats, wild rats, horses and cattle were discovered to be reservoir hosts. Horses were shown to be more resistant to the infection than cattle, and were therefore substituted for them for use in paddy fields.

It was noticed that there were always more snails in the ditches surrounding rice fields than in the fields themselves, and that snail populations were much smaller in cemented than in soil-lined ditches. The

construction of cement-lined ditches was therefore incorporated into the National Parasite Prevention Act from 1950, and was eventually fully-funded from public funds. The construction of cement-lined ditches became one of the mainstays of control in Japan, and by 1970, 65% of ditches in endemic areas were cemented. Schistosomiasis control was further facilitated by land reclamation, introduced either to improve agricultural production, or as a direct contribution to schistosomiasis control.

The first epidemiological surveys were carried out in 1910. Subsequently, active cases were sought out by direct faecal smear and the merthiolate-iodine-formalin concentration methods and by intradermal and serological testing. Beginning in 1921, there was large-scale treatment using sodium antimony tartrate and other antimonial drugs, and the remaining cases were treated with praziquantel when this became available in the 1970's. Active case numbers dropped continuously from 1920 onwards, except that there was some resurgence in World War II. The total number of patients was reduced to 438 in 1970, and the last autochthonous case was detected in 1977. However, (uninfected) snails persist to the present day in two of the former endemic areas. It is also possible that the infection persists in the animal reservoir, and vigilance is essential to prevent reintroduction by human immigration from nearby endemic countries. The Japanese intermediate host *O. nosophora* is susceptible to Chinese and Philippine strains of *S. japonicum*, and in 1998 over 400,000 migrants from these countries entered Japan. It is therefore highly desirable completely to eliminate the snail host from Japan, which now survive in only two residual foci totalling 1300 hectares. Finally it is important to note that the control efforts in Japan were greatly facilitated by two key politico-administrative measures: the strong support received from the Ministry of Health and Welfare following enactment of the National Parasite Prevention Act; and making schistosomiasis a notifiable disease.

**Morocco**

*Schistosoma haematobium* had been endemic in rural areas of the south of Morocco for decades, the first cases being detected in 1914. The construction of large hydro-agriculture projects from 1967 onwards resulted in the disease spreading to new foci in the centre and north of the country. The resultant increasing importance of schistosomiasis led to the implementation of an integrated control programme in the early 1970's (Programme de Lutte Anti-Bilharzienne, PLAB), starting with a preparatory phase in 1976-1979, a pilot phase in three provinces in 1979-1981 and the implementation of an operational phase in all areas beginning in 1982.

The control strategy was based on four fundamental approaches:
(i) disease control by diagnosis and treatment was the major component of
the control strategy. Both screening and treatment were free; (ii)
transmission control and reduction of snail infestation by environmental
modification and/or chemical mollusciciding depending on the ecological
setting; (iii) health education of the population to ensure co-operation and
involvement in the control programme; and (iv) involvement of non-health
sectors.

Successful implementation of the programme was built on the
experience gained during the earlier malaria control programmes in
Morocco. Organization and evaluation of the programme was controlled by
a national programme team but implementation was integrated into the
activities of the local health system.

Diagnosis was based on the examination of sedimented urine, and a
variety of different ways of screening were used: (i) mass detection by
annual screening in schools and villages in all known transmission foci;
(ii) passive detection in health centers; (iii) active detection by mobile teams
in villages distant from health centers; and (iv) detection among household
members of positive patients (contact tracing).

Treatment was generally selective, although mass treatment has been
used in a few situations. Initially, treatment was with niridazole and later
with metrifonate, but the introduction of praziquantel in 1987 was a major
boost to the programme. Used as a single dose (40mg/kg) it reduced the
treatment failure rate, side effects and cost.

Malacological surveys to determine the level of infestation in
different foci in transmission zones was carried out by travelling nurses
and/or by mobile teams during their periodic surveillance (once/month or
once every two months). The preferred method of snail control was
environmental modification but chemical mollusciciding with niclosamide
was also extensively employed in certain situations.

The provision of information, education and the raising of awareness
was carried out by regular health personnel or by those involved in carrying
out the mass diagnosis.

Evaluation was carried out by quarterly and/or annual reviews and
based on indicators such as the total number of cases, the percentage of
positive cases, annual incidence rates, and the coverage rate. The number of

parasitologically confirmed cases in 1982 was 6582, representing a positivity rate of 6.2% (amongst 105,541 urine samples tested). The exposed population by then was deemed to be 799,284 and the annual incidence rate 8.2 per 1000 population. These levels of infection and risk reduced year on year following the implementation of control, falling to 1108 cases in 1994 (0.5% positivity rate, 519,818 people at risk of exposure and annual incidence rate 2.1 per 1000). Over the same time the number of affected localities dropped from 477 to 210. The level of transmission was also shown to have declined by the shift in age-specific infection patterns e.g. school aged children (7-14) accounted for 67% of cases in 1983 but only for 38% in 1996.

The successes achieved between 1983 and 1994 led to a reassessment of the goal of the control effort in 1994, and to a consensual decision to aim for elimination of the disease by 2004 (the adoption of the Bilharziasis Elimination Process - PEB). The objective was to eliminate schistosomiasis from all transmission foci by 2004. To this end a 10-year plan was devised for each province with annual review.
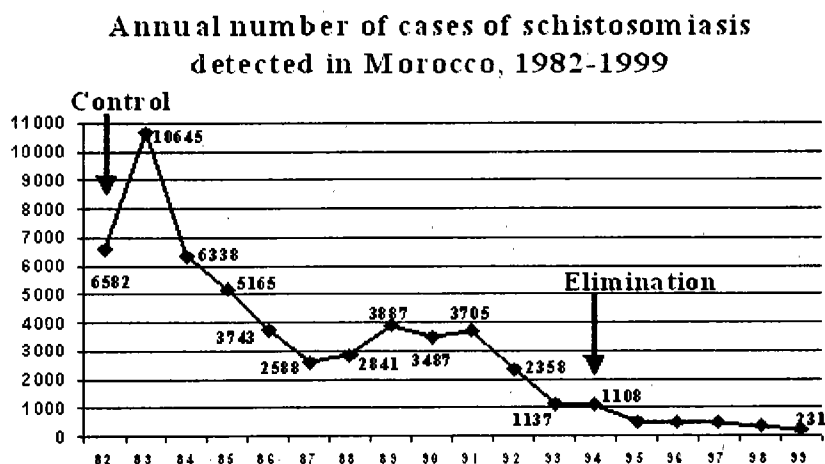
**Annual number of cases of schistosomiasis detected in Morocco, 1982-1999**



Source: Direction de l'Epidemiologie et de Lutte contre les Maladies, Ministère de la Santé, Royaume du Maroc

The strategies to achieve this were: (i) diagnosis and treatment (as in the PLAB); (ii) snail control, focusing on environmental modification; (iii) health education; and (iv) participation of other sectors (agriculture, national education, public works). Elimination was defined as a reduction to zero incidence in a defined geographic area as a result of deliberate efforts, with

continued control no longer being required. The criterion established for elimination was a record of zero cases of infection for a period of 5 years provided that continued monitoring had been carried out.

The distribution of schistosomiaisis of Morocco

in 1983:          in 1993:          in 1999:

Number of cases detected

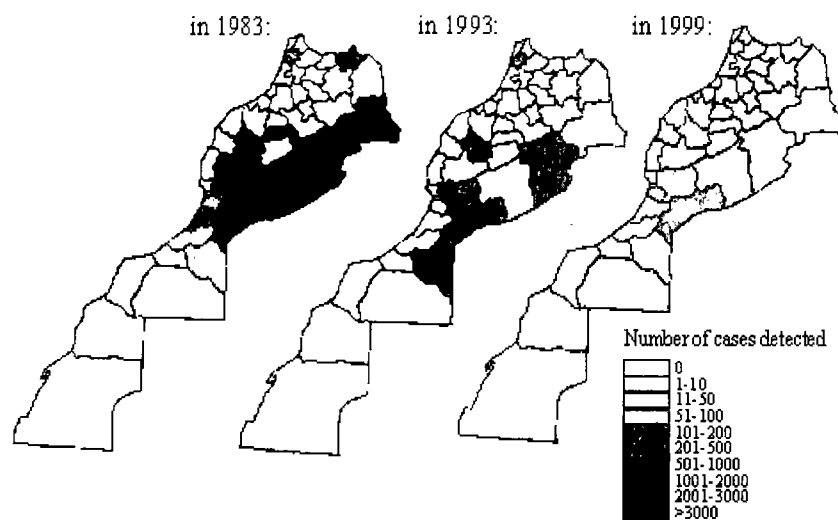| | |
|---|---|
| | 0 |
| | 1-10 |
| | 11-50 |
| | 51-100 |
| | 101-200 |
| | 201-500 |
| | 501-1000 |
| | 1001-2000 |
| | 2001-3000 |
| | >3000 |

Source: Direction de l'Epidemiologie et de Lutte contre les Maladies, Ministère de la Santé, Royaume du Maroc

In 1999 the at-risk population was estimated to be 299,564 and the number of affected locations to be 86. Based on mass or selective screening of 183,155 individuals (a 61% coverage of the total at-risk population) only 231 cases were detected (a positivity rate of 0.13%). Incidence was down to 0.8 per 1000 population and 40% of cases occurred in the school-aged population. 83% of cases were found in only 4 areas and most cases still occurred in those areas which had the highest levels prior to the start of control.

Remarkable progress has been achieved towards the aim of elimination based on the reduction in the total number of cases and on the reduction in the number of areas in which schistosomiasis is still present.

The prospect of elimination can maintain government and financial support and enthusiasm on the part of those involved in running the programme. But as the number of cases falls, and elimination from residual

foci proves difficult, it is less easy to maintain this support and enthusiasm. So there is a need for new approaches. These may include the use of new diagnostic methods to reduce operator fatigue (e.g. antibody/antigen detection, if the cost is competitive), selective treatment on the basis of seropositivity to cure all residual cases, and enhanced emphasis on snail elimination.

**Saudi Arabia**

Both *S. mansoni* and *S. haematobium* are endemic in Saudi Arabia, and schistosomiasis was until recently a public health problem in most parts of the country, with prevalence rates of up to 40%. The main snail habitats were streams ("wadis"), dams, swamps, springs, and wells. In 1977, with an estimated 2 million people at risk of infection, the Ministry of Health established Schistosomiasis Control Centers in all endemic areas, to carry out control programmes based on diagnosis, treatment with antimonials, niridazole, or metrifonate, snail control with copper sulphate and niclosamide, and health education. From 1975 to 1979, very little was achieved. Medical and geographical surveys were incomplete and in most regions the population coverage was very poor. Only 2-3% of the at-risk population was examined and treated, and overall prevalence was 7.8%. Furthermore, the antimonial drugs were perceived to be ineffective and not accepted by the population.

As praziquantel became available, better results were achieved, but population coverage remained low. In each of the years 1980-1984, between 3.9% and 5.5% of the at-risk population was examined and treated with oxamniquine or praziquantel by mobile teams, and niclosamide was used in area-wide mollusciciding wherever snails were found. By 1984, overall prevalence was down to 6.8%.

In 1986, a new control strategy was introduced, based on population-based chemotherapy with praziquantel and focal mollusciciding, with the goal of reducing prevalence to under 1% within 5 years. As prevalence dropped towards 1%, the use of this 'vertical' approach gradually became less economically justified, and in 1989, the Ministry of health recommended that schistosomiasis control be integrated into the Primary Health Care (PHC) system. By that time, Saudi Arabia had an advanced PHC system covering >90% of the population, which offered excellent opportunities to conduct chemotherapy and maintenance operations. Follow-up of patients and screening of the population was also relatively easy, because of the family health files maintained by each PHC centre.

Between 1985 and 1989, between 12% and 49.3% of the at-risk population was covered, and infected persons were treated with praziquantel by mobile teams. Overall prevalence had fallen to 1.0% by 1989.

Since 1990, both *S. mansoni* and *S. haematobium* prevalences have been maintained at <1% in all regions. In the period 1990-1996, 61%-78.4% of the at-risk population was covered, and infected persons treated with praziquantel, mostly within the PHC system but with support from mobile teams. Overall prevalence was only 0.1% in 1996. Case numbers dropped from 26,000 in 1983 to only 1272 in 1998, more than 50% of cases being non-Saudi. *S. haematobium* predominates in Gizan and *S. mansoni* in the Al-Baha region, and the disease has completely disappeared from its endemic foci in the North.

Factors favouring a successful outcome for these control efforts were the facts that 95% of the population had access to safe potable water and 88% to hygienic waste disposal by 1988. There were also sufficient funds to buy praziquantel and niclosamide and to carry out all the programmed activities. The presence of experts, the existence of a National Malaria and Bilharzia Training Centre, and the fact that nearly all children attended school, facilitated screening, treatment, and health education. The excellent roads facilitated movements of the control team.

Constraints were identified as: border migrations; the fact that the Saravat Mountains in the South-West act as reservoirs of snails and during floods snails are transported to new habitats; there is no in-depth knowledge of snail ecology or transmission dynamics. The current control strategy is to eliminate transmission wherever possible, with the ultimate goal of complete elimination. In the interim, prevalence is to be maintained at <1% everywhere, integrating schistosomiasis control with the control of malaria, leishmaniasis, and gut parasites, and implementing these through PHC and vector control stations. These efforts involve co-ordination between government and non-governmental sectors at all levels, with emphasis on socio-economic development and the provision of community services, health education, water, and sanitation. Community involvement is regarded as essential. There is now a need, at the district level, to develop an operational plan to cover the entire target population. A total of 3 examinations is required before a person can be declared to be uninfected. There is also a need to introduce more sensitive diagnostic methods, and to arrive at a more thorough knowledge of the dynamics of transmission.

**Tunisia**

To encourage the development of tourism in Tunisia in the late 1960's, there was pressure to control the major endemic diseases. Transmission of urinary schistosomiasis had been a problem in parts of Southern Tunisia and led to the implementation of a WHO-assisted control project in June 1970.

In an initial survey based on the microscopic examination of urine sediment in 1970-71, transmission in suspected endemic areas was confirmed by screening schoolchildren, and followed by mass screening of the whole population. In 1971 this revealed a prevalence of 8.9% amongst the 54,754 individuals examined. Infection was greatest in the school-aged population in whom prevalence reached 80% in some areas.

A malacological survey of all potential water sources in these regions showed *Bulinus truncatus* in 43% of the sites. Habitats were mainly natural springs, small streams, irrigation canals and temporary rivers (oueds). Most endemic areas were associated with oases in the Saharan region. Human water contact and the density of snails were highest in the warm months resulting in seasonal transmission.

The strategy for the control of schistosomiasis was regular surveying of all water bodies and mollusciciding those containing *Bulinus truncatus* using niclosamide, mass screening and treatment of infected people with niridazole (or metrifonate and praziquantel when these became available), development of health education and environmental modification. Community involvement and persistence of expertise in control was assured by recruitment of local people to the programme. This also avoided cultural or communication problems.

Control was evaluated by the monthly searching for *Bulinus* in water bodies, annual (until 1978, then every two years) parasitological surveys of prevalence in 10 selected communities with previous high transmission rates, assessment of prevalence rates in schoolchildren across the previous endemic area, and clinical case detection and reporting (schistosomiasis is a notifiable disease in Tunisia).

Mollusciciding was highly effective, eliminating *Bulinus* from 75% of the treated sites following a single treatment. Due to incomplete elimination or invasion from other sites, some areas required a second or subsequent treatment. Some areas showed more persistent infestations and

in these areas regular and complete surveying of water bodies was important. In one of those areas (Gafsa), for example, a lapse in complete surveillance in 1981-1982 led to a focal increase in snail numbers and renewed transmission. In many oases deep wells have been sunk and the high rate of water abstraction has meant that some natural snail habitats simply dried up. In other areas snail elimination was facilitated by minor water management such as construction of walls or canals.

A total of 11, 641 cases were treated between 1971 and 1979. Following the initial round of treatment, 276 people received repeated treatment due to treatment failure or reinfection. The others treated after 1972 represented positively diagnosed individuals who were absent from the areas (many Tunisians work abroad) or not treated due to contraindications. In this latter group 85% became egg negative spontaneously.

The control programme had a rapid impact. Transmission was successfully interrupted in most sites as soon as 1972-1973 and in all sites by 1981. The few cases which now occur are in travelers from other endemic areas abroad. The success of the control programme was helped by the commitment to interrupt transmission, and by the fact that each endemic region (mainly oases) could be considered as an isolated focus. Transmission sites were also well-defined with limited volumes of water from natural sources or from artesian wells feeding irrigation canals.

Currently there is periodic monitoring for snails in potential breeding sites in natural or man-made water bodies, and targeted monitoring of infection in school-aged boys in selected areas in order to detect any new transmission. Serology has not been used previously, but in the school-aged sentinels of transmission, antibody/antigen detection may become an efficient option if long term monitoring is required.

**Venezuela**

*Schistosoma mansoni* transmitted by *Biomphalaria glabrata* has probably been endemic in Venezuela since its introduction with the slave trade in the 16th century. In 1943, the Ministry of Health introduced an effective integrated control programme based on snail elimination, health education, environmental and sanitation improvement, parasitological diagnosis and treatment, and epidemiological surveillance. This program resulted in the prevalence (based on stool examination) being reduced from 50% in the 1940's and 1950's to 15% in the 1960's and to 1.7% in the 1980's. Host snails were eliminated from 60% of the rivers and water bodies and

transmission became highly focal and intensities of infection light. These indicators suggested that the disease was disappearing and control efforts were eased. Subsequent resurgence of transmission in certain residual foci demonstrated that the infection was persisting, but at a low level and below that readily detected by routine parasitological diagnosis. This led the Venezuelan Schistosomiasis Working Group to the development and application of highly sensitive immunological assays for the detection of asymptomatic and chronic infections and a reassessment of the epidemiology of schistosomiasis in this low transmission area.

The tests carried out were: (i) circumoval precipitin test (COPT) for the detection of anti-egg antibodies; (ii) ELISA using soluble egg antigen (SEA) treated with sodium metaperiodate to reduce cross reactivity with other helminth antigens (SMP-ELISA); (iii) alkaline phosphatase immunoassay (APIA), a highly specific test based on the detection of IgG against adult worm alkaline phosphatase; and (iv) Western Blot (WB) with an $n$-butanol extract of an adult worm membrane fraction.

The overall comparison of these diagnostic tests led to the following conclusions: (i) faecal egg count showed limited sensitivity; (ii) COPT showed high sensitivity (96%) and specificity (100%) compared to faecal egg counts, but was less sensitive (i.e. gave lower prevalences) than other immunoassays; (iii) APIA combined with SMP-ELISA was highly sensitive and specific and it was recommended that these two tests should be used for diagnosis (ahead of treatment).

By measuring both faecal egg loads and antibody responses in this range of serological tests in individuals of different ages in a community it was possible to assess whether a region could be considered as being a traditional or newly established focus and whether there was a high or low risk of transmission. For example, anti-adult worm responses (APIA and WB) were relatively higher in the older areas and the anti-egg responses (COPT and SMP-ELISA) higher in the newer transmission areas.

In Caraballeda (littoral central region of the Vargas State) a survey in 1983 showed a prevalence of 34.7% by faecal egg counts (Kato Katz). By 1985 the snail hosts had disappeared curtailing further transmission and in 1997, twelve years later, the faecal egg count prevalence rate was still 3.5%. However, by the highly specific WB and APIA, the prevalence was 35% which, given the length of time from cessation of transmission, is taken to demonstrate persistent low level adult worm infections. In the region known as El 25 (Carabobo State), a traditional rural transmission site, the

parasitological prevalence dropped from 25% in 1986 to 0.4% in 1998, but low numbers of snails persisted and the APIA and WB indicated prevalence of 25%. It is concluded that transmission is still ongoing in this site. In the rural community of Belén (Carabobo State), control stopped in 1992 and the focus became active again with parasitological prevalence reaching 4% in 1998. Here the SMP-ELISA showed a prevalence of 19% with a significant proportion being in the younger population demonstrating that transmission was ongoing. Finally the Leonardo Chirinos community (Valencia, Carabobo State) represents a new peri-urban focus with a parasitological prevalence of 0.6% but an SMP-ELISA rate of 14% with a significant proportion of children showing positive.

The experience in Venezuela demonstrates that even when control efforts bring about a marked decline in prevalence, intensity and distribution of schistosomiasis, careful consideration must be given to the risk of resurgence of the disease before control and surveillance efforts are relaxed. Owing to the lack of sensitivity of parasitological diagnosis when transmission is low, serology employing reliable specific and sensitive assays can provide valuable data on transmission status and impact of control measures.

## Clinical case definitions in areas where transmission is low or has been interrupted

Clinical cases indirectly reflect the transmission status and dynamics of schistosomiasis in endemic areas. However, due to the longevity of the adult worms and the irreversible nature of late-stage sequelae, the relationship between transmission of schistosomiasis and its clinical presentation is not always straightforward. Particularly in areas which have been subject to sustained large-scale chemotherapy the level of (reversible) morbidity as it is classically experienced may be very low. Case definitions may therefore have to be reviewed and adapted to a given setting. The adequate detection of (especially early) clinical cases is important in view of surveillance and preparedness.

The clinical aspects of schistosomiasis can be classified according to the time which elapses until they become apparent. Grossly, the following stages can be identified.

**Cercarial dermatitis:** however this can be due to different schistosome species, many of them not pathogenic to humans. Cases of "Swimmer's Itch" therefore do not prove ongoing transmission or the

reintroduction of human schistosomiasis into the area. The occurrence of Swimmer's Itch may, however, suggest the need for investigations in order to rule out human schistosomiasis.

**Acute schistosomiasis:** this may be inapparent or non-specific, accompanied by acute febrile hepatosplenomegaly or by acute focal neurologic symptoms (acute neuroschistosomiasis). It is generally recognised to be more prevalent in Asian schistosomiasis.

**Early chronic schistosomiasis:** this may be reflected by haematuria and polyposis of the bladder in *S. haematobium* infection and by bloody stools in intestinal schistosomiasis. Splenomegaly may occur, due to reactive hyperplasia.

**Chronic schistosomiasis:** manifestations may include urinary bladder fibrosis or calcification, genital lesions, chronic colitis with or without pseudopolyposis, periportal and gallbladder fibrosis associated or not with hepatitis, dwarfism and retardation of sexual development, and glomerulonephritis.

**Late stage sequelae:** in *S. haematobium* infection there may be hydronephrosis and renal failure, bladder cancer, ectopic pregnancies and infertility. Sequelae of the *S. mansoni, S. japonicum,* and *S. mekongi* infections include portal hypertension, splenomegaly and hypersplenism, ascites, upper gastrointestinal bleeding from oesophageal and gastric varices, and pulmonary hypertension. Immune complex nephrotic syndrome is frequently seen in late stage schistosomiasis with significant hepatic fibrosis and portal hypertension. The relationship between schistosomiasis, chronic hepatitis, colon and liver malignancies, still needs further investigation.

*Late stage sequelae* due to schistosomiasis may persist for a long time after the elimination of transmission and are therefore not useful indicators of persisting transmission. In contrast, the signs and symptoms of early disease are highly relevant. The following scenarios have been identified:

**Interruption of transmission:** the typical early signs and symptoms of chronic schistosomiasis do not disappear in children or subjects born after the interruption of transmission but irreversible consequences and late stage sequelae of schistosomiasis may persist in formerly infected individuals.

**Low transmission** this has to be looked at from two different angles: low transmission in a whole region - a less frequent epidemiological situation – or low or interrupted transmission in some foci but persistent transmission in others. The risk or occurrence of morbidity in this latter case is related to the geographical distribution and the degree of transmission, and to migration patterns of individuals or populations. Acute schistosomiasis is more likely to occur in individuals from areas where transmission has been interrupted who have been exposed to schistosomiasis in those sites where transmission still persists.

**Resurgence of transmission:** in an extinct focus resurgence may be detected by the occurrence of acute or early chronic signs and symptoms in subjects who were born after the interruption of transmission.

**Introduction of schistosomiasis in a formerly non-endemic area:** this is shown by the occurrence of acute and/or early chronic signs and symptoms in subjects, irrespective of their age. Typical examples of this situation are the introduction of schistosomiasis into formerly unaffected areas due to water resource development (e.g. northern Senegal) and recent foci of urban schistosomiasis.

In areas where transmission has been interrupted clinical surveillance and preparedness has to continue, particularly in areas where the transmission potential remains high. It is therefore crucial to continue to detect acute infections and early chronic morbidity, and to determine whether they are imported cases or cases caused by a resurgence of transmission. However, as transmission decreases to low levels, the traditional clinical case definitions may change (e.g. in *S. haematobium* areas there is a change from gross haematuria to dysuria as the most common symptom), and clinical case definitions have to be adapted to the particular situation and context. The residual chronic cases must also continue to have access to proper case management. Misdiagnosis in a situation of low or interrupted transmission is of particular concern to public health authorities as it may lead to inappropriate treatment or trigger unnecessary concerns about the resurgence of transmission.

## Conclusions and recommendations

### Diagnosis of schistosomiasis in low level transmission/low prevalence or zero transmission areas

Considerations relate to areas with previous higher prevalence which have been reduced by control efforts.

- **Issues relating to parasitological diagnosis**

Areas in which successful large-scale chemotherapy programmes have been implemented, with the aim of reducing the parasite reservoir, will have low prevalence and persisting or new infections will be of low intensity. However, in view of possible elimination, there is a need to continue to diagnose these low level infections, whether it be to further eliminate the parasite reservoir, to assess if transmission is still occurring or, in some regions, to monitor the infection status of immigrants. Continued parasitological monitoring of infection in such areas has a number of drawbacks.

Because of the perceived need to monitor large nu mbers of individuals, high-throughput, microscope-based assays are generally carried out ( e.g. Kato-Katz for *S. mansoni* or *S. japonicum* or filtering 10ml of urine for *S. haematobium*). These have a relatively low sensitivity and so will miss a significant proportion of low intensity infections (false negatives). Because the positivity rate is so low (e.g. in 1999 in Morocco only 231 *S. haematobium* cases/egg positives were found out of 183,155 urine samples tested), the diagnostic personnel are inclined to suffer a loss of motivation or to feel that the problem has been solved. The tests are labour intensive and cumbersome in a low transmission setting, and are usually not well accepted anymore by populations who have stopped perceiving morbidity. It become increasingly difficult to maintain good coverage rates, and a significant proportion of the population may be missed (e.g. in Morocco 61% of the population was covered) and continue to represent a risk for the maintenance of infection.

- **Possible ways of improving the monitoring process**

(i)     More sensitive parasitological diagnosis:
        Sensitivity can be increased by repeated sampling and/or sampling of a larger volume of stool or urine e.g. by the modified Ridley, the hatching

test or by sedimentation of whole urines prior to filtration of the concentrated sediment. However, given the large numbers of samples involved in the mass screening phase of control programmes or in the post-control, surveillance phase, it is not practical to employ such, more complicated, concentration tests on the whole population at risk.

(ii)     Selective parasitological screening:
         Use of more accurate mapping of "hot-spots" of infection/transmission e.g. by use of GIS methods might allow the numbers of individuals to be monitored for ongoing transmission to be greatly reduced. However there is a risk of new foci of transmission arising especially in areas where flooding can change the geographical location of transmission foci.

(iii)    Antibody or antigen detection:
         In view of the inherent problems with parasitological diagnosis in low endemic areas, there may be a role for e.g. antibody or antigen detection. Such techniques may have advantages over parasitological diagnosis. With regard to sensitivity, there is evidence that certain existing serological techniques are more sensitive in detecting infection than parasitology. The COPT and APIA gave higher sero-prevalences in children than prevalence based on Kato in areas where resurgence of infection is suspected after suspension of control programmes in Brazil. In the Phillipines a proportion of COPT positive/ single Kato-Katz negatives were shown to have eggs on repeated sampling. Available data does not indicate that the current antigen detection tests have the same sensitivity as a three-times repeated Kato-Katz examination.

- **Possible ways in which antibody or antigen detection may be used in low/zero transmission areas:**

(i)      *Routine screening* for case detection in low transmission areas, or detection and treatment of residual infections in very low transmission areas, in order to eliminate the parasite reservoir and aid interruption of transmission. Antibody detection has generally been considered to be of limited use in endemic areas because of the persistence of antibodies after cure resulting in a high proportion of false positives. However, if cheap, simple, sensitive and quantitative antibody assays were available they would be a useful adjunct to diagnosis in low endemic areas.

         In areas with very low transmission, mass diagnosis by optimal antibody or antigen assays could be considered. All sero-positives may then

be considered for treatment even though a proportion that have been subjected to mass/targeted chemotherapy will be free of infection and only have persistent antibodies. This strategy would mean that drug would not be wasted on antibody/antigen negatives (putative genuine parasite negatives) although some false negatives would be treated. Apart from the ethical issue relating to the treatment of negative individuals a major practical issue here would be the relative costs of conducting the assay in relation to the saving in drug costs.

It is recommended that this strategy, aimed at facilitating the move from low to zero transmission, be tested once the efficacy and cost of optimal serological assays are determined (see below). Success of this strategy would depend on a high coverage rate and would be most efficient if the diagnostic test could be applied on the spot followed by immediate treatment.

(ii)　*Monitoring interrupted transmission* by incidence in children (replacing parasitological surveillance). Schoolchildren are a valuable group to target for monitoring absence of ongoing transmission because traditionally they have high water contact and the highest intensities of infection, and seropositivity is more likely to indicate active (not previously treated) infection than in older people from a previously endemic area. It is suggested that monitoring should start at first grade (5yrs) in regular school and perhaps continue for 5-10 years. Efforts should be made to aim for maximum coverage of all social and economic groups, including parallel educational systems such as Koranic schools.

A test for this monitoring of transmission needs to be highly *specific* or false alarms will constantly be raised although it also needs to have a significantly higher level of sensitivity than parasitology. It is recommended that this type of surveillance is introduced once appropriate tests are identified (see below). In areas where transmission has been interrupted no sero-positives would be detected and such monitoring should be continued for some time, but thereafter: (a) stopped in areas where the risk of resurgence is deemed to be low owing to environmental modification/elimination of snail habitats or (b) continued in focal historical "hot spots" where the risk of resurgence is deemed to be significant.

(iii)　*Where resurgent transmission is suspected.* Where seropositive cases are detected after interruption of transmission, a second confirmatory antibody/antigen detection test should be carried out. If the second test is also positive, multiple samples from these individuals should be examined

with a quantitative, sensitive, concentration ova detection assay, such as formol-ether concentration, miracidial hatching tests, or whole urine concentration methods. Exhaustive investigation for the possible source of infection for individuals who are found to be both serologically and ova-positive should also be conducted and appropriate treatment/snail control implemented. Vigilant follow-up of serologically-negative residents of affected areas during consecutive transmission seasons may also be indicated. Local health workers and physicians should be alerted to be on the look-out for symptoms associated with acute infection, such as dermatitis, bloody diarrhoea, haematuria, febrile hepato-splenomegaly, unclear focal neurological symptoms, and proteinuria.

- **Antibody or antigen detection assays: which future?**

    It would be of great benefit if an antibody test could be developed which becomes negative (or drops dramatically in titre) soon after cure so that only active infections were detected. However, data from Bohol Island in the Philippines (a low transmission area for *S. japonicum*) indicates that SEA-ELISA becomes negative only after more than 3-4 years, while the COPT takes more than 2 years to become negative. However, antigen detection shows active infection and could become a method of choice depending on cost, simplicity and sensitivity.

    Various technological developments for both antibody and antigen detection may make such assays increasingly practicable for field use in endemic areas, for example: the use of finger-prick/ear lobe blood or urine for antibody or antigen detection (CAA on blood, CCA on urine); the development of lateral flow assays ("dipstick") formats for simple and quick use in the field; the use of detectors simply applied to the skin; the use of synthetic peptides or oligosaccharides for highly specific and sensitive antibody detection.

    For the present it is recommended that a variety of the currently available antibody and antigen tests be compared using sera collected from low endemic areas, and the results compared with rigorously collected parasitological data as the "Gold Standard" under WHO sponsorship. This may involve both testing in laboratories and in the field. Efforts should be made to encourage commercial companies to become involved in developing tests by informing them of the recommendations herein.

    A list of possible tests and references to their laboratories of origin is given in the table below. In inviting laboratories to participate in this trial

important issues to be considered are: cost, sensitivity, specificity, ease of use of the tests.

- **Summary of major assays for the immunodiagnosis of schistosomiasis**

| Ref | Method | Antigen | PROS | CONS |
|---|---|---|---|---|
| **Antibody detection assays:** | | | | |
| 1 | IFA | AW | Good sensitivity (85% with egg + cases) | No relationship between titer and onset or severity |
| 2, 17 | IFA | GASP/CCA | Light infection detectable, high sensitivity and specificity | |
| 2 | RIA** | PSAP | Correlation with egg counts acute patients predominantly IgM | Radioactive isotopes |
| 3 | RIP** | AW | Acute serum has bands: 55,52,35kd | Requires technical expertise and radioactive isotopes |
| 4* | COPT | EGG | 80% sensitive/97% specific | Low level infection not detectable |
| 4* | ELISA | SEA | 83% sensitive/94% specific | Low level infection not detectable |
| 4*, 4a | ELISA | CEF6 | 92% sensitive/95% specific | |
| 5, 10-12 | Fast-ELISA, EITB | MAMA (adult worm antigens) | Quantitative, 96% sensitive/99% specific, species specific for *S. mansoni* | |

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| 5, 10-12 | Fast-ELISA, EITB | JAMA (adult worm antigens) | Quantitative, 96% sensitive/99% specific, species specific for S. japonicum | |
| 5, 10-12 | Fast-ELISA, EITB | HAMA (adult worm antigens) | Quantitative, 96% sensitive/99% specific, species specific for S. haematobium | |
| 6 | WB | Sm31/32 | 99% Sensitivity/99% specific | |
| 13, 14 | APIA | Alkaline Phosphatase Antibody | Can be used as complementary test to egg examination | Require special algorithms for diagnostic determination |
| 15 | IEP | AW | Good sensitivity (80% with egg + cases | No relationship between titer and onset or severity |
| 16 | Dipstick | Gp30 (S.mansoni) Gp23 (S.haematobiu m) | Qualitative, genus and/or species specific with >98% sensitivity and specificity | Field applicable, multiple steps require minimum expertise, can be transported at room temperature with easy to read output |
| **Antigen detection assays:** | | | | |
| 7, 8 | ELISA | CAA(serum) | Correlation with egg count; 98% specificity, shows less fluctuation than egg output | Sensitivity depending on worm burden; detects 10 pg/ml serum |
| 9 | ELISA | CCA(urine) | Correlation with egg count; 98% specificity | Sensitivity depending on worm burden |

\* Adult worm antigens were better than egg antigens for detecting low level infections (<100 eggs/g); egg antigens typically detect only 65-85% (7 assays tested). AW assays (n=14) ranged from 55-91%.
\*\* Not performed routinely

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## Control in low transmission areas

It has been demonstrated, in a number of formerly heavy burden countries, that sustained control efforts, based on regular chemotherapy, have resulted in significant reductions in morbidity and mortality. When disease is no longer a public health issue, and the endemic level has sufficiently decreased, new objectives may need to be defined in terms of possible elimination. In turn this will lead to new approaches and algorithms defined according to local situations.

Where elimination is aimed for, detection and treatment of all infected people should be the first goal. As the parasite reservoir decreases, focusing on sustainable transmission control (hygiene and sanitation improvement, environmental snail control) should become the major consideration. This will decrease the risk of resurgence of schistosomiasis as well as contribute to the improvement of the general health of the population.

Globally, three different operational scenarios have been identified:

1.      low endemic level reached due to control pressure, but where transmission is still present;

2.      low endemic level, but with persistent transmission potential, and therefore a significant risk of re-emergence due to population movements and/or environmental change;

3.      low endemic level, but with low or zero transmission potential, and therefore a low risk of re-emergence.

In these situations, commonly used clinical and parasitologic diagnostic procedures may lack sensitivity for case detection and surveillance, and should be reinforced by more sensitive diagnostic techniques. Algorithms must change to incorporate more sensitive high throughput and inexpensive modern technologies.

With regard to transmission control, in addition to chemotherapy and health education, the following priorities have been identified: (i) water supply and sanitation, with improved hygienic behaviour; (ii) environmental management; and (iii) focal snail control where required.

Each country has a unique situation which must be taken into consideration on a case by case basis. Where they occur, zoonotic reservoirs must be taken into consideration in control efforts (*S. japonicum* and *S. mekongi* in general; and *S. mansoni* in a few documented situations).

In scenarios 1 and 2, more cost-effective use of resources may be obtained by the central authorities delegating implementation of control to the regional authorities. Thus more reliance on established health and education resources will be required, and transfer of expertise and training is essential. Integration of schistosomiasis control with services dealing with hygiene and hygiene-related diseases will result in synergistic improvements

of the public health, and particularly if combined with the introduction of novel, highly-sensitive assays, may enhance motivation of the control workers.
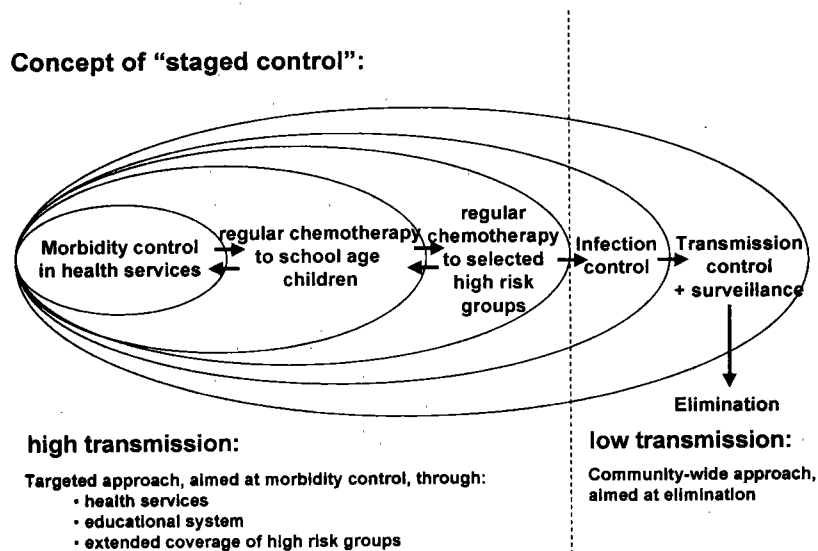
In scenarios 2 and 3, surveillance and preparedness become extremely important. Surveillance should be adapted to suit the local situation. A sound data management and reporting system is essential. Surveillance should ideally be implemented through existing structures such as health services, complemented by surveys in populations at high risk. Planning and management should be flexible, so that operational decisions will be based on sound geographical knowledge of high-risk areas.

Surveillance for schistosomiasis should also be integrated with the surveillance of other diseases, complemented by more general information such as demographic and environmental data, and also indicators of hygiene and social behaviour. The analysis of local Geographical Information System (GIS) data may reveal disease clustering, and be useful for determining local integrated control and surveillance measures.

Surveillance should only be eased as the risk of resurgence is demonstrated to have diminished. Snail information is essential to indicate the potential for resurgence.

Operational research should be promoted to adapt control and surveillance to particular local conditions, and to allow for changing situations.

**Concept of "staged control":**



**high transmission:**

Targeted approach, aimed at morbidity control, through:
- health services
- educational system
- extended coverage of high risk groups

**low transmission:**

Community-wide approach, aimed at elimination

## Criteria for elimination

Schistosomiasis is currently not considered as a disease which is globally targeted for eradication or elimination and thus WHO has not established a standardized Certification Process which would involve the setting up of an International Commission, and the definition of standardized criteria to certify that schistosomiasis is no longer endemic in a country or area. Indeed, the fact that asymptomatic cases of schistosomiasis are common and that for certain schistosome species an animal reservoir exists would make the definition of criteria for elimination a complex issue.

Also, interruption of transmission may be reached in different ways: by the elimination of the parasite reservoir, by the elimination of the snail intermediate host (e.g. through the use of competitor snails), by an improvement in socio-economic status and hygiene so that contamination and infective water contact does not occur any more, or by a combination of these scenarios. The issue is further complicated by the risk of re-introduction of the disease in an area where it was previously eliminated, particularly where water resource development and/or migration occurs.

A possible way for individual countries to demonstrate that schistosomiasis has been eliminated from their territory is to document that no new, locally contracted (human and animal) infections were observed over an appropriate time period. The observation period, during which no cases should be detected in order confidently to declare that transmission has been interrupted, depends very much on the risk of re-emergence or re-introduction in a particular context. The degree of certainty that no new cases were detected also depends very much on the performance of the surveillance system, in terms of sensitivity of the diagnostic method used, and the operational performance of the reporting system.

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