WHO Technical Report Series

830

THE CONTROL OF SCHISTOSOMIASIS

Second report of the
WHO Expert Committee

World Health Organization

Geneva 1993

WHO Library Cataloguing in Publication Data

WHO Expert Committee on the Control of Schistosomiasis
The control of schistosomiasis : second report of the WHO Expert Committee.

(WHO technical report series ; 830)

1. Schistosomiasis – prevention & control I. Title II. Series

ISBN 92 4 120830 9 (NLM Classification: WC 810)
ISSN 0512-3054

Printed in Switzerland
92/9367 – Benteli – 7000

Contents

WHO Expert Committee on the Control of Schistosomiasis

Geneva, 8–15 November 1991

Members

Professor F. Abdel-Wahab, Tropical Medicine Department, Cairo University, Cairo, Egypt

Dr M. Amin, Health Affairs, Ministry of Health, Gizan Province, Saudi Arabia

Dr F. Arfaa, Danville, CA, USA

Dr B. Blas, Schistosomiasis Control and Research Service, Department of Health, Manila, Philippines (*Vice-Chairman*)

Dr Chen Ming Gang, Institute of Parasitic Diseases, Chinese Academy of Preventive Medicine, Shanghai, China

Dr T. A. El-Khoby, Director General, Department of Endemic Diseases, Ministry of Health, Cairo, Egypt

Dr P. Jordan, Ware, Herts., England

Professor A.B.O. Oyediran, Department of Preventive and Social Medicine, University of Ibadan, Ibadan, Nigeria (*Rapporteur*)

Dr M. A. S. Porto, National Foundation of Health, Ministry of Health, João Pessoa, Paraíba, Brazil

Dr L. Rey, Oswaldo Cruz Foundation, Rio de Janeiro, Brazil (*Chairman*)

Dr B. Sellin, Centre de Recherche sur les Meningites et les Schistosomiases, Organisation de Coordination et de Coopération pour la Lutte contre les grandes Endémies, Niamey, Niger

Professor F. Von Lichtenberg, Department of Pathology, Harvard Medical School, Boston, MA, USA

Representatives of other organizations

United Nations Development Programme/World Bank

Dr P. Taylor, Training Centre for Water and Sanitation, University of Zimbabwe, Harare, Zimbabwe

Secretariat

Dr N.R. Bergquist, Secretary, Steering Committee of the Scientific Working Group on Schistosomiasis, UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases, WHO, Geneva, Switzerland

Mr R. Bos, Secretary, Joint WHO/FAO/UNEP/UNCHS Panel of Experts on Environmental Management for Vector Control (PEEM), WHO, Geneva, Switzerland

Dr J. Cook, Tropical Diseases Research Program, Edna McConnell Clark Foundation, New York, NY, USA (*Temporary Adviser*)

Dr B. Gryseels, Department of Parasitology and Tropical Medicine, University of Leiden, Leiden, Netherlands (*Temporary Adviser*)

Dr R. Korte, Division of Health, Population and Nutrition, German Agency for Technical Cooperation (GTZ), Eschborn, Germany (*Temporary Adviser*)

Mr M. Laaziri, Chief, Planning Division, Ministry of Health, Rabat, Morocco (*Temporary Adviser*)

Dr K. E. Mott, Chief, Schistosomiasis Control, Division of Control of Tropical Diseases, WHO, Geneva, Switzerland (*Secretary*)

1. Introduction

The WHO Expert Committee on the Control of Schistosomiasis met in Geneva from 8 to 15 November 1991. Dr R.H.Henderson, Assistant Director-General, opened the meeting on behalf of the Director-General.

At its meeting in 1984, the Committee endorsed a strategy for the control of morbidity due to schistosomiasis (*1*). Over the past seven years this strategy has proved to be both feasible and effective. WHO has placed increased emphasis on the role of health education and safe and adequate domestic water supplies, as well as sanitation, in the maintenance of control of schistosomiasis, and some governments have given priority to programmes for the installation of safe and protected water supplies to help control the disease.

Experience is now demonstrating that the control of schistosomiasis is optimal when specific control tasks are carried out within the primary health care system. Although the integration process is slow, a growing number of countries are adopting this approach as an essential part of health care.

Schistosomiasis control requires a long-term commitment. While the prevalence of schistosomiasis can be reduced in the short term, long-term planning over at least 10–20 years, depending on a country's level of socioeconomic development, is required if adequate surveillance and control are to be maintained.

Schistosomiasis continues to be a major health problem where water resources are being developed, particularly in small reservoirs and irrigation systems, and planning directed towards control of the disease in these situations is often inadequate. Those responsible for development can now introduce effective control measures to reduce and even eliminate the risk of schistosomiasis.

Since the Committee's meeting in 1984 (*1*), two more countries have notified WHO of the presence of schistosomiasis within their national boundaries and, owing to changes in political boundaries, 74 countries and territories are now considered to be endemic for the disease. Moreover, environmental degradation associated with water resources development and the movement of people because of civil strife have created new foci of transmission. Nevertheless, for the first time, a country previously endemic for the disease has requested WHO to consider criteria for achieving eradication.

Despite cautious optimism owing to the success of large-scale control programmes, economic constraints in developing countries impair the realization of the full potential of current approaches to control.

The Director-General of WHO, Dr Hiroshi Nakajima, has stated: "We now know that the disease is preventable and curable. A new alliance is needed, whereby the international organizations, governments and the private sector join together to control this disease." In its report, the Expert

Committee analyses the various successes and failures of the past seven years, and emphasizes how the strategy for the control of schistosomiasis can be implemented flexibly within locally available systems for the delivery of health care. No single solution applies to all situations; this report therefore aims to present various options for control appropriate to the different health and development objectives of individual countries where the disease is endemic.

2. The basis of the strategy for control of schistosomiasis

Experience has shown that the strategy for control of morbidity endorsed by the Committee in 1984 is both feasible and effective (*1*). Each country must define its own goals for the control of schistosomiasis depending upon its resources and capabilities. Where appropriate, the components of control are health education, chemotherapy, provision of water supply and sanitation, and snail control. The optimal balance between these components for the most cost-effective strategy will differ from one country to another, as well as over time.

Cost will always influence the development of control strategies, for example by limiting the use of chemotherapy in some countries. Chemotherapy plays a central role in any strategy of control and will dramatically reduce morbidity in the short term. Transmission of schistosomiasis will depend on how rigorously chemotherapy can be applied as well as on epidemiological factors. In order to achieve a sustainable reduction in transmission, health education, attention to water supply and sanitation, environmental management and, where appropriate, snail control need to be part of the strategy from the very start. The implementation of control measures at the primary health care level is also a prerequisite for achieving sustainable benefits.

The following six factors should be considered when developing schistosomiasis control strategies for specific countries:

- the felt needs of the community;
- the type(s) of schistosomiasis present, the prevalence and intensity of infection, and the prevalence and severity of morbidity;
- ecological, environmental and epidemiological characteristics;
- the accessibility of primary health care;
- the capacity for central and district management and technical support;
- the strength of intersectoral coordination.

3. Public health significance of schistosomiasis

The public health significance of schistosomiasis is often underestimated for two reasons. First, like all helminthic infections, the distribution of worms in any community is widespread but uneven, i.e. few have heavy

infections and severe disease, while many have lighter infections and fewer symptoms. Some people with very few worms may have no symptoms. Secondly, severe disease usually follows after many years of silent or mildly symptomatic infection. Even if only 10% of those infected with schistosomiasis have severe clinical disease, this still represents 20 million seriously ill people. Of the remaining 180 million infected people, an estimated 50-60% also have symptoms – a public health problem of enormous proportions. The impact on public health can be assessed in terms of the frequency and severity of schistosomiasis-related disease, incapacity and premature death.

Children of school age have been identified as the target group for intervention since the WHO Expert Committee on Bilharziasis first met in 1953 (*2*). In recent years, the detrimental effects of schistosomiasis on the growth and development of children of school age have been further documented (*3*). Many health programmes in developing countries have given emphasis to the improvement of health in early childhood, setting specific targets for the reduction of infant mortality and morbidity. The health problems of children of school age, who are often affected by schistosomiasis and other parasitic diseases, have sometimes been neglected by comparison, yet represent a challenge of public health importance. The benefits of treating schistosomiasis in programmes directed to improving nutritional status have recently been emphasized in a United Nations report (*4*).

The public health impact is most obvious in the case of *Schistosoma haematobium* infection: up to 80% of infected children have symptoms and signs of disease with dysuria or haematuria or both. Severe disease usually occurs later in life as the result of damage to the urinary tract caused by fibrosis and scarring. Hydroureter and hydronephrosis may lead to renal damage with subsequent kidney failure and death in a small number of cases. There is also a clear association between *S. haematobium* infection and squamous cell carcinoma of the bladder.

The degree of morbidity is related both to the intensity and to the total duration of *S. haematobium* infection. The intensity of infection, as measured by the urinary excretion of *S. haematobium* eggs, increases during childhood but characteristically diminishes in adulthood. If intensity of infection is plotted against a patient's age, the calculated area under the curve is relevant in predicting the degree of morbidity, which may be life-threatening, resulting from infection with *S. haematobium.*

The control of urinary schistosomiasis is directed in particular to the treatment of school-age children in order to shorten the duration of heavy infections. In the long term, treatment of urinary schistosomiasis is an important measure for preventing carcinoma of the bladder (*5*).

In *S. mansoni* infection, most patients will have intestinal signs and symptoms – colicky abdominal pain, diarrhoea and blood in the stools. In the chronic severe form of this disease, seen more often after 20 years of

age, scarring and fibrosis result in enlargement of the liver and spleen. The ensuing portal hypertension is the cause of death from massive haematemesis from oesophageal varices. Control of intestinal schistosomiasis must be directed at reducing the intensity of infection, particularly in childhood, in order to reduce the risk of severe disease.

Acute disease, or Katayama fever, usually associated with *S. japonicum* infection, is growing in public health significance. Such disease is also caused by other species of *Schistosoma*, especially in urban areas where transmission is spreading. Patients with severe acute schistosomiasis may require admission to hospital for diagnosis and treatment.

S. japonicum infection is similar to *S. mansoni* in causing intestinal lesions and hepatic fibrosis. Enlargement of the liver and spleen is similar to that caused by *S. mansoni* infection, but is seen in all age groups and is more severe. Blood loss resulting from ruptured oesophageal varices is the major cause of death. The clinical manifestations of *S. mekongi* infection are similar to those caused by *S. japonicum*. *S. japonicum* infection may also cause disease of the central nervous system with seizures.

Strategy of control

4. The status of control

In theory, every country with endemic schistosomiasis could initiate specific public health and intersectoral activities directed towards control of the disease. In practice, the major challenge over the next decade will be to promote the development of strategies with feasible objectives in those countries without active control programmes. The Committee considered that such strategies should focus on:

- school-age children in all endemic areas, who should be the major target for chemotherapy;
- flexibility of delivery of health care, based on integration of efforts within the health sector, particularly between primary health care and specialized disease control services;
- intersectoral efforts, emphasizing school education, safe water supply and sanitation, environmental management and community participation.

The key determinants of the selection of the strategy will be the availability of resources and a functional peripheral health care system.

4.1 Countries without schistosomiasis control

Some endemic countries have not initiated control of schistosomiasis. In these countries the disease is only one among many health problems, the available health staff is often limited, and the total per capita expenditure for health is usually low. Nevertheless, there are interventions that can be

undertaken within the health sector and through other sectors to combat schistosomiasis.

The available data on schistosomiasis from the ministry of health, national research institutions, and the scientific literature will provide a basis for estimating the geographical distribution of the disease.

Within all programmes to strengthen health services, the provision of drugs for the treatment of schistosomiasis and basic laboratory facilities can be considered. In the long term, only effective community-based health services can ensure successful implementation and maintenance of control.

In countries with high morbidity due to schistosomiasis, but without the financial resources to initiate even minimal interventions for disease control, WHO could have a role in coordinating a collective international effort to support control.

4.1.1 *Countries with limited peripheral health services*

In countries without effective primary health care, coordination with other sectors – education, agriculture and water resources – could help to promote prevention and mitigate some of the effects of schistosomiasis. In poorer countries, agricultural and water resources development often have high economic priority, and present opportunities to achieve control by improving basic services in the communities at risk.

Where the incidence and prevalence of haematuria are high among school-age children, the objective of reducing morbidity would be feasible in areas where urinary schistosomiasis is endemic. From the beginning, primary health care programmes would include training in identification of infected persons, and antischistosomal drugs would be on the list of essential drugs. Economically important areas of agriculture and water development should be priority targets for control.

4.1.2 *Countries with peripheral health services*

In countries with an operational primary health care system there are many opportunities for inclusion of schistosomiasis control activities. In areas where urinary schistosomiasis is endemic, primary health care workers can be trained to identify infected persons. At the village level, primary health care workers can promote health education and personal hygiene, creating awareness of the need for protected water supplies and sanitation.

Intervention is possible where the high prevalence and morbidity of schistosomiasis are confined to limited areas. Means should be explored of identifying the extent of the problem and of intervening in order to prevent the disease and mitigate its effects, with the support of development agencies in collaboration with ministries of health. The peripheral health services may be strengthened through (a) the provision of drugs for the treatment of clinical cases, and (b) treatment of high-risk groups, e.g. schoolchildren or irrigation workers.

In areas where the prevalence and morbidity of schistosomiasis are low, diagnosis and treatment of clinical cases may be sufficient to maintain these low levels. Control of transmission can be considered if resources are available and technical support can be provided. Monitoring of the potential introduction, spread or aggravation of schistosomiasis in areas of water resources development is recommended.

4.2 Countries with limited control activities

In the past 10 years many small-scale control projects have been supported by national, bilateral and multinational organizations. In particular, the UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases has given high priority to this type of project. Based on the experience of these local pilot programmes, in collaboration with national investigators, a national or regional plan of action can be elaborated.

4.2.1 *Countries with local pilot control programmes*

Local pilot control programmes, which have been planned and integrated with health services, will facilitate the transition to regional or national control programmes.

The efficiency of the primary health care system will determine whether control can be extended beyond the pilot schemes. In Zanzibar, for example, a local pilot programme provided the basis for an island-wide control programme (*6*). Schistosomiasis control has sometimes been a catalyst for the strengthening of evolving primary health care systems.

4.2.2 *Countries with national or regional control plans yet to be implemented*

An important challenge exists in countries that have recognized schistosomiasis control as a priority with national plans of action. The main constraints are lack of financial support and trained personnel to implement control. Countries in this situation may decide to initiate control with available resources in areas of priority for economic development or with high morbidity from the disease. Immediate action can be taken through linkage with other development activities concerned with water supplies, sanitation and water resources development. The provision of drugs through the health service for the treatment of clinical cases is a basic requirement for the control of morbidity.

4.3 Countries with national control programmes

The reduction in the incidence and prevalence of severe clinical forms of schistosomiasis being achieved in most countries with national control programmes is encouraging. The current operational challenges for these programmes are coordination with other sectors and integration with the primary health care system for the detection and treatment of patients.

In all these countries, the potential for further reduction of prevalence and

morbidity will be in jeopardy if surveillance and maintenance of intervention are not continued and adapted to changing epidemiological, social and economic conditions. The focal nature of schistosomiasis becomes even more pronounced with the success of control using chemotherapy (*6*), and gives an opportunity to target intervention. However, analysis and presentation of data at the district, provincial, regional or national levels may not reflect the importance of focal changes. All national programmes must face the challenge of identifying problem areas and giving priority to action within those areas.

Epidemiological surveillance is the basis for targeting control programme activities. Consequently, the efficient collection, analysis and interpretation of epidemiological data at the peripheral level will facilitate appropriate and prompt intervention as well as the modification of approaches, as necessary.

National control programmes usually have an independent organizational and management structure. This financial and staffing independence creates a strong *esprit de corps* which militates against integration of control into the general health care services. However, economic realities as well as the essential role of maintenance through the health system dictate otherwise. Integration can be accomplished without a loss of flexibility of interventions for control or a reduction in the technical expertise necessary for all programmes.

Intersectoral cooperation can support the maintenance of control. Where priority is given to the development of agriculture and water resources there will be opportunities for improving the infrastructure, which will help to maintain control and reduce the risk of schistosomiasis.

In many countries there is now an increased emphasis on decentralized management for disease control. Thus local authorities manage financial and human resources at the local level. There is great potential for implementation of control at this level, but only if the supervision and training of personnel are adequate. One role of national programmes will be to promote training at the peripheral level of the health care system.

5. Selection of control strategies

In its assessment of the status of schistosomiasis control, the Committee noted that countries that had adopted strategies for morbidity control had met success in achieving this objective. It therefore recommended that the strategy of control of schistosomiasis should now be directed to a broad spectrum of goals rather than to one narrow goal.

Morbidity reduction should be the first objective. Subsequently, but not exclusive of morbidity control, reductions in both the intensity and the prevalence of infection in individuals are objectives as well as indices of the effectiveness of control. The elimination of transmission is the ultimate

goal for the strategy of control. None of these objectives is independent; all interventions to achieve any one objective will contribute to achievement of the others.

5.1 Priority ranking

In assessing priorities for the control of schistosomiasis, three basic situations can be distinguished:

1. In countries with a high prevalence of schistosomiasis where morbidity rates are high, such as Egypt or Sudan, schistosomiasis control is usually considered a national priority. Most of these countries now have well established control programmes.
2. In other countries, where schistosomiasis control is given less priority, the need for control has to be carefully balanced against other health priorities in the context of available resources. It has to be viewed in particular against the background of overall health policies as well as the infrastructure and quality of available health services. For countries with low health budgets it is difficult to reach consensus on national, regional or local control measures for schistosomiasis. However, since schistosomiasis is often very focal in nature, it is possible to direct policy decisions to specific areas and groups at risk (see section 9). The importance of schistosomiasis is often underestimated since aggregated reports from larger regions may not identify foci of high prevalence. In addition, the number of cases of schistosomiasis reported through the health service may be an underestimate since, if drugs are not available, even patients with significant symptoms may not seek treatment. The felt need of the community should be a major determinant when allocating priority.
3. The risk of schistosomiasis associated with water resources development projects should always receive high priority, starting at the early planning and design stages of the project and continuing throughout its implementation, management and evaluation. The required resources should be calculated as part of overall development and maintenance costs, especially concerning the provision of safe water and sanitation facilities. Such measures may be of benefit far beyond the control of schistosomiasis.

5.2 Epidemiology

Epidemiological factors must be considered in the assessment of a country's ability to undertake control. The epidemiology of schistosomiasis, within a particular ecosystem, involves the complex interrelationship between people and their environment. However, much epidemiological information is available that can help countries to implement effective control measures (*7, 8*).

5.2.1 *General aspects*

The population dynamics of schistosomes are complex and are not determined by simple proportional rules. Host-related factors, such as human behaviour and immunity, as well as ecological factors, such as density of snail populations and infection rates, determine the size and distribution of the parasite population in human communities, which will vary according to the level of endemicity. Consequently, a reduction of transmission by use of molluscicides will not automatically result in a proportional reduction of reinfection rates, particularly in areas with high rates of transmission.

In most endemic areas, the highest prevalence and intensity of infection are found in children between 5 and 15 years of age. Chronic morbidity may develop later, in adulthood, when egg counts may be lower or even zero. Susceptibility to severe disease varies between individuals, and is determined by the intensity of infection and to a lesser degree by immunogenetic factors. Mean egg counts are a useful indicator of morbidity at the community level, but in an individual the relation is weaker.

In areas of moderate or low transmission, the geographical distribution of the infection and of severe morbidity may be very localized. This may also be the case after control measures have been carried out in areas where the disease is highly endemic. Satisfactory control may be achieved in most villages, but the rate of (re)infection will still be high in the remaining few.

Despite widespread distribution of snails and frequent opportunities for human contact through water, high rates of transmission may occur at only a few sites. The identification of such sites may be possible only through the analysis of reinfection patterns after chemotherapy.

5.2.2 *Species-specific aspects*

Schistosomiasis is caused by several different *Schistosoma* species, each requiring a different approach to treatment and control. While the broad strategy of morbidity control is similar for all species, differences between them affect the implementation, management and follow-up of control. Health workers or schoolteachers can be trained to identify people with *S. haematobium* infection by noting the red or brownish discoloration of their urine or by using reagent strips to detect haematuria. For a variety of reasons, urine specimens can more easily be provided than stool samples. Regular reporting of rates of haematuria among people attending health centres can facilitate surveillance. Since reinfection rates are generally higher among children of school age, surveillance in schools may also be appropriate.

The morbidity due to *S. mansoni* and *S. intercalatum* is often limited to nonspecific intestinal or mild hepatosplenic involvement. The microscopic screening necessary to identify infection is labour-intensive and cannot easily be integrated into routine health care activities. Therefore, control

programmes have so far been largely limited to countries where severe morbidity occurs and in which the health care system is relatively well developed.

5.2.3 *Reinfection*

Although currently available drugs rapidly reduce morbidity and egg output, some treated patients continue to excrete a small number of eggs and are difficult to distinguish from patients who have been reinfected. In most endemic areas, and particularly in those with high rates of transmission where morbidity is high and control is most needed, reinfection of treated individuals is anticipated. In areas with low reinfection rates and adequate health care facilities, passive case detection and surveillance through health centres may be sufficient. In other areas, treatment may have to be repeated at regular intervals depending upon results. Reinfection is generally less frequent and less intense in adults than in children, owing to acquired immunity and lower levels of exposure, so retreatment should be directed principally towards younger people. The impact of retreatment on morbidity lasts longer than its impact on the prevalence and intensity of infection; thus, intervals between retreatment may also be longer than reinfection rates might imply.

5.2.4 *Natural habitats*

The natural habitats of the snail intermediate host are usually widely dispersed but localized foci of high rates of transmission may occur. The level of transmission varies widely according to the physical characteristics of the surface water, ranging from static to flowing and from small streams to the largest lakes of Africa and Asia.

5.2.5 *Man-made lakes*

There are many examples from all over the world of the introduction or spread of schistosomiasis as the result of development of man-made water resources (*8*).

According to the International Commission on Large Dams (*9*), between 1951 and 1986 the annual rate of construction of large dams increased from 209 to 357; a large part of this development is taking place on the African continent. In Zimbabwe alone, a total of 101 large dams were constructed up to 1988. New impoundments have been proposed in Algeria, Côte d'Ivoire, Ghana, Morocco and Nigeria. In the Americas the number of man-made lakes is continuously increasing, particularly in Brazil and Venezuela. During the past decade in Asia, 206 large dams were constructed in India, 21 in Indonesia, 22 in Malaysia and 83 in Thailand (*8*).

The risk to health increases as a result of the construction of so many dams with the increased presence of waterborne and other endemic diseases, such as malaria, schistosomiasis and filariasis. The risk of disease in these areas will further increase as the result of uncontrolled immigration,

urbanization and the movement of refugees. It may be difficult to prevent the introduction of schistosomiasis in such conditions and close epidemiological surveillance and adequate health services should be provided.

The populations of both *Bulinus* and *Biomphalaria* snails increased considerably two years after completion of two dams in Côte d'Ivoire, and both urinary and intestinal schistosomiasis were detected among local children and migrants.

In Ghana, construction of a dam on the river Volta created the world's largest man-made water impoundment. As a result, the prevalence of *S. haematobium* infection, which was 5-10% in the Volta basin before construction, increased to 90% in the same area. There is also a high prevalence of schistosomiasis around large dams in Nigeria, Senegal, Sierra Leone, the United Republic of Tanzania and Zimbabwe. The risk of schistosomiasis near the Maareh Dam in Yemen was confirmed in 1990, when both *Bulinus* and *Biomphalaria* snails appeared in the reservoir.

5.2.6 *Irrigation*

The global area under surface irrigation continues to expand, although less rapidly than was foreseen at the start of the 1980s. Development policies in Africa and Latin America give prominence to irrigation schemes in order to increase food production and safety and reduce imports. By 1984, 18 African and Latin American countries were irrigating a total area of 25 320 000 ha. Between 1974 and 1984 the rate of irrigation expansion in Madagascar, Mali and Nigeria exceeded 100% and vast irrigated areas have been developed in Brazil, China, Indonesia, Malaysia, the Philippines and Thailand. These areas are potential sites for colonization by the snail intermediate hosts for schistosomiasis.

There are many examples of increased transmission of schistosomiasis as a result of irrigation (*8*), the most dramatic being found along the Nile Valley in Egypt and Sudan. The development of irrigation schemes in northern Cameroon resulted in an increase in the prevalence of urinary schistosomiasis, rising from 15% in 1950 to 30% in the early 1960s and up to 40% more recently.

Three important aspects of irrigation that determine schistosomiasis epidemiology are the type of irrigation, the selection of crops, and the operation and maintenance of a scheme. In connection with these, three current trends are of relevance to health:

1. The increasing use of more sophisticated irrigation techniques (e.g. overhead, drip irrigation) that reduce the risk of schistosomiasis transmission associated with traditional surface irrigation. The higher cost of these techniques may be offset against the benefit to health resulting from their use.
2. In areas where irrigated rice is an important food crop, the trend towards multiple cropping, alternate cropping systems (spacing rice

with other crops) and alternative crops (replacing rice with other food crops). Such practices tend to reduce the snail habitat areas and contribute to reducing the risk of transmission.

3. The shift from building new irrigation schemes towards the rehabilitation and modernization of existing schemes in countries where there is a shortage of irrigable land. This process provides a good opportunity to include health promotional measures.

5.2.7 *Small reservoirs*

Many small reservoirs have been constructed in developing countries during the past decade. Many were built as the result of community initiatives, often with the support of nongovernmental organizations or bilateral assistance. There are probably many more small dams than other types of dam, but information on them is scarce. The human and animal contact with water in these small impoundments is usually high, creating ideal conditions for the transmission of vector-borne diseases.

In Nigeria and Zimbabwe, the surface area of these impoundments has been estimated to be 8 to 10 times that of the large reservoirs in those countries. In Mali, the construction of some village dams provided a constant source of water, but resulted in an increase in the prevalence of urinary schistosomiasis.

In Cameroon, in addition to the construction of other dams, over 100 small artificial lakes have been constructed in the past decade. The impact of these developments has been considerable in increasing the prevalence of schistosomiasis, onchocerciasis, dracunculiasis and malaria. In response to population pressure and seasonal hunger in Ghana, between 1958 and 1960, 104 small dams were constructed in the north-east of the country. As a result, the prevalence of *S. haematobium* infection in the local populations has tripled, from 17% to 51% in 38 survey areas. Known as "red water", indicating blood loss in the urine, the disease reached a prevalence of 70% in some areas (*8*). The prevalence of urinary schistosomiasis in Mali was found to be five times as high in villages with small dams (67%) as in savanna villages (13%). Intestinal schistosomiasis showed a similar pattern.

In WHO's Eastern Mediterranean Region, particularly in Saudi Arabia, many small dam reservoirs are infested with the snail hosts of both urinary and intestinal schistosomiasis. In any one area, infestation of small ponds with *Biomphalaria arabica* has been followed by *S. mansoni* infection among the inhabitants.

5.2.8 *Aquaculture and fisheries*

Schisostomiasis can be an occupational hazard of freshwater fish farming in countries where the disease is endemic. Fish-ponds are often the habitat of the snail intermediate hosts of *S. haematobium* and *S. mansoni.* On the other hand, the construction of fish-ponds to stabilize water levels is a means of eliminating the amphibious *Oncomelania* snails in areas endemic for *S. japonicum.*

Little is known about the public health implications of aquaculture in relation to schistosomiasis. However, in one example, in Nyanza Province of Kenya, some 10 000 fish-ponds were dug with the aim of increasing fish production. As a result there was a considerable increase in the number of mosquitos transmitting malaria and the prevalence of *S. haematobium* infection exceeded 30% among schoolchildren in some villages near these ponds (*8*).

5.2.9 *Urban schistosomiasis*

In some countries where schistosomiasis is endemic, nearly 40% of the population can be considered to be urban. Transmission of schistosomiasis is now recognized in major metropolitan areas of north-eastern Brazil, west-central Africa and central China. Facilities for diagnosis and treatment in many urban areas are inadequate or nonexistent, and the introduction and spread of schistosomiasis in these communities continue (*10*).

Women and children are at highest risk of infection in periurban areas where natural water bodies are the sources of water for domestic and recreational purposes. When rural migrants with a high prevalence of schistosomiasis move into a periurban area there is a high risk of disease transmission owing to the contamination of natural water bodies that results from poor sanitation, inadequate sewage/refuse disposal, overcrowding and unsound personal hygiene practices.

Schistosomiasis is also related to the employment pattern in periurban areas. The small irrigated vegetable gardens, which provide food for city dwellers, offer ready employment to the rural migrant who may have been a farmer. However, schistosomiasis is often endemic in these areas, and the worker, if not already infected, will be at risk for the disease.

5.2.10 *Refugees*

The patterns of migration of refugees have significant impact on the distribution, transmission and control of schistosomiasis. Many refugees settle in rural and periurban areas where serious health problems may arise. For example, *S. mansoni* was recently introduced into north-west Somalia by refugees coming from Ethiopia. In one refugee camp where transmission of *S. mansoni* was occurring, 72% of its population of 27 000 were found to be infected. When inhabitants of the Ogaden region of Ethiopia, where no *S. haematobium* was found, migrated to the southern part of Somalia, 30% became infected with *S. haematobium*.

5.3 Situation analysis

5.3.1 *Global distribution*

The global estimate of 200 million people infected with schistosomiasis of a total 600 million at risk has not changed since the Committee's last meeting in 1984, despite the success of control programmes, largely

because population growth is continuing in developing countries where the disease is endemic (*11*).

Throughout the world, schistosomiasis is now endemic in 74 countries and territories (Table 1, Figs 1 and 2). *S. haematobium* is endemic in 54 countries, mainly in Africa and the eastern Mediterranean; *S. mansoni* is endemic in 52 countries and territories of South America, the Caribbean, Africa, and the eastern Mediterranean; and in 41 countries of Africa and the eastern Mediterranean, both parasites are present. *S. intercalatum* has

Table 1
Geographical distribution of schistosomiasis by species

Country or area (by WHO region)	*S. mansoni*	*S. haematobium*	*S. intercalatum*
African Region			
Algeria		+	
Angola	+	+	
Benin	+	+	
Botswana	+	+	
Burkina Faso	+	+	
Burundi	+		
Cameroon	+	+	+
Central African Republic	+	+	+[a]
Chad	+	+	+[a]
Congo	+	+	+[a]
Côte d'Ivoire	+	+	
Equatorial Guinea			+
Ethiopia	+	+	
Gabon	+	+	+
Gambia	+	+	
Ghana	+	+	
Guinea	+	+	
Guinea-Bissau	+	+	
Kenya	+	+	
Liberia	+	+	
Madagascar	+	+	
Malawi	+	+	
Mali	+	+	+[a]
Mauritania		+	
Mauritius		+	
Mozambique	+	+	
Namibia	+	+	
Niger	+	+	
Nigeria	+	+	+[a]
Rwanda	+		
Sao Tome and Principe		+[a]	+
Senegal	+	+	
Sierra Leone	+	+	
South Africa	+	+	
Swaziland	+	+	
Togo	+	+	
Uganda	+	+	

Country or area (by WHO region)	*S. mansoni*	*S. haematobium*	*S. intercalatum*
United Republic of Tanzania	+	+	
Zaire	+	+	+
Zambia	+	+	
Zimbabwe	+	+	
Region of the Americas			
Antigua	+		
Brazil	+		
Dominican Republic	+		
Guadeloupe	+		
Martinique	+		
Puerto Rico	+		
Saint Lucia	+		
Suriname	+		
Venezuela	+		
Eastern Mediterranean Region			
Egypt	+	+	
Iran, Islamic Republic of		+	
Iraq		+	
Jordan		+	
Lebanon		+	
Libyan Arab Jamahiriya	+	+	
Morocco		+	
Oman	+	+	
Saudi Arabia	+	+	
Somalia	+	+	
Sudan	+	+	
Syrian Arab Republic		+	
Tunisia[b]		+	
Yemen	+	+	
European Region			
Turkey		+	
South-East Asia Region			
India		+	
Indonesia	*S. japonicum*		
Thailand	*S. japonicum*		
Western Pacific Region			
Cambodia	*S. mekongi*		
China	*S. japonicum*		
Japan[b]	*S. japonicum*		
Lao People's Democratic Republic	*S. mekongi*		
Malaysia	*S. malayensis*		
Philippines	*S. japonicum*		

[a] Confirmation required.

[b] No recent transmission: Japan, Tunisia.

Figure 1
Global distribution of schistosomiasis due to *Schistosoma haematobium, S.japonicum* and *S.mekongi*

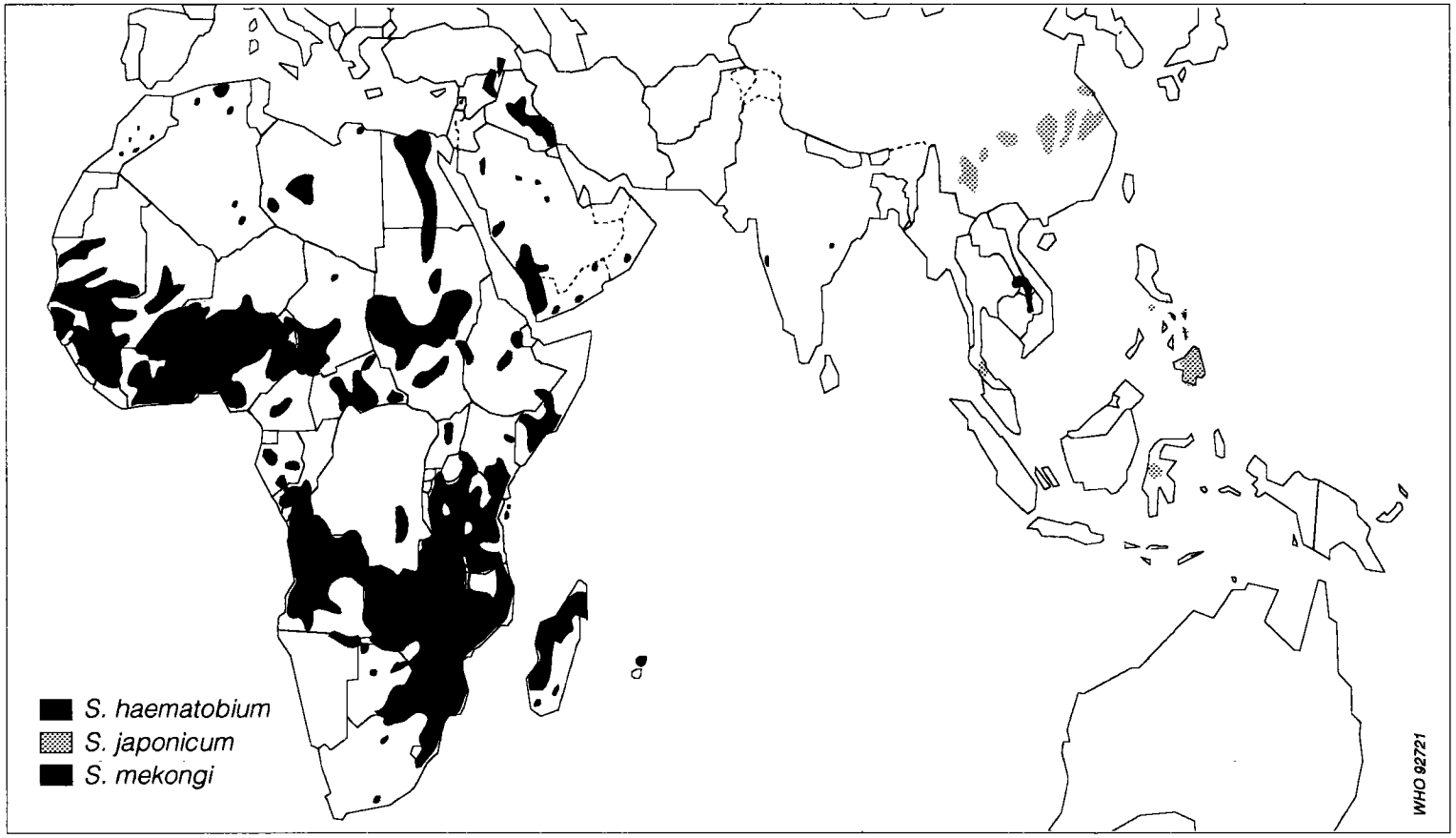
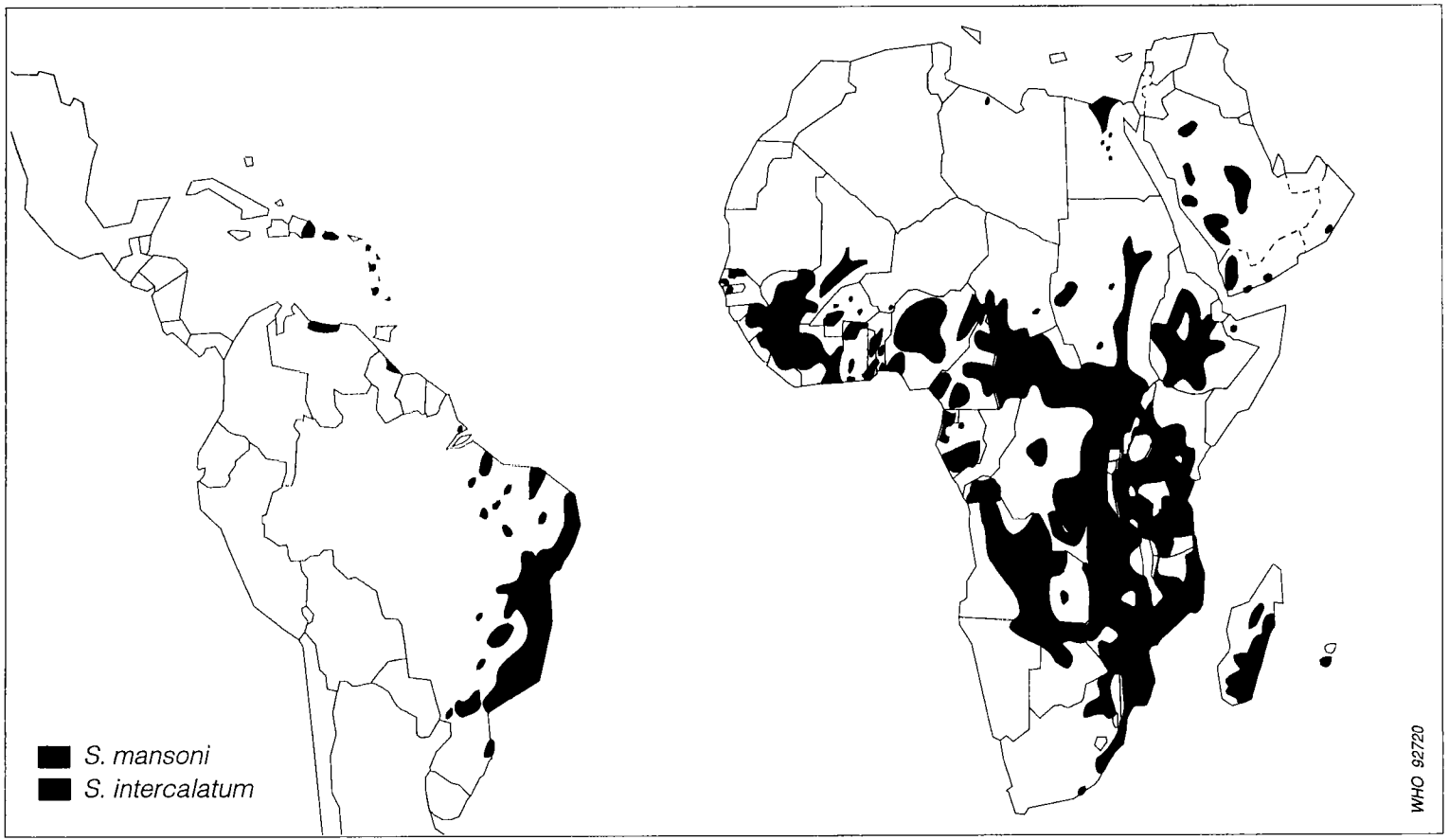


Figure 2
Global distribution of schistosomiasis due to *Schistosoma mansoni* and *S. intercalatum*



been reported from 10 countries – all, except Equatorial Guinea, with *S. mansoni* and/or *S. haematobium* as well. Either *S. japonicum* or *S. mekongi* has been reported from 7 south-east Asian and western Pacific countries. In Malaysia, a schistosome infecting humans and related to *S. mekongi* has been designated *S. malayensis.*

There are other areas, such as French Guiana and Haiti, with the potential for transmission, where human infection has not been reported. Since 1984, autochthonous cases of urinary schistosomiasis have occurred in Jordan.

In India, Lebanon, Oman, and Sao Tome and Principe, *S. haematobium* has been reported, but knowledge of the extent of the endemic areas, the distribution of the snail intermediate host and the epidemiology of the disease is lacking. Since 1980, *S. mansoni* has been found for the first time in Niger and Somalia. In Japan and Montserrat, schistosomiasis has been eradicated.

In Brazil, China, Egypt, Morocco, the Philippines, the Sudan and Venezuela, schistosomiasis has been given priority in national health programmes and the implementation of control is fully supported. All these programmes, which are periodically evaluated, have attempted to control schistosomiasis throughout each country, except for the Sudan where control has been limited to the Gezira.

Schistosomiasis has some unusual epidemiological features in islands off the African continent, including Madagascar, Mauritius, Sao Tome and Principe, and Zanzibar, where *S. haematobium* is endemic with, in addition, *S. mansoni* in Madagascar. There is little immigration to the islands and internal migration patterns are well described. At least limited control measures are in operation in all these islands.

5.3.2 *Country distribution*

Within a given country, the distribution of schistosomiasis can vary widely (*7*). In some countries, almost the whole population is exposed to the infection, as in Egypt, where food production throughout almost the entire country depends upon irrigation by water from the Nile River.

In many other countries, the prevalence and severity of infection vary focally; for example, in Mali, scattered foci mostly of *S. haematobium* and, to a lesser extent, *S. mansoni* are found throughout almost the entire country. However, high infection rates and morbidity are found particularly in the Office du Niger and Dogon regions. In the first, a large rice and sugar-cane irrigation scheme is responsible for infection with both *S. mansoni* and *S. haematobium.* In the second, the construction of many small village dams has led to a rapid increase of *S. haematobium* infection.

5.3.3 *Local and national morbidity and mortality*

In most countries there are too few data to make an accurate assessment of morbidity due to schistosomiasis. Nevertheless, in order to assess the

effectiveness of schistosomiasis control, an objective evaluation of morbidity is essential. Such an evaluation should take place at national, regional and local levels since morbidity is often unevenly distributed.

High morbidity may be very localized. In Burundi, for example, morbidity increased significantly in villages where the prevalence of the disease was over 40%. In Kenya, areas of high morbidity have been described within the Machakos area where morbidity in most villages is low.

The occurrence of severe and chronic disease, where there is haematemesis or gross haematuria, can in principle be assessed from available health statistics. The occurrence of less specific morbidity, such as dysenteric syndromes, can be assessed from health statistics and related to schistosomiasis endemicity. Hospital data on admissions and surgical procedures and analysis of the origin of patients with severe disease can indicate areas of significant morbidity. Such data have shown an unexpectedly high frequency of portal hypertension in patients from endemic areas in Kenya and Zimbabwe.

The available data can be complemented by field surveys using relatively simple approaches, such as questionnaires recording haematuria, dysuria, bloody diarrhoea, and blood in stools. The increasing availability of portable ultrasound equipment will help to provide more accurate data on morbidity.

6. Adaptation of control approaches to national strategies

A control strategy for schistosomiasis can be developed for each endemic country by harmonizing the objectives, resources and managerial capacity of the ministry of health. These may be different at national, regional and local levels.

The approaches emphasized in a strategy for control of morbidity could be health education, diagnosis and treatment, and promotion of a safe water supply and sanitation. A strategy for control of transmission would also include these activities, together with snail control, environmental modification and expanded intersectoral coordination based on the needs of the community. The approaches within these strategies are neither independent nor limited to a single strategy; all of them, if optimally timed and managed, will both reduce morbidity and control transmission.

6.1 Health education, public information and communication

Health education aims to promote and reinforce healthy behaviour with full participation of both the individual and the community. Schistosomiasis could largely be prevented by changing human behaviour, and health education is of paramount importance to achieve this. The aim of health education in schistosomiasis is to help people understand that their own

behaviour – principally water use practices and indiscriminate urination and defecation, as well as failure to use available screening services or to comply with medical treatment – is a key factor in the transmission of the disease and its effects.

A health education programme will be more likely to succeed if it has clearly defined, quantifiable, and attainable objectives; if it is designed for a particular community; if it encourages the community to be involved in control measures and to accept responsibility for parts of the programme; and if it emphasizes positive action rather than prohibition of activities in an affected community. WHO has published a useful book to assist countries to develop health education programmes in schistosomiasis control (*12*).

Simple, inexpensive, culturally acceptable communication techniques that address the community's perceptions of the disease are likely to have the greatest impact, particularly if they are at a technical level that can be understood and taught by the members of the community. In countries where schistosomiasis is endemic public information can be disseminated through posters, films, the mass media, especially radio and television, community meetings, traditional communication channels like story-tellers or town criers, or individual counselling by health workers. In Egypt, several short (two-minute) health education films have been made featuring well known Egyptian actors. Since these have been shown regularly on national television, the number of children being examined annually has doubled. Health messages should be acceptable and feasible in practice, and where necessary should be supplemented by positive action (e.g. provision of concrete latrine slabs).

The schistosomiasis control programme could benefit from the expertise of a health educator from the outset to help develop community-based health education plans, involving all members of the control team. In schools, the increasing educational emphasis on the environment offers new opportunities to improve understanding about schistosomiasis through the training of school teachers. In countries where agricultural extension programmes are well developed, health issues can be included in environmental management education. Health education targeted at women's groups is likely to result in the rapid spread of knowledge about the disease within the community.

Community participation is essential in any schistosomiasis control programme. This could involve the community installing its own water supply, cooperation with health authorities to reduce contact with unsafe sources of water, or ensuring compliance with diagnostic and treatment schedules. Community participation helps to reduce costs and ensures the continuity and sustainability of control measures. Health workers who are established residents of a locality can more readily secure the support and cooperation of community leaders in mobilizing the community to participate in control.

Advocacy is an essential component of all health education strategies, and will enable technical and managerial staff, as well as political and funding authorities, to recognize health education as an important and integral part of schistosomiasis control programmes that should be adequately funded.

6.2 Diagnosis and treatment

The adequate diagnosis and treatment of patients with symptomatic schistosomiasis is the primary component of any morbidity control programme. In the short term, where the prevalence of schistosomiasis is high, population-based chemotherapy can reduce the prevalence, severity and morbidity of the disease. From the start, however, long-term operational and budgetary planning should be made for diagnostic facilities and retreatment schedules, as well as treatment throughout the health care system, and for transmission control.

6.2.1 *Hospitals*

The clinical management of patients with advanced disease usually takes place in a referral hospital. Patients with severe disease, such as hydronephrosis, haematemesis, acute infection with involvement of the central nervous system, and hepatosplenic disease with ascites, generally require hospitalization for accurate diagnosis and treatment. For the diagnosis of the severity of organ involvement, non-invasive ultrasound techniques are now available in many hospitals. In chronic disease, stool and urine examination may be negative. Several studies (e.g. *13*) have shown that even advanced lesions regress after treatment with praziquantel or oxamniquine.

6.2.2 *Peripheral health centres with diagnostic facilities*

In health centres with diagnostic facilities, microscopic parasitological confirmation of clinically suspected schistosomiasis is feasible. Parasitological examination requires trained staff using standardized techniques and reporting procedures, and local support services for supplies and equipment will need to be in place (*14*).

For identifying parasite eggs in urinary schistosomiasis, relatively simple sedimentation, centrifugation or filtration techniques can be used. For intestinal schistosomiasis, the direct faecal smear is not a very sensitive test; concentration techniques (such as sedimentation, formaldehyde-ether extraction, or Merthiolate-iodine-formaldehyde concentration (MIFC)) or the Kato (cellophane thick-smear) technique may be preferable for broader screening of intestinal helminths and protozoa.

The delivery of antischistosomal drugs must be assured throughout the health care system. The choice of drugs depends on the species of parasite and on financial and operational considerations. Praziquantel is the drug of choice for the *S. japonicum* group and for mixed infections. For *S. haematobium*, praziquantel or metrifonate can be used, but compliance

with the repeated doses of metrifonate must be ensured. For *S. mansoni* infection, praziquantel or oxamniquine in a single dose is effective.

6.2.3 *Peripheral health units without diagnostic facilities*

A presumptive diagnosis of urinary schistosomiasis can be made on the basis of clinical symptoms, such as haematuria, or the detection of haematuria using chemical reagent strips. Treatment of clinical cases and active case detection can be carried out at this peripheral level of the health system by appropriately trained health workers.

The management of schistosomiasis due to *S. mansoni* and *S. japonicum* is difficult without facilities for microscopy. Advanced hepatosplenic disease may be recognized clinically, but patients must be referred to hospital for further management; when this is not possible, treatment with anti-schistosomal drugs may be indicated. Patients with intestinal, particularly dysenteric, symptoms require investigation of differential diagnoses and thus referral is necessary.

6.2.4 *Treatment at the community level*

In areas with high morbidity, chemotherapy can be given by health workers at the community level in order to reduce quickly the prevalence and severity of infection. A decision to implement this strategy depends on the level of morbidity and the ability of the health services to purchase and administer the appropriate drugs. Schistosomiasis is a focal disease and it is possible to target such active intervention to specific localities or areas. Target communities can be identified on the basis of morbidity data from the health care service or from surveys. The community diagnosis of urinary schistosomiasis can be based on the frequency of haematuria. Disease caused by *S. mansoni* and *S. japonicum* infection can be recognized by the occurrence or frequency of severe symptoms of disease, such as haematemesis. The cause of less specific symptoms such as diarrhoea or blood in the stool is more difficult to elucidate.

The target groups for chemotherapy will depend upon infection and morbidity patterns as well as budgetary and operational feasibility. In many cases, schoolchildren will be the most easily accessible target group, and they generally belong also to the most heavily infected age group. However, in some areas school attendance rates are low, and precisely those children who do not attend school may be the most at risk of heavy infection. Severe chronic morbidity develops mainly in young adults. At the very least, accessible curative care should be provided for adults with the disease.

When the entire community is to be treated, there are considerable operational difficulties. Health workers or special teams have to visit the villages to inform the community, collect and process urine or stool samples, and give treatment. Detecting urinary schistosomiasis on the basis of gross haematuria or microscopic haematuria detected by reagent

strips is a rapid and reliable screening method. Microscopic examination of the stools is still the only reliable screening technique for *S. mansoni* and the *S. japonicum* group. The Kato technique, with various adaptations, is the most appropriate technique.

In areas with poorly developed peripheral diagnostic facilities, the capacity to treat on the basis of microscopic screening, particularly for *S. mansoni* and *S. japonicum*, may be limited. Where schistosomiasis is an important health problem and adequate epidemiological data are available, mass treatment may be feasible, but proper epidemiological follow-up and monitoring should be assured. High-risk target groups and communities can be identified and retreatment may be necessary only in children. This approach can only be effective if the development of primary health care diagnostic capacity is given high priority, as well as provision of a safe water supply, sanitation, snail control and other environmental measures. Follow-up strategies must be based on actual results and be as selective as possible.

6.3 Water supply and sanitation

The provision of safe and adequate water supplies and sanitation contributes to reducing the prevalence and severity of schistosomiasis (*15, 16*). Water supply and sanitation development agencies should consider this relationship in the establishment of programme priorities and the allocation of investment.

Safe water remains an important priority for most developing countries and demands a great deal of investment. Experience has shown that schistosomiasis control alone is unlikely to provide sufficient motivation for investment in water supply and sanitation in most endemic countries. Rather, the linking of schistosomiasis control activities with ongoing activities for the provision of water and sanitation facilities should be encouraged.

The potential for reducing the incidence of schistosomiasis is related to the technical design of water and sanitation projects. Design technology should be directed at improving the safety of drinking-water and minimizing contact with infected water. To this end, a comprehensive approach considering water supply, excreta disposal, stormwater, domestic drainage, and bathing and laundry facilities is needed.

Water supply programmes continue to be implemented by other branches of government with little or no coordination with ministries of health. Active collaboration to link these programmes is necessary at national, regional and community level. Laundry and shower facilities that reduce contact with contaminated water can be incorporated into most water supply programmes. Coordination with existing water and sanitation programmes will allow all endemic countries to embark on feasible, realistic and sustainable strategies for reducing the prevalence and severity of schistosomiasis.

6.4 Snail control

The possible role of molluscicides in schistosomiasis control programmes depends on local epidemiological and ecological circumstances, and the human and financial resources available. The relationship between the population dynamics of the intermediate snail hosts and transmission is poorly understood. Reduction of disease transmission may not result in a proportional reduction in the rate of reinfection.

Area-wide molluscicíding, usually associated with large irrigation schemes, is costly and requires knowledge of malacology and skilled personnel as well as considerable logistic means and equipment. Focal molluscicíding, in which the important transmission sites in communities where prevalence is high are targeted, is feasible in smaller, circumscribed transmission sites. Where human contact with contaminated water occurs over a wide area, it is difficult to determine the appropriate sites and timing of molluscicide application. Rapid reinvasion of the intermediate snail host usually follows focal molluscicíding, and regular applications are therefore necessary.

Eradication of the intermediate snail host has been possible in only a few situations, e.g. in oases in Tunisia. In all other situations, snail control is perpetual. Environmental modifications to eradicate the snail host are possible and, on a large scale, have been highly effective in parts of China.

6.5 Primary health care

Since the last meeting of the Expert Committee in 1984, the use of the primary health care system in schistosomiasis control has produced a significant reduction in morbidity in many countries. The integration of approaches such as chemotherapy, health education, water supply and sanitation has resulted in more effective control. The greater the proportion of the population covered through primary health care, the greater the number of infected people identified and treated, and the more rapid the reduction in the prevalence and morbidity of the disease. Community-based health education, where health workers have a better understanding of, and closer contact with, the community, results in better cooperation of the inhabitants in seeking diagnosis and treatment and better understanding of the role of environmental modification in control and the need for self-help to improve sanitation and water supply (*17*).

Primary health care workers are in a good position to assist the community in the planning and coordination of efforts for environmental modification, including the assessment of potential transmission, snail control, and the building of facilities for supplying clean water.

6.6 Water resources management

The development of water resources for agricultural production and to generate energy continues to contribute significantly to the spread of schistosomiasis (*8*). An example of this comes from northern Senegal,

where the completion of a dam near the Senegal river and the rehabilitation of an irrigation scheme led to the rapid and unforeseen invasion of the canals and the river by *Biomphalaria pfeifferi*, and to an epidemic of schistosomiasis due to *S. mansoni*.

There is a significant variation in the level of development of water resources in different parts of the world, but there is a general trend towards reduced supply and a deterioration in the quality of water resources already in use. It can therefore be expected that the public sectors needing water (irrigation, industry, energy, domestic and drinking-water) will increasingly coordinate their activities during the 1990s to achieve optimal and sustainable resource management.

In many countries, river basin development authorities have been established that are responsible for the integrated management and development of resources. The involvement of ministries of health in the planning and management of these authorities is of great importance for effective control of all water-associated parasitic diseases, and in particular schistosomiasis. Monitoring and, where necessary, modification of environmental determinants relevant to the epidemiology of schistosomiasis and other parasitic diseases should provide a basis for strengthening health services and improving human health status.

Small-scale water resources development is being increasingly promoted in many countries. Communities, local government authorities and nongovernmental organizations collaborate in the creation of small impoundments for drinking-water, watering cattle or local irrigation. Guidelines on the health implications of aquaculture impoundments have been published by the Food and Agriculture Organization of the United Nations (*18*). In the decentralized planning of such projects it is difficult to ensure that health implications are considered, even though the cumulative effect of these small-scale developments on schistosomiasis may be more dramatic than that of one large development.

6.7 National strategy

The national strategy on control of schistosomiasis will be developed into a national plan of action. A national plan does not imply that control is under way throughout all endemic areas. Periodic revision of the national strategy on schistosomiasis control should be on the basis of dialogue between the health and other sectors. The changes in the national strategy will be dictated by social and economic factors and by the rate of development of the health care delivery system.

The national strategy for schistosomiasis control should be an integral part of both health and development policy. If developed in isolation, its objectives and operation may not be coordinated with overall development. Within the health sector the national strategy will promote the aims of that sector, for example, by increasing the capacity of

peripheral health care and laboratory services, by improving epidemiological surveillance, and by implementing responsible drug distribution.

7. Negotiating strategies for ministries of health

Key professionals, such as economists, engineers, agronomists and others, are usually unaware of the cost in terms of disease, suffering and incapacity produced by water-related diseases, the most important being schistosomiasis.

7.1 Economic impact of schistosomiasis

Determination of the costs arising from disease, disability and death due to schistosomiasis continues to be a subject for research. Despite the limitations of existing studies and routinely collected health statistics, conclusions can nevertheless be drawn about the economic impact of schistosomiasis.

In the Philippines, the work-days lost as a result of *S. japonicum* infection have been estimated at up to 40 per infected person per year. The Ghana Health Assessment Team found that, for *S. haematobium* infection, 4.4 work-days were lost per infected person per year. There is a delay of 5-15 years from the time of *S. mansoni* infection to the development of severe disease, and hepatosplenomegaly will develop in about 10% of patients. Severe liver fibrosis, with oesophageal varices and bleeding, is seen in varying frequencies but affects up to 7% of the inhabitants of highly endemic communities. In Kenya and Zimbabwe, around a 10% reduction in exercise performance was found in children infected with *S. mansoni.*

7.2 Intersectoral development dialogue

In intersectoral dialogue, a ministry of health will have to take the initiative to develop liaison and lines of communication with other agencies and have adequate information available to create interest among water development authorities. Beyond this, administrative agreements on linkages between sectors of government will promote intersectoral collaboration.

It is essential to establish a dialogue between the health sector and water development planners at the start of the water resources project cycle, by incorporating an explicit health component in the terms of reference for the pre-feasibility and feasibility studies.

National epidemiological data will be the most persuasive in this intersectoral dialogue, and there is a need to afford priority to national health research programmes that generate such information. The health sector should assume an active role rather than passively responding to decisions by other planners.

Donors of resources should be made aware of the importance of the health consequences of water development projects and encouraged to involve the health sector at all stages of planning, from project identification and appraisal to implementation, monitoring and evaluation. Donor involvement should not, however, detract from the primary responsibility that lies with national authorities. Most donors now have a policy to assess the environmental impact of development projects, which should include the impact on health but, all too often, focuses only on the natural environment (e.g. forests, animals, and toxic waste) rather than on contamination by human waste and problems caused by vectors, parasites and other microorganisms.

Although the public sector plays the most important role in water development, efforts by nongovernmental organizations should not be overlooked. These may sometimes promote water development without appropriate attention to health aspects, but they may also be forceful advocates for health promotion and protection if their activities are coordinated with efforts by ministries of health.

The equitable distribution of development funds to include health as well as the other sectors involved would establish a new basis for intersectoral collaboration in health promotion. Intersectoral collaboration should aim to involve ministries of education in introducing appropriate health messages in school curricula; the social services could concentrate on adult education to promote community participation to follow healthier lifestyles; and ministries of agriculture could optimize the design and ensure the maintenance of irrigation channels and drains.

8. Integration with primary health care services

Schistosomiasis control should be integrated with health services as much as possible. The decentralization of decision-making is an important new dimension in disease control allowing greater community involvement.

8.1 The role of health services in planning control

Once it has been decided when intervention is necessary, the information required for planning a suitable strategy should be collected from pilot, short-term and long-term feasibility studies. The operational plan of action should involve the ministry of health and other relevant sectors at both central and peripheral levels – in particular, education, water resources development, agriculture, finance and planning and, where relevant, the pharmaceutical and chemical industries.

The central level may have the responsibility for purchasing supplies and for organizing the training of personnel for implementing control, but the current trend is to decentralize planning as much as possible. A central, specialized team, which may also be responsible for the control of other diseases, has a useful role both in planning and in supervising field operations.

8.2 The role of health services in implementation and maintenance

Primary health care is most important in the implementation of the programme. Primary health care units should be responsible for active and passive case-finding and there should be a reliable delivery system for treatment – particularly important during the maintenance phase of the control programme. The primary health care system should also be responsible for health education in the community. In the planning phase of the programme, training should focus on communication for health education, household visiting, and techniques of community motivation, especially for improving sanitation.

Health workers should also be trained in basic technical tasks, such as the collection of demographic data, individual and population-based community diagnosis and treatment, survey techniques for snail habitats and transmission sites, and snail control, where appropriate. Supervision and quality control are essential for effective control operations and evaluation.

Senior workers should be responsible for supervising and ensuring the quality of work done by their staff. The help of a health educator is essential in mobilizing community support for the control programme. The worker's responsibility for the various tasks required for schistosomiasis control should be well reflected in detailed job descriptions.

8.3 Integration with other disease control activities

There is growing interest in the integration of schistosomiasis control with control of other diseases. The coordination of different disease control activities is partly determined by epidemiological factors and the recognition that some control mechanisms require similar tools, e.g. microscopes. In addition, financial constraints force services to pool resources, e.g. transport. However, so far there has been only limited experience of coordinating disease control between different diseases.

An obvious example of a combined control programme is that of intestinal schistosomiasis and intestinal helminthiasis. In schistosomiasis control programmes using faecal screening, intestinal helminthiasis can also be diagnosed and treated, not only for medical reasons but also as an incentive to people to come and seek help. In such a close association of diseases it is difficult to merge control objectives, methods and strategies in a consistent way. Nevertheless, such integration of specific disease control programmes can be beneficial in terms of both economy and efficiency.

Malaria control programmes could be valuable partners for cooperation in environmental management, community mobilization and epidemiological studies. Laboratory facilities, transport and other resources could be shared by appropriate scheduling of different activities.

Closer coordination for the control of different diseases is exemplified by the devolution of the Onchocerciasis Control Programme (OCP). There is

a demand that treatment and basic epidemiological surveillance should be devolved, even to remote areas. Most participating countries have developed plans to coordinate and integrate these efforts with the control of dracunculiasis, schistosomiasis, trypanosomiasis, and leprosy. There has been too little practical experience with these approaches to justify firm conclusions.

In Morocco, as in some other endemic countries, the Parasitic Diseases Service (PDS) at the central level coordinates leishmaniasis, malaria and schistosomiasis control. It sets the overall objectives and the annual plan of action, which are summaries of provincial plans according to the national development plan. The PDS also determines the need for resources and can negotiate for them.

Experience shows that, with programmes working at the periphery and using the resources of the primary health care system, it is necessary to maintain some degree of disease control expertise at the central level to guarantee quality and ensure the efficiency of control efforts. The qualitative and quantitative operational and outcome objectives of schistosomiasis control should be clearly understood within such integrated efforts to control disease.

9. Planning and management

The planning process and management are unique for each country. There are several increasingly important features. Overall economic planning may have input from the health sector with the participation of the ministry of health. At the central level of the ministry of health, the priority, financing and lines of responsibility for schistosomiasis control co-ordinated with other health sectors should be defined. Experience in endemic countries has shown that operational planning can best be implemented from the provincial or district level. Participation in this type of planning draws upon an assessment of operational objectives, procedures and programme monitoring at the periphery, allowing a more precise analysis of operational and disease objectives. In this way, different objectives can be harmonized with the help of local data.

In the broadest sense, planning and management will contribute to the success or failure of efforts at control. The financial resources allocated to health in many endemic countries are limited. The negative effects of the widespread structural adjustment policies of the international lending agencies on the social sector, including health, have now been recognized. Efficient management in ministries of health should ensure that limited resources are used effectively.

9.1 Management

Management of control activities forms part of management of health services, but in large national programmes the management of disease control has special characteristics. Priority assessment is an ongoing

process based on direct communication with the peripheral level. The mechanisms for mobilization of resources may require the identification of sources of funds. A marketing strategy is based on the need and the anticipated outcome of control. The certainty or commitment of financial support over time is an important factor for effective planning.

Increasingly, management of control will include assessment of the best opportunities for supporting control interventions in the existing health care system. The functional and administrative procedures of an organization will help to determine staff understanding of the organization and its objectives.

Implementation of a plan of action is a matter for the health professionals involved in the control operations. Those professionals should therefore have the skills needed to accomplish their tasks. Their training should be a priority and a continuing process, so that their skills are improved and strengthened. Communication, coordination and supervision arrangements as well as programming and evaluation mechanisms should be clearly stated and put into effect.

9.2 Training

Besides funding, control operations need a sufficient number of appropriately trained personnel. Well organized staff development using fully proven training methods is necessary to ensure proper use of the funds available for the control of schistosomiasis.

Training at all levels remains a high priority in schistosomiasis control and the comments made by the Expert Committee in 1984 remain appropriate (*1*). Training, while essential, will not remedy problems such as high staff turnover or lack of motivation due to poor conditions of service. Low salaries, lack of career development policies, and poor supervision contribute to difficulties in developing and managing disease control programmes in many endemic countries.

The integration of control activities within peripheral health services should use community groups or organizations to promote treatment compliance or behavioural change. Target groups for training may range from teachers who support health workers in community diagnosis and treatment of schoolchildren to members of local health committees.

10. Cost analysis

The economic constraints in developing countries where schistosomiasis is endemic require careful analysis and review to assess the feasibility of control with limited resources.

10.1 Estimation of cost

An estimation of the cost of different interventions is the first step in a cost-effectiveness analysis of options for control strategies. In a strategy

aimed primarily at morbidity control, the main elements will be chemotherapy and health education. The simplest item to estimate is the actual cost of the antischistosomal drugs, but the cost of central and peripheral storage, transportation to distribution centres, and administrative support must also be considered.

After choosing the most appropriate drug and establishing a dosage schedule, the next cost is that of delivery. This will reflect the choice of drug and the dosage schedule. Cost calculations must also include the requirements for diagnosis. Selective diagnosis of *S. haematobium* infection using chemical-reagent strips costs relatively little compared with the high cost of stool examination to detect *S. mansoni* infection. The cost of large-scale chemotherapy will be affected by the method of identifying communities for treatment.

Cost calculations frequently omit the cost of employing the necessary personnel. The cost of equipment, particularly vehicles, usually appears in the accounting, but the cost of offices and laboratories is rarely considered, nor is the depreciation of these capital assets. In a strategy that aims at morbidity control and the reduction of transmission, the additional costs of, for example, molluscicide and environmental management must be considered.

The cost of molluscicide includes the purchase of molluscicides and the cost of their application (e.g. transport, storage, administration, equipment and personnel). The cost of environmental management includes capital investments in engineering and equipment and recurrent operational costs (e.g. personnel and materials).

Since the cost estimates above are intended to allow comparison, a uniform method of cost calculation must be used so that costs can be adjusted to reflect local variation.

10.2 The costs of control

Studies on the costs of control programmes, based on chemotherapy, have been published since the Expert Committee noted at its previous meeting the inadequacy of the available data. Costs estimated in these studies ranged from US$0.70 to US$3.10 per head of population, but development costs, salaries, and the cost of failure were often excluded.

Some hypothetical projections based on pilot projects have been made. The cheapest regimen using praziquantel involved existing health services in areas of low endemicity. When specialized programmes were required, costs varied from US$1.50 to US$6.53 per person per year. Costs per infected person treated were inevitably higher, with a minimum cost of US$3.00 for the specialized programmes.

When the annual per capita expenditure on all forms of primary health care is only between US$1 and US$4 in many endemic countries, most cannot afford vertical programmes, except perhaps in small areas. Drugs

account for a relatively low proportion of total delivery costs in vertical programmes. On the other hand, their cost is more prominent and may be the major expenditure in programmes integrated into primary health care. A reduction in the price of praziquantel could significantly reduce the cost of such programmes.

The cost of identifying communities with a high prevalence of *S. haematobium* infection can be substantially reduced by using questionnaires and reagent strips. Chemotherapy targeted at schoolchildren will also reduce the costs of control, and in most communities will reach the groups with the highest prevalence and severity of infection. Increasing the interval between treatments will also reduce costs, but this has to be balanced against a reduced impact on morbidity. Further studies are needed into ways of reducing the cost of identifying communities for treatment (especially for *S. mansoni* infection) and the cost of drug delivery.

10.3 Estimation of effectiveness

Effectiveness has been estimated in terms of coverage (number of people receiving treatment/number of people infected or at risk) or cure (coverage × drug efficacy). This allows estimation of the cheapest approach to delivering treatment, which is not necessarily the same as the most cost-effective approach to reducing disease.

For a better assessment of effectiveness, more information is required on the morbidity due to schistosomiasis at the community level, the relationship between this morbidity and the prevalence and intensity of infection, and the relationship between morbidity and disease predisposition. This approach may require modelling the dynamics of transmission and morbidity, and the impact of control, in similar ways to methods developed for other helminthic infections.

10.4 The costs of lack of control

In costing lack of control, a distinction is traditionally made between the cost of health care for infected people and the cost of reduced economic productivity as a result of the disease. Little is known about the health-seeking behaviour of people suffering from schistosomiasis and the direct cost incurred by the health system, and more research is needed in this area.

Given levels of prevalence and intensity of infection can be associated with very different levels of clinical disease both between and within countries. Economic estimates show similar variations in the indirect cost of the disease. These inconsistencies do not imply that schistosomiasis has no demonstrable economic impact, but rather that the indirect costs might be considerable in certain circumstances, as in areas where the prevalence of clinical disease is high or in communities that have recognized schistosomiasis as a significant health problem. In the assessment of

indirect costs, rural household income should be the focus of analysis rather than the wages of individual workers.

The long-term economic consequences of the disease should also be explored. *S. haematobium* infection can be associated with reversible anaemia, malnutrition and stunting of growth in children. There is a positive correlation between education and productivity, and if schistosomiasis inhibits educational achievement it could also eventually affect production.

11. Data management

Data are often readily available for the planning, implementation, monitoring and evaluation of control programmes. The management of these data aims to identify operational priorities and to target control activities on a sound epidemiological basis. As a country progresses in controlling schistosomiasis it will need to improve epidemiological analysis so that it would be possible to tackle situations that prevent further advancement. Analysis and evaluation should, therefore, be a continuous process integrated into the control programme.

11.1 Monitoring through general health statistics

The prevalence of infection and of disease is often underestimated from data obtained from the general health services. The reliability of such data will depend on accurate diagnosis at source.

Although data-reporting by individual health units may be inconsistent, it may nevertheless be clear that the prevalence of schistosomiasis is comparatively high in a particular area. The relative risk for a given community can then be established. After control has been initiated, this type of reporting can be improved and serve to monitor progress.

11.2 Outpatient data

Outpatient clinics are the major source of data for the ministries of health. Efforts should be made by health workers to improve the accuracy of diagnosis based on signs and symptoms, to identify correctly the geographical locations where patients were infected, and to determine whether patients have been treated in the past.

A differential diagnosis should be made since diseases other than schistosomiasis could be present. The record should include the treatment given after the patient has been diagnosed as having active schistosomiasis, and the efficacy of treatment if the patient can be followed up.

11.3 Hospital data

Neither the prevalence of schistosomiasis nor the impact of control programmes on morbidity can be reliably estimated from hospital data.

The value of such information will depend on the type of hospital (teaching or general) and its range of services. However, the data will give some indication of the severity of the disease in the region served by the hospital. The data collected by the hospitals should cover the management of disease complications.

11.4 Data from control programmes

Epidemiological data should be broken down in order to identify high prevalence areas of focal transmission. Epidemiological tools for rapid assessment in these areas are available and may help to target appropriate intervention.

Collection of data immediately relevant to management decisions, e.g. treatment frequency and resource allocation, should be encouraged. Excessive data collection usually leads to an unacceptable delay between its collection and its use. The use of "sentinel" populations for programme monitoring and evaluation would reduce the need for a great deal of resources for data collection and analysis. Sound statistical methods should be used to select appropriate sentinel groups.

While it is important to ensure a rapid flow of information to the central decision-making level, it is essential to have feedback from the field staff. Data analysis for decision-making should take place as close as possible to the population affected, and the population should be aware of the decision-making process.

12. Global monitoring

Management information systems based on personal computer technology allow large amounts of data to be processed very quickly. Such systems can assist ministries of health in making timely decisions regarding disease control programmes.

12.1 Schistosomiasis database

A computerized global database for schistosomiasis has been established in the Schistosomiasis Control unit of WHO (*19*). This database includes information on the epidemiology of schistosomiasis, control activities, and people responsible for control, water resources, and chemotherapy for each endemic country. With the assistance of the ministries of health in endemic countries, data will be periodically updated.

12.2 Geographical information systems

Geographical information systems (GIS) are computerized systems for the capture, storage, management and display of data associated with geographical areas such as villages, districts, provinces or countries. A common system of geographical coordinates links the data. In many countries GIS are established in ministries dealing with resources

development and management, and ministries of health may collaborate with those ministries in order to integrate health data into the systems. This computerized information can be used to monitor the results of schistosomiasis control and to identify priority areas.

13. Policy conclusions

Development policies designed to improve the economic conditions and quality of life of communities often have unintended effects on health (*8*, *20*). While these effects can be positive, many policies create additional health risks for vulnerable groups, thereby compromising the welfare objectives of development policies. In the case of schistosomiasis the adverse consequences of development policies manifest themselves in a number of important ways:

- implementation of development programmes and projects with little or no regard for health protection;
- economic policies that reduce hard currency available for the health sector;
- rural development policies that sacrifice social goals for economic ones; and
- urban development policies that impede the development of a social service infrastructure.

13.1 Health and development

Most national development policies are implemented through programmes and projects specific to the economic sector responsible, e.g. water resources development, energy development, agriculture development. Development projects associated with changes in the local environment often lead to greater disease transmission, for example through the creation of new vector habitats, leading to a burden of disease far beyond the affected population's capacity to prevent or treat (*8*). Furthermore, the local population may not derive any benefit from the implicated development project, as is the case with energy projects that provide electricity to distant urban centres or irrigation schemes that enhance cash crop production for the benefit of others.

In view of the gross inequities of these situations, sufficient funds should be available during the development and maintenance stages of such projects to meet the public health consequences of changes in the local environment and living conditions. The health sector should be involved sufficiently early in project planning to help put such funds to good use.

The plea for building health safeguards into development projects and for the early involvement of the health sector is one that has been made repeatedly, but there are still countries where appropriate policies do not exist. Nevertheless, the Committee emphasized the potential benefits of linking health and development policies. The internationally recognized

importance of linking health to human development, economic development and the environment should be reflected in policy decisions taken by governments as well as by national and international funding agencies.

Recently adopted World Bank policies on the incorporation of health concerns in the assessment of environmental impact are of particular importance (*21*). They will at the very least ensure that the potential for the spread of disease will be considered during the planning of future projects. For example, the environmental effects of dams and reservoirs relevant to the risk of schistosomiasis, malaria, onchocerciasis and Japanese encephalitis have been specifically noted. However, the lack of national capacity to undertake such health impact assessments may lead to lack of real follow-up on the potential health risks identified. These capacities need to be strengthened within the health and social development sectors of government.

Policies related to environmental management for disease vector control were reviewed by the Joint WHO/FAO/UNEP Panel of Experts on Environmental Management for Vector Control (PEEM) (*22*). Three categories of policies were distinguished:

1. Sectoral government policies with an inadvertent negative effect on human health. These may range from food and pesticide subsidy policies, and policies for irrigation development and management to resettlement policies and policies to generate income from related activities.
2. Policies aimed at promoting better environmental and health conditions in the context of development. Most of these policies allow the impact on the environment to be assessed at an early stage in the project. Unfortunately, the assessment of public health impact is limited and the approaches to health remain conventional. Health promotion is generally not considered an integral part of development, but rather a series of measures taken to strengthen health services so that they can better cope with inevitable health problems.
3. Policies of bilateral/multilateral agencies. For resource development projects requiring external funding, government officials will negotiate with donor agencies at the appraisal phase, following feasibility studies. The dialogue will be influenced by policies on environmental and health safeguards that may be incompatible.

The picture of increased vulnerability to disease associated with development projects must not overshadow the already large numbers of rural and urban poor and underserved who suffer the greatest health deprivation. The health of these population groups is mostly determined by social and economic conditions far beyond the capacity of the health sector alone to change. Development programmes are required to provide basic community services including health care, education, water and sanitation, and electricity. Schistosomiasis has disappeared from many

areas because of improvements in the quality of life and not as a result of specific control measures.

Despite the limited potential of the health sector to effect significant social and economic development, it can adopt a health advocacy policy, promoting health objectives within all national development policies. At the same time, it can aim at educating governmental and funding officials in the importance of linking health with development.

Placing schistosomiasis control within a broader health and development framework can have an important impact on external funding. For example, the reliance of many countries on external loans to meet the cost of praziquantel has handicapped the ability of such countries to develop links within the health sector and outside it. Drug delivery has become the *raison d'être* of the control programme instead of being part of a general strengthening of local health services to provide treatment. In one instance, other priorities prevented the full use of available funds, which were then lost to the health sector at the end of the project. Long-term, more flexible commitments to build up a sustainable programme would be preferable to short-term, rigidly conceived investments, which improve neither delivery services nor the capacity to target the use of available resources.

Long-term (20 years or more) commitments would enable schistosomiasis control to become an important strategic element in implementing national policies to extend the coverage of primary health care and to decentralize decision-making and epidemiology to lower administrative levels. Instead of allowing the success of a programme (achievable within a few years with the use of drugs) to undermine policy-makers' interest and support, those in the control programme would be able to find more cost-effective ways of protecting long-term gains. These efforts could involve research aimed at developing better control measures as well as improved means of monitoring transmission, morbidity and cost.

Long-term commitment to schistosomiasis control within a national development framework would also encourage more constructive approaches to solving difficulties in unsettled rural areas (see section 5.2.10) and growing periurban populations (see section 5.2.9).

The role of the health sector in advocacy must also influence the many small governmental and nongovernmental projects that inadvertently contribute to environmental changes dangerous to health. Their total impact may be greater than that of major development projects funded by external agencies. Information about health protection needs to be readily available to the communities involved as well as to those responsible for supporting these projects.

13.2 Economic policies

Many developing countries face severe economic constraints that cut into funds available for social development and force countries to adopt

austerity measures dictated by international funding agencies. The consequences for the health sector have been devastating.

Drugs, supplies and equipment are the most tangible elements of health services that are being jeopardized by current macroeconomic policies and reforms adopted to meet growing economic constraints. National health programmes, particularly preventive services, have seen their capacity to deliver health care radically reduced in the face of economic recession that has cut the hard currency available for such services. Reduced budgets are barely enough to meet staff salaries. Governments have turned to international lending agencies to meet the costs of drugs, supplies and equipment. This support has been forthcoming but may not be in the best interests of long-term development.

Dependency on outside funding to acquire an adequate supply of drugs leaves national programmes at the mercy of different funding policies and decisions taken elsewhere. Priorities are usually set without the benefit of adequate data from the communities where severe disease is present. Already, at national level, statistical aggregation distorts the true pattern of schistosomiasis distribution. Moving to the international level only further undermines the quantitative and qualitative arguments in favour of significant investment in control.

The major tropical diseases are concentrated in the poorest population groups, those least able to afford medical care. Emphasis should be given to innovative ways of using available funds to protect the health of such groups.

The high cost of praziquantel must be considered in the funding of schistosomiasis control. Countries that normally paid for this drug from their own budgets have had to request international funding owing to the economic recession. Negotiations to secure such funding tend to focus on cost-containment rather than on programme development, and the Committee welcomes the recent WHO/UNICEF initiative to seek reduced prices for praziquantel for national health services and national control programmes. Through the reduction of drug costs, national programmes should be in a better position to concentrate on some of the programme development strategies outlined in this report.

13.3 Rural development

Rural development is largely synonymous with agricultural development where schistosomiasis is concerned. One review of development policy issues has identified four areas linking health and agriculture: irrigation systems, pesticide use, land policies and resettlement, and agricultural research (*23*). The importance of irrigation systems has already been discussed (p.11). Pesticides used for schistosomiasis control are not of great concern in rural development since molluscicides *per se* have limited agricultural applications. Pesticide use and environmental protection are, however, important issues, and can be expected to be at the centre of

negotiations between those pursuing agricultural development and those responsible for the environment. Policy guidelines adopted may be relevant to the use of molluscicides and must therefore be revised according to the needs of the schistosomiasis control programme.

Land policy and resettlement are central issues in rural development and schistosomiasis control. Many rural disease foci are linked with unstable populations, e.g. colonization schemes in the early stages of development, refugee camps in rural areas, mining settlements, and large farms with migratory workforces, usually made up of poor agricultural workers. A common feature of all of these situations is the virtual absence of a social infrastructure within which health services could operate. Often in resettlement schemes transmission may be particularly high in the exposed population, which has had little if any previous contact with the disease.

Agricultural research, which in the past has concentrated almost exclusively on improving productivity, is beginning to include the social and health concerns of the rural agricultural population. The International Agricultural Research Centres (IARCs), coordinated by the Consultative Group on International Agricultural Research (CGIAR), have made a substantial effort to incorporate health, nutrition, welfare and environmental objectives into their research policies. The International Rice Research Institute (IRRI) will address health issues in the work planned for this decade. The Joint WHO/FAO/UNEP/UNCHS Panel of Experts on Environmental Management for Vector Control is also concerned with health, and is working together with other agencies to promote research into health and environmental issues.

These initiatives and their implications for different countries should be reviewed by schistosomiasis control programme managers. Coordinating mechanisms should be established to ensure that fieldwork covers rural areas where schistosomiasis poses its greatest threat. Programme managers should work to ensure the inclusion of problem assessment procedures in the policy reviews of rural and agricultural development agencies. Most importantly, programme managers should ensure the inclusion of health protection and promotion measures in rural and agricultural development projects carried out by these and other agencies.

13.4 Urban development

Poor health is not confined to undeveloped and remote rural settings. The world's urban population has almost tripled in the past 30 years, mostly in developing countries. High growth rates in urban areas have exceeded the capacity to provide adequate resources, housing, employment and other services, and have resulted in the exposure of increasing numbers of peripheral urban dwellers to the hazards of poverty, unemployment, inadequate housing, poor sanitation, pollution, disease vectors, poor transport and psychological and social stress.

Schistosomiasis is one of the many disease burdens of the urban poor (*10*),

and must be considered together with other threats that undermine urban public health. A concerted public health policy and programme are required. The city has often been a focus of public health development, but largely confined to developed countries. Most developing countries have seen their urban health policies and services develop along fragmented lines dictated by predominant interests in clinical services and specific disease control campaigns managed centrally at national level.

Future urban health development will have to address a wide spectrum of socioeconomic issues. Healthy urban development will be achieved by implementing social and economic policies at all levels to sustain urban development and to preserve a healthy environment that reduces the risk of schistosomiasis and other tropical diseases. The impact of health policies concerned with energy, food, agriculture, macroeconomic planning, housing, industry, transport and communication, and education and social welfare will be to promote healthier communities and a healthier environment in cities, and to enable intersectoral and community participation in the planning and implementation of urban development, which, in the long term, will militate against the introduction of schistosomiasis.

Technical issues in control

14. Disease and mortality due to schistosomiasis

Schistosomiasis is caused by any of five species of trematode parasite. Each species may give rise to acute or chronic disease with widely differing symptoms and clinical signs (*24*). Since the advent of safe and effective chemotherapy, clinicians have recognized an improvement in the general health of treated patients, even when specific signs or symptoms of the disease were not evident before treatment. A thorough understanding by health workers of the disease patterns of schistosomiasis and of the beneficial effects of treatment will facilitate diagnosis and improve the quality of reporting as control progresses.

14.1 Morbidity

Recent studies of morbidity caused by chronic schistosomiasis have confirmed a general relationship between the intensity of infection and high morbidity in children (*24*). In communities with a high prevalence and intensity of infection there is a wide range of clinical manifestations. Until recently, physical examination and laboratory investigation were the standard diagnostic techniques. The recent introduction of portable ultrasonography equipment that can be used in the field – at village level if required – should enable diagnosis to be made with greater accuracy and sensitivity in the future.

14.1.1 *Schistosoma haematobium*

Infection with *S. haematobium* is associated with very high morbidity. Up to 50-70% of infected individuals in any endemic locality have symptomatic urinary tract findings including haematuria, dysuria or frequency.

The severity of the disease depends mainly on the intensity of infection. A high proportion of moderately or heavily infected patients, particularly children, have considerable damage of the urinary tract, sometimes leading to obstructive uropathy.

The acute granulomatous response to parasite eggs in the early stages causes urinary tract disease, such as urothelial ulceration and bladder polyposis. By contrast, in chronic disease, usually in older patients, ureteric and bladder fibrosis and calcification are more common. In the early stage, the intensity of infection usually reflects the severity of the disease. In the late stage, urinary egg count is less related to the severity of the disease, and morbidity can be better assessed by laboratory investigations, radiography and ultrasound.

Hospital radiological evaluation of urinary schistosomiasis includes a plain abdominal X-ray, intravenous urography, and retrograde cystography and pyelography. Typical lesions demonstrated radiologically are hydronephrosis, hydroureter, ureteric stricture, dilatation or distortion, ureteric calcification, polyps, ureterolithiasis, calcified bladder, bladder filling defect caused by granuloma, polyps or carcinoma, reduction in bladder capacity, irregular contraction of the bladder wall or dilated bladder due to bladder neck fibrosis. In general, more urinary tract disease is seen radiologically in communities with a high intensity of infection in children.

Some of the urinary tract lesions in children may be reversed by treatment; in adults, the more severe changes, with bladder calcification, may not regress.

A major advance in the understanding of the natural history of *S. haematobium*-related urinary tract morbidity has come through the introduction of the portable ultrasound machines for non-invasive examination of the kidneys and bladder. In studies from different geographical areas, results of ultrasound studies have correlated well with findings from intravenous urography and cystoscopy.

Renography can be used to assess the function of each kidney and detect obstruction of the urinary tract, especially in children. Following treatment in children, the renogram is restored to normal more quickly than the pyelogram, which may still show structural damage.

Although computed tomography (CT) can clearly demonstrate calcification of the urinary tract, such hospital-based investigations, including renography, have a limited role in monitoring morbidity control within the community.

14.1.2 *Schistosoma japonicum and Schistosoma mekongi*

Acute clinical disease, or Katayama fever, following penetration of the cercaria, is characterized by organomegaly, fever and eosinophilia. It is usually seen either in people living in an endemic area at the time of their first exposure or in uninfected people who enter an endemic area for the first time. Patients with active chronic infection or with a history of infection and antischistosomal treatment may occasionally present with acute symptoms due to massive exposure to cercariae over a short period.

In most people with chronic schistosomiasis the disease is subclinical. The main symptoms are weakness, abdominal pain, irregular bowel movement and blood in the stools. By palpation the liver is smooth and enlarged, but in severe cases may be nodular or irregular. Splenomegaly is frequent, especially in the late stage or in heavy infection. Patients with gross splenomegaly often have hypersplenism. Advanced hepatosplenic disease is usually associated with dilatation of abdominal collateral veins, gastro-oesophageal varices and eventually ascites.

In intestinal schistosomiasis liver function usually remains normal, but in patients with hepatic disease there is often some functional impairment. The decrease in serum albumin and the increase in immunoglobulin concentration are usually well demonstrated by serum electrophoresis. When viral hepatitis B and *S. japonicum* infection occur together, there is higher morbidity and mortality than would be caused by either infection alone.

In adult hospital patients with schistosomiasis, cerebral schistosomiasis occurs in 1.7-4.3%. The acute form presents as a meningoencephalitic syndrome. In the chronic phase, Jacksonian convulsions and grand mal seizures with permanent electroencephalographic changes are most frequent, while psychomotor and autonomic seizures are rarely seen.

Ultrasound evaluation of *S. japonicum* morbidity is currently in progress in China and in the Philippines and preliminary findings suggest that this technique is as good as or more effective than surgical biopsy in evaluating the presence and degree of portal fibrosis before treating a patient. A similar success in evaluation is reported for *S. mansoni.*

The clinical manifestations of *S. mekongi* infection are similar to those of *S. japonicum.* Morbidity due to *S. mekongi* alone is difficult to distinguish from that due to other parasitic infections in the same endemic areas, especially *Opisthorchis viverrini.* Hepatomegaly and splenomegaly due to other causes are very common in endemic areas.

14.1.3 *Schistosoma mansoni*

The main impact on public health is due to chronic infection leading to intestinal and hepatosplenic involvement. In areas of low prevalence severe clinical features are seen in a relatively small proportion of patients. Symptoms such as abdominal pain, bloody diarrhoea and fatigue are reported by infected people in high-prevalence localities.

The principal intestinal lesions of *S. mansoni* infection are colonic polyposis (especially in Egypt), focal fibrosis, and inflammation. Schistosomal polyposis is directly related to the intensity of infection. Within the polyps the concentration of *S. mansoni* eggs is much higher than elsewhere in the intestine. Polyps are inflammatory and not adenomatous.

Hepatosplenic involvement is the most important cause of morbidity in *S. mansoni* infection. Hepatic fibrosis and portal hypertension may be life-threatening and are irreversible in advanced disease. In endemic communities, hepatomegaly in childhood has been correlated with intensity of infection. Patients with intestinal symptoms may remain otherwise asymptomatic until the disease is well advanced or haematemesis occurs. In the early stages, the left hepatic lobe is predominantly enlarged. In the late stages, the size of the liver may decrease and ascites may develop due to portal hypertension and hypoalbuminaemia. Haemorrhage from gastro-oesophageal varices is often caused by schistosomal hepatic fibrosis. Hepatocellular failure may be life-threatening, especially if there is concomitant viral infection. In some patients with hepatosplenic *S. mansoni* infection nephrotic syndrome due to immune-complex glomerulonephritis may develop.

Ultrasonography can demonstrate the characteristic schistosomal portal fibrosis as well as the dilatation and patency of portal and splenic veins, and can clearly differentiate schistosomal fibrosis from post-hepatitic cirrhosis (*13*). Excellent sensitivity and specificity have been shown for ultrasonography compared with hepatic wedge biopsy in the diagnosis of schistosomal hepatic fibrosis. Since ultrasonography equipment is portable, clinical epidemiological studies can be carried out using the technique within the community.

Community-based ultrasound monitoring of morbidity due to *S. mansoni* infection is still scarce. Guidelines are available for evaluating the application of ultrasound in schistosomiasis morbidity surveys (*25*).

14.1.4 *Schistosoma intercalatum*

Compared with other schistosomes that infect humans, less is known about infection with *S. intercalatum* from west and central Africa but it is considered to be the least pathogenic.

Differences between the Cameroon and Zaire strains of *S. intercalatum* need to be better defined before any conclusions are drawn about their pathogenicity.

The highest prevalence and intensity of infection occur between the ages of 5 and 14 years. The intensity of infection tends to decrease with age, and people over 45 years of age are rarely infected. The main clinical manifestations of disease due to *S. intercalatum* infection are lower abdominal pain and dysentery.

There is a positive association between the intensity of infection, assessed

by stool egg count, and symptoms of diarrhoea and blood in the stool. As with other schistosomal infections, *S. intercalatum* may be associated with severe *Salmonella* infections.

Lesions of the intestine are limited to the rectum and sigmoid colon. Egg granulomas are occasionally seen in the portal area of the liver. Left-lobe liver enlargement is associated with heavy infections. Liver fibrosis and portal hypertension have not been seen.

14.2 Schistosomiasis and cancer

While associations between schistosomiasis and several cancers exist, epidemiological evidence suggests that schistosomes are probably co-carcinogens. On the other hand, there is experimental evidence for *S. haematobium*-associated carcinoma of the bladder in non-human primates.

An increased incidence of squamous cell carcinoma of the bladder has been reported in many areas endemic for *S. haematobium* infection. Supporting data have been reported from Egypt, Iraq, Kuwait, Malawi, and elsewhere, and confirmed in case-control studies from Zambia and Zimbabwe. Individuals with concurrent schistosomiasis develop malignancy at a lower mean age than do non-infected cohorts. In these areas, squamous cell carcinoma of the bladder is more frequent than transitional cell tumours, accounting for 44-82% of the total, whereas the opposite is observed when schistosomiasis is not endemic.

Although the mechanism of carcinogenesis in the urinary bladder is unknown, there is evidence that early treatment of schistosomiasis is a primary preventive measure. Such intervention will lower the risk of carcinogenesis that is directly (if immune-mediated) or indirectly (if due to increased urinary carcinogen exposure secondary to bladder outlet obstruction) related to the infection by allowing early lesions to heal or by reducing the risk of their development. Cancer registry surveillance is recommended to confirm these effects.

Although colorectal cancer has been associated with *S. japonicum* infection, there is little experimental or epidemiological evidence to confirm a predisposing role for schistosomiasis. A nationwide retrospective survey of cancer in China, between 1973 and 1975, showed that cancer of the large intestine was seen mainly in areas with a high prevalence of schistosomiasis. The National Cooperative Group on Pathology and Prognosis of Colorectal Cancer in China reported that the five-year survival rate of patients with colorectal cancer complicated by schistosomiasis was significantly lower than in patients without schistosomiasis.

There is no proven link between schistosomiasis and hepatic and gastric carcinoma. However, in Brazil and Egypt, splenic lymphoma and schistosomiasis have been observed to occur concurrently.

14.3 Schistosomiasis and nutrition

S. haematobium infection is associated with anaemia, and probably causes or aggravates anaemia in the presence of low dietary iron, hookworm infection or malaria (*3*). In Africa, urinary schistosomiasis is associated with low weight for height in both children and adults. The disease can inhibit growth in children, but the growth rate improves after successful treatment. Further studies are needed to determine the effect of urinary schistosomiasis on children's school attendance and performance, and on the work capacity and productivity of both children and adults.

S. mansoni and *S. japonicum* infections cause intestinal blood loss. However, the magnitude of this loss over time and its effect on nutritional status, anaemia, growth and physical fitness remain unclear. In addition, the contribution of treatment of schistosomiasis in improving nutritional status has not been assessed. Growth retardation due to severe *S. mansoni* or *S. japonicum* infection can be reversed by treatment.

14.4 Schistosomiasis and intercurrent infections

14.4.1 *Viral hepatitis*

In hospital patients from Egypt, Kuwait, Malawi and the Sudan, hepatitis B virus (HBV) antigenaemia has been significantly more common in *S. mansoni*-infected patients, particularly those with hepatosplenic schistosomiasis, than in uninfected controls. In Egypt, *S. mansoni* infection has been significantly more frequently associated with the presence of hepatitis B surface antigen (HBsAg) and anti-hepatitis B antibody (anti-HB) than has *S. haematobium* infection. However, in most population-based studies, this association has not been found, because of the high frequency of hepatitis B in the general population. These observations suggest that interaction between HBV and *S. mansoni* infection causes serious liver disease and that people with both infections are more likely to be hospitalized.

Recent studies showing a decreased response to hepatitis B vaccine among children of mothers with schistosomiasis should be confirmed by further studies and follow-up in the large-scale vaccination programmes under way in endemic areas. Hepatitis B vaccination protects against hepatocellular carcinoma and may diminish the severity of liver disease in patients with schistosomiasis.

Higher morbidity and mortality are seen with combined HBV and *S. japonicum* infection than with either infection alone. As in the case of *S. mansoni* and HBV, clinical and pathological studies have confirmed the association but population studies have not.

14.4.2 *Bacterial infections*

The frequent association of *Salmonella* spp. with schistosome infection and complete cure after treatment of schistosomiasis have long been

recognized. The bacteria are found in the tegument or in the intestinal tract of *S. haematobium* and *S. mansoni* adult worms. These concomitant infections are characterized by prolonged fever, significant hepatosplenomegaly, eosinophilia, with or without leukocytosis, and persistently positive blood cultures for salmonellae. Effective treatment of schistosomiasis may eliminate both infections, although antibiotic treatment may also be required for the bacterial infection.

Other concomitant bacterial infections such as *Escherichia coli* may cause important complications in hepatosplenic disease due to *S. mansoni* and in obstructive renal disease due to *S. haematobium.*

14.4.3 *Human immunodeficiency virus (HIV)*

Thus far, reports of the association of schistosomiasis and HIV infection have been infrequent. The recent discovery of immunological cross-reactivity between an HIV-1 virion infectivity factor (vif) and a surface antigen of *S. mansoni* lends support to the hypothesis that schistosomiasis, which also produces marked alterations of immune function, could alter a patient's vulnerability to HIV and vice versa.

People with simultaneous *S. mansoni* and HIV infections form few granulomas around *S. mansoni* eggs. However, persons with terminal AIDS and those positive for HIV-1 antibodies who are infected with *S. mansoni* have been reported to develop antibodies to *S. mansoni* egg antigens.

14.5 Immune response to schistosomiasis

Immune responses in schistosomiasis are related both to the development of resistance to reinfection and to a granulomatous reaction around schistosome eggs. Epidemiological studies in different endemic areas indicate that the prevalence and intensity of schistosome infection rise during the first 15 years of life, followed by a decline suggesting a gradual diminution of infection coupled with the development of resistance.

In Kenya, following treatment of *S. mansoni* infection, both susceptible and resistant children demonstrate high levels of IgG antibodies that can mediate eosinophil-dependent damage to schistosomula *in vitro*, but blocking antibodies, including some IgM and IgG isotypes, prevent the expression of immunity in the susceptible group of children. In the Gambia, protective immunity increasing with age against *S. haematobium* infection has been seen. Observations on reinfection after treatment in the Gambia (*S. haematobium*), in Brazil (*S. mansoni*) and in Egypt (*S. mansoni* areas) indicate that resistance may partly depend on IgE/IgG4 ratios, with IgE mediating resistance and high levels of IgG4 antibodies blocking these mechanisms in children. These studies, demonstrating that immunity in humans develops as age increases, give hope that it may be possible to develop a vaccine against the disease.

The immunological consequences in children of an infected mother are unknown, but the fact that children born in endemic areas may express a wide range of immune responses should be considered with regard to both morbidity studies and vaccine development.

The peripheral blood mononuclear cells of patients with early infection respond strongly to soluble egg antigen (SEA), while their response to adult worm antigens and cercarial antigens develops more slowly. As the infection becomes chronic, a reduced anti-SEA proliferative response and a greater response to adult worm antigens are seen. Antibody production in acute and early infection clearly differs from that observed in most chronically infected patients who have lower levels of IgM and IgG anti-schistosome antibodies. Acute and chronic schistosomiasis can be distinguished serologically on the basis of high specific IgM and/or IgA titres and high titres of anti-keyhole limpet haemocyanin (KLH) IgG in acute infections.

Immunoregulation in relation to granuloma formation in chronic schistosomiasis seems to be predominantly cellular, implicating a CD8+ T lymphocyte that is activated by a set of cytokine mediators. When treated with sera from patients with chronic schistosomiasis, lymphocytes from patients with active schistosome infections inhibit granuloma formation *in vitro*. Circulating immune complexes may regulate granulomatous hypersensitivity to *S. mansoni* eggs in patients with chronic schistosomiasis by inducing macrophages to secrete suppressive prostaglandins.

14.6 Mortality

Mortality from schistosomiasis has been poorly documented in most endemic countries, and death certificates and patients' records rarely identify schistosomiasis as the underlying cause of death. There is, therefore, no doubt that mortality due to schistosomiasis continues to be underestimated, and improved data collection in health services is needed.

Annual mortality due to *S. haematobium* infection in east Africa has been estimated at 1 per 1000 infected adults. It has been estimated, however, that primary prevention by control of urinary schistosomiasis would reduce the global rate of carcinoma of the bladder by 5000-10 000 cases per year (5).

In 1984, the annual mortality due to schistosomiasis caused by *S. mansoni* in Brazil was estimated at 0.5 per 100 000 total population; at the same time in Suriname the figure was estimated to be 2.4 per 100 000 inhabitants. Before the introduction of praziquantel in China, severe acute schistosomiasis due to *S. japonicum* had a 2.5-20.7% mortality rate, and in Leyte, the Philippines, the annual mortality among 135 untreated patients was 1.8%. The control of schistosomiasis through large-scale chemotherapy in Brazil was associated with a decline in annual mortality between 1977 and 1988, from 0.67 to 0.44 deaths per 100 000 inhabitants.

It is expected that the more widespread use of current antischistosomal drugs for morbidity control in highly endemic areas will also reduce mortality. *S. intercalatum* infection has never been reported as a cause of death.

15. The parasite

Schistosomes are digenetic trematodes requiring a freshwater intermediate snail host to complete their life cycle. Five species of *Schistosoma* are important in different parts of the world, although *S. haematobium, S. mansoni* and *S. japonicum* are a greater threat to public health because of high prevalence, wide distribution and pathogenicity. Non-human schistosomes, including members of the genus *Trichobilharzia*, can cause swimmer's dermatitis and are a growing public health problem in countries with temperate climates.

15.1 Genetics

Different isolates of the same species may show marked differences in their biological characteristics. Intraspecific variation includes: differences in minor morphological characters; infectivity to snails; periodicity of cercarial emergence; response to drugs; ability to develop in different definitive hosts; growth rates; egg production; prepatency periods; pathogenicity; and immunogenicity. Means for characterizing schistosomes are continually being developed and refined. Examples include: scanning electron microscopy; chaetotaxy of cercariae; enzyme electrophoresis; molecular biology, including DNA analysis; snail compatibility studies; cloning and cryopreservation; and chronobiology techniques.

Compatibility between the parasite and its snail intermediate host is largely determined by genetic factors. Different strains of parasite exhibit different intermediate host specificities. There is a wide variability between snail populations and in responses to schistosome infection within the same species of snail and the same geographical area.

Oxamniquine-resistant strains of *S. mansoni* have been isolated in laboratory and field studies from Brazil, Kenya and Puerto Rico. Little is known about the normal variation in drug response of local parasite populations. Molecular studies on two strains of *S. mansoni*, one resistant and the other susceptible to hycanthone, have demonstrated that the development of resistance is accompanied by a genomic rearrangement.

15.2 Taxonomy

Out of 19 species of schistosome currently recognized, five are primarily human parasites: *S. mansoni, S. haematobium, S. intercalatum, S. japonicum* and *S. mekongi.* Other species occasionally infect people. The 19 recognized species can be subdivided into four different groups: *S. haematobium, S. mansoni, S. indicum* and *S. japonicum.*

15.2.1 *S. japonicum group*

This group contains *S. japonicum, S. mekongi, S. sinensium* and *S. malayensis. S. malayensis* is found in the foothills and mountainous regions of Peninsular Malaysia. It is a relatively recently described species, more closely related to *S. mekongi* than to *S. japonicum. S. malayensis* is compatible with *Neotricula aperta*, the intermediate host of *S. mekongi.* Both *S. malayensis* and *S. mekongi* are compatible with *Neotricula bollingi*, a snail not known to be a natural intermediate host for either species. The surface of *S. mekongi* shares many features with *S. japonicum*, but there are also major differences.

15.2.2 *S. haematobium group*

Field studies show that *S. curassoni*, within the *S. haematobium* group, is a parasite of domestic stock in Mali, Niger, Nigeria and Senegal. No evidence has been found to support the view that *S. curassoni* causes disease in people.

Two distinct strains of *S. intercalatum* are recognized, which differ from each other in certain biological characteristics including intermediate host specificity and the periodicity of cercarial emergence. Recent studies have confirmed the presence of a strain of *S. intercalatum* on Sao Tome and Principe that is closely related to the Lower Guinea strain.

Field studies have confirmed the existence of quite distinct strains of *S. haematobium* in parts of west Africa.

15.2.3 *S. mansoni group*

This group includes *S. mansoni*, the most important parasite causing intestinal schistosomiasis in the Americas and Africa, and the only parasite of this group infecting humans.

15.2.4 *Hybridization*

The original focus of *S. intercalatum* in Loum, Cameroon, is being gradually replaced by parasites with hybrid characteristics and *S. haematobium.* Additional foci of hybridization of *S. intercalatum* and *S. haematobium* have been identified elsewhere in Cameroon.

15.3 Snail/parasite relationships

With only one known exception, every species of schistosome is only capable of larval development in one particular species of snail or in several species belonging to the same genus. The one known exception is the cattle parasite, *Schistosoma bovis*, which is able to develop in two species belonging to different genera, *Bulinus truncatus* and *Planorbarius metidjensis.*

The behaviour of the parasite at the infective stage plays a critical role in its encounter with the host. A glycoprotein, uniformly distributed throughout

the body of *Biomphalaria glabrata*, facilitates the incorporation of methionine by the *S. mansoni* miracidium and determines its metamorphosis into a sporocyst.

Schistosomes divert their host's metabolites to their own uses by stimulating the production of a neuropeptide in the central nervous system of the snail, which inhibits oviposition by the snail.

Within the snail the production of second-generation sporocysts may be limited in time. The production of third-generation sporocysts may be essential for the colonization of the snail, as is the case with *S. mansoni*. With *S. haematobium*, third-generation sporocysts play only a minor role. They play a seasonal role with *S. japonicum* and no apparent role with *S. intercalatum*.

In addition, the site of sporocyst formation is not the same in all species; development takes place at the point of penetration with *S. mansoni*, whereas active migration is possible in *S. japonicum* infection.

Comparative studies on the periodicity of cercarial emergence of parental species and their hybrids suggest that the control of shedding patterns of *Schistosoma* spp. is genetically determined.

The pattern of cercarial emergence permits quick and easy distinction between human and animal schistosomes, even when they emerge from the same snail. In many cases, production continues for the lifetime of the snail and is related to the susceptibility of the snail to the parasite, with changing seasonal rates. Non-seasonal patterns of production are particularly marked in *S. mansoni* snail infections.

15.4 Mammalian reservoirs and schistosomiasis

Incidental infections of mammals and true reservoir hosts do occur; they are capable of maintaining the infection among themselves, without the presence of humans, but could cause human infection. Reservoir hosts of *S. haematobium* have not been found.

Animal reservoirs of *S. japonicum* are of major public health importance. In China, 40 species of wild and domestic animals belonging to 28 genera and 7 orders have been found naturally infected with *S. japonicum*. The major animal reservoirs other than humans are, in descending order of importance: cattle, buffalo, pigs, dogs and rats. In the lake region in China, infected animals contribute as much as 90% of the total potential contamination of the environment with *S. japonicum* eggs, whereas in the plains region they contribute less than 20%.

In the Philippines, animal reservoirs, including cows, carabaos (water buffalo), dogs and pigs, are considered responsible for about 25% of the total potential environmental contamination, with people accounting for the remainder. In Indonesia, five species of rodent as well as deer, wild pigs, civet cats, shrews and domestic animals (i.e. cows, buffalo, dogs and horses) are infected with *S. japonicum*. Infected mammals can no longer be

found in the formerly endemic areas of Japan. In endemic areas in the Lao People's Democratic Republic, dogs are the only animals known to be a reservoir of *S. mekongi.*

The mammals found with natural infection in endemic foci in Brazil are generally wild rodents and, rarely, marsupials. *Nectomys squamipes* and *Holochilus brasiliensis* (or *H. sciureus*) are the most frequent and most abundant rodent hosts of *S. mansoni* found in these areas. Since they can transmit infection, their epidemiological importance merits further study. In east Africa there is strong evidence that baboons and marsh rats are reservoir hosts of *S. mansoni* in a few areas.

16. The snail

Freshwater aquatic and amphibious snail intermediate hosts transmit schistosomiasis. Aquatic snails of the genus *Bulinus* transmit *S. haematobium* and the genus *Biomphalaria* transmits *S. mansoni*; amphibious snails of the genus *Oncomelania* transmit the *S. japonicum* group and the hydrobiid snails of the genus *Neotricula* transmit *S. mekongi.*

16.1 Taxonomy of snail intermediate hosts

The taxonomy of the snail intermediate hosts is based on their shell morphology, radula and anatomy, including that of the reproductive organs. Identification keys and handbooks can assist field identification of snails based on these characteristics.

Enzyme electrophoresis and isoelectric focusing are now well established techniques for studying snail chromosomes, and allow closely related species to be distinguished. Restriction enzyme analysis of DNA from *Bulinus* snails has been useful in revealing differences between poorly related species, but not between closely related species. However, the poorly related species can also be distinguished by classical morphological methods.

16.1.1 *Snail hosts of the S. japonicum group*

The systematics of the snail host of *S. japonicum* and related species outside China is well understood. Differences exist between *Oncomelania* spp. from the Philippines and from China, which justify the recognition of *O. quadrasi* as an individual species. Electrophoretic studies have revealed that *Neotricula aperta* is in fact a sibling species complex. It remains to be established which of the newly recognized *Neotricula* species is responsible for the transmission of *S. mekongi. Robertsiella kaporensis* is the intermediate snail host responsible for the transmission of *S. malayensis.*

16.1.2 *Snail hosts of S. mansoni*

The systematics of *Biomphalaria* spp. from both Africa and the Americas is well understood and their identification is not difficult. Biological

differences between populations of the same species found in Africa remain to be clarified.

16.1.3 *Snail hosts of S. haematobium*

Within the genus *Bulinus* the understanding of systematics has improved.

- *B. africanus* group. The taxon or taxa responsible for transmission on the east coast of Kenya have yet to be clearly identified. In west Africa the identity of a *B. umbilicatus*-like taxon has been questioned. As the taxon contains the intermediate hosts for several schistosome species, it needs to be identified.
- *B. forskalii* group. Questions on susceptibility and species identification remain to be answered in this group.
- *B. reticulatus* group. This group is well established.
- *B. truncatus/tropicus* group. The systematics of this group has not been agreed. *B. truncatus*, the intermediate snail host for *S. haematobium* in northern Africa, is reported to be spreading to islands in the Mediterranean, where it has not previously been found. The distribution of other species has also changed, e.g. a taxon similar to *B. natalensis* has been found in Cameroon, although *B. natalensis* has previously only been known in eastern and southern Africa.

16.2 Ecology of the snail intermediate host

Over the past few years our understanding of snail ecology has improved. Snail population dynamics show greater year-to-year variability than previously observed. Variations in snail density correlate more closely with climatic rather than with physicochemical factors.

16.3 Importation of snails

The extensive transport of freshwater plants either commercially or privately, or for exchange between botanical gardens, has often resulted in snail species passing natural barriers. In order to meet an increasing demand for ornamental plants and fish, commercially based breeding farms have been established, mainly in Asia, where *Biomphalaria straminea*, a snail intermediate host for *S. mansoni*, was discovered in 1973. Since then, the snail has spread in the areas around Hong Kong and into China. It is also spreading in tropical areas; it was first recorded in Costa Rica in 1976 and in the Dominican Republic in 1981.

16.4 Control

Snail control is one of the methods of choice for the control of transmission of schistosomiasis, and may entail the use of molluscicides, plant molluscicides, biological agents and environmental management. Chemical control remains the best method for the destruction of snail hosts. Two strategies for snail control have been in general use: focal control and area-wide control.

16.4.1 *Molluscicides*

No new molluscicide of any great significance has been developed in the past decade. Only one molluscicide, niclosamide, is predominantly used in control programmes. While copper salts have largely been abandoned for snail control, copper sulfate is still used in Egypt. B-2 (sodium 2,5-dichloro-4-bromophenol) is used in Japan against *Oncomelania nosophora*. Sodium pentachlorophenate is used in China.

Before using molluscicides the water bodies should be surveyed for the presence of snail hosts of schistosomiasis. The molluscicide application technique depends on the type of water body. In marshes and stagnant water the recommended technique is hand or power spraying. For slow-flowing water in small rivers, streams and irrigation canals, the application method known as drip-feed is used, where the chemical is applied at one dispensing point upstream of the stretch to be treated.

16.4.2 *Plant molluscicides*

Although there has been much research on plant molluscicides, none has been used extensively in an endemic country, nor have there been consistent efforts to ensure adequate supplies of the candidate compounds for laboratory studies (e.g. those extracted from *Phytolacca dodecandra* (endod), *Ambrosia maritima* and *Swartzia madagascarensis*).

16.4.3 *Biological control*

The most studied competitor-snails are *Thiara granifera, Marisa cornuarietus* and *Helisoma duryi*. However, experience has shown that such snails are successful only in very specific habitats. Neither the introduction of new snail species nor any other method of biological control of snail intermediate hosts is recommended in any area.

16.4.4 *Environmental management*

Natural water bodies, such as marshes, ponds and swamps, where snails breed and from where they may infest irrigation schemes and other water projects, can be modified or completely eliminated. Land can be reclaimed for agricultural purposes. In many countries, however, wetlands are now protected and where there is a significant risk, strict regulations should be applied to limit human settlement in these areas.

In irrigation development, selection of the technique (i.e. surface or overhead drip) is the first decision with potentially important health consequences. Where surface irrigation is the technique of choice, design features to reduce the risk of schistosomiasis transmission should be considered. Proper drainage has been effective in reducing transmission of *S. haematobium*. Other engineering measures are minimum night-storage facilities and, where feasible, canal lining. In Zimbabwe, specially designed hydraulic structures have been successful in maintaining low levels of snails. Environmental engineering has also been

important in the control of *S.japonicum* in China, Japan and the Philippines. Periodic removal of aquatic vegetation from canals and regular flushing of canals will help to reduce snail intermediate host populations.

The siting of human settlements in and near irrigation areas should be strictly controlled. The provision of water and sanitation should be given priority when planning a settlement.

17. Water supply and sanitation

Schistosomiasis and water are closely linked and the high prevalence of schistosomiasis in many parts of the world is directly related to human contact with natural water bodies. Some water contact is occupational and, to some extent, necessary, but most transmission of schistosomiasis occurs during water contact for domestic and recreational purposes.

Improvement of the water supply continues to be neglected as a measure for the control of schistosomiasis. Although in some countries, e.g. Botswana, Brazil and Zimbabwe, control activities have been linked to the development of, and investment in, water supply, such linkage tends to be nominal and there is generally little, if any, coordination.

17.1 Global situation

Modest progress in extending water-service coverage to the populations of developing countries, many of which are endemic for schistosomiasis, took place between 1980 and 1990 during the International Drinking Water Supply and Sanitation Decade (IDWSSD). In a report on the impact of the Decade on schistosomiasis (*16*), it was concluded that a 10-20% reduction in the number of people with schistosomiasis (18-36 million cases) might be achieved as a result of providing safe public water supplies. The impact has been shown to be greatest where prevalence is highest, indicating the need to match water supply programmes with epidemiological data to gain maximum cost benefit.

17.2 Country experience

Water supply is central to the control of schistosomiasis. Any control strategy that does not take this into account is likely to have only a temporary impact, sustainable only with a continued input of resources. A wide range of appropriate and affordable water supply and sanitation technologies is now available for most environmental conditions. However, a safe water supply by itself may not be sufficient to reduce disease transmission and epidemiological data are also necessary.

Water is used for a variety of domestic purposes that may not be satisfied by the provision of a hand pump or standpipe alone. The provision of safe water supplies catering for all domestic needs – not only drinking-water but also washing facilities, cattle watering facilities, and bathing – will

reduce not only transmission but also contamination since human contact with natural water bodies is reduced. The provision of latrines in the home is unlikely to affect transmission if people continue to have close contact with natural water elsewhere, whether for domestic activities such as washing or for agricultural or recreational purposes.

Water supplies in rural and urban areas of many developing countries have been difficult to install or maintain, largely for administrative reasons, in that most water supply programmes have been centrally planned and executed, perhaps with community participation, but usually without community responsibility. As a result of country experiences during the IDWSSD, it is expected that there will be more community management of water supplies and therefore greater community responsibility and control. Water supply interventions are being implemented in closer collaboration with communities and there are now many examples of communities in poor urban areas (e.g. in Brazil and Kenya) successfully managing their own water supplies, and as a consequence greatly reducing their dependence upon natural, usually contaminated, water. These situations are ideal for promoting schistosomiasis control within communities already motivated towards self-help and with proven ability to address priority issues.

Many studies of the impact of improved water supplies on health have not used methodology specifically to test the efficacy of such supplies in controlling schistosomiasis. However, one of the better studies, the intervention study from Saint Lucia, showed a 59% reduction in the prevalence of schistosomiasis in 0-10-year-olds, and a 27% reduction for all age groups, after installation of a safe water supply.

Domestic and social activites such as washing clothes, bathing and swimming account for most water contact and justify the emphasis on facilities at water points in addition to the tap or pump itself. Improvements in water supply and associated facilities have a significant impact on the infected community, as was demonstrated in Saint Lucia, where schistosomiasis control measures included provision of water facilities that reduced exposure to infected water for domestic purposes. Water supply must be adequate, particularly in the transmission season, and the system must be well maintained with delivery points conveniently located for easy access. Facilities for washing and bathing should be provided and the design of laundry units – such as height of washing slab or tub – should be discussed with the potential users. Little information is available on the effect of safe water supplies on *S. japonicum* infection. In spite of this species' extensive animal reservoir, water supply is still likely to contribute to the control of its transmission.

18. Diagnostic techniques

Parasitological, immunological and indirect techniques are available for diagnosing schistosomiasis. Quantitative estimates of the intensity of

infection are useful for epidemiological purposes and quantitative parasitological techniques suitable for use in control programmes have been developed.

18.1 Diagnosis in public health

Diagnosis for public health purposes requires that the technique is robust and simple, using supplies and equipment that are readily available (*14*). Development of diagnostic capacity is a goal of many health services and will contribute to overall efforts to control schistosomiasis.

18.1.1 *Parasitological techniques*

The selection of a parasitological diagnostic technique will depend on the resources available and the objectives of their use (*14*). A qualitative technique is adequate for identifying infected people in large-scale screening, and a number of different sedimentation and concentration techniques can be used. The sensitivity of these techniques compares favourably with that of quantitative techniques.

The quantitative urine filtration technique for *S. haematobium* and the Kato (cellophane faecal thick-smear) technique and its modifications for *S. intercalatum, S. japonicum* and *S. mansoni* can also be efficiently used in screening for infection (observation of one or more eggs) or in defining the intensity of infection (counting the number of eggs up to a specific limit: up to 50 *S. haematobium* eggs per 10 ml of urine or up to 34 *S. mansoni* eggs on a Kato-Katz template, i.e. ≥800 eggs/g of faeces).

The quantitative parasitological techniques can be used in a representative subsample of the target population. Commonly applied egg count classifications are: ≤100 eggs/g of faeces, 101-400 eggs/g and > 400 eggs/g in *S. mansoni* and *S. japonicum* infection; and < 50 eggs/10 ml of urine and ≥50 eggs/10 ml of urine in *S. haematobium* infection. However, these classifications may be adapted to the specific techniques used, the local epidemiological situation and the objectives of control. Geometric or logarithmic mean egg counts can be useful for monitoring.

The excretion of *S. haematobium* eggs in urine follows a circadian rhythm with a peak around noon. Specimens should preferably be collected between 10 a.m. and 2 p.m. For filtration of urine, filter paper, polycarbonate, polyamide or membranes derived from other synthetic fibres may be used, and staining of the eggs is required. Usually 10 ml of urine are filtered, but larger volumes can be examined to increase the sensitivity of the test; however, results should still be reported per 10 ml of urine.

The cellophane faecal thick-smear technique, first described by Kato and since modified, is widely accepted as a valuable compromise for field work on *S. mansoni, S. japonicum* and *S. intercalatum.* Slides prepared from templates delivering 20-30 mg clear within 15 minutes, allowing rapid screen-and-treat operations. Thick smears of 40-50 mg take 6-24 hours to

clear but are more sensitive. Slides may be stored for weeks and can be used for quality control. Instead of cellophane a second glass slide may be used as a coverslip. In primary health care programmes a Kato thick smear will also permit identification and counting of *Ascaris, Trichuris* and *Taenia* eggs. Hookworm eggs can only be seen for a short time after preparation of the Kato slide.

A miracidial hatching technique is widely used in China. It involves examination of several grams of stool, but is not quantitative and is being replaced in some areas by the Kato technique.

18.1.2 *Immunological methods*

Currently available antibody-based serological assays do not allow discrimination between active and previous infection or reinfection. The detection and measurement of circulating schistosome antigens in serum or urine may overcome some major shortcomings and show promise for future use in epidemiological studies and control programmes. Antigen detection may be especially useful for follow-up after chemotherapy. Before these methods can be considered for operational use, controlled trials and standardization are required.

18.1.3 *Other indirect methods*

Direct observation for gross haematuria is a simple and reliable indication of heavy *S. haematobium* infection in children in endemic areas. It can be used effectively at the primary health care level (*17*). Detection of microhaematuria by reagent strips is a valuable method for determining prevalence, for identifying infected individuals, and for assessing the effectiveness of intervention. In control programmes, a single high positive value for haematuria is a useful indicator for identifying patients for selective population chemotherapy.

18.1.4 *Quality control*

Supervised quality control should be based on two complementary principles. First, bias in interpretation of data will be avoided if sampling conditions, technical procedures and the expression of results are first standardized and adhered to. Second, the reliability of individual results should be checked by an appropriate control system.

18.2 Diagnosis in hospital patients

The diagnosis of infection in individual hospital patients is usually based on parasitological findings. Repeated stool examination by concentration techniques (such as the Merthiolate-iodine-formaldehyde concentration (MIFC) technique, formaldehyde-ether concentration, and sedimentation) may be used when infections are of low intensity. Twenty-four-hour urine collection will facilitate the diagnosis of *S. haematobium* infection of low intensity.

In the absence of eggs in the stool, and if clinically warranted, rectal biopsy with compression preparation of the specimen is a reliable alternative method of diagnosis if interpreted by an experienced observer. This method also permits determination of the viability of eggs. Antibody-based serological tests may be useful in patients not usually resident in endemic areas.

Cerebral and spinal manifestations of schistosomiasis can be difficult to diagnose. A history of water contact and other clinical manifestations of acute infection may suggest the diagnosis, but serological examination of the cerebrospinal fluid or invasive diagnostic procedures may be necessary.

19. Chemotherapy

The primary objective of chemotherapy in schistosomiasis control should be the reduction and prevention of morbidity. Whenever antischistosomal drugs are to be used the objectives of treatment must be clearly defined; the most appropriate drug(s) must be chosen; the correct dosage schedule must be followed; and adequate information on the drug and its side-effects must be widely available.

19.1 Current drugs

The treatment of schistosomiasis has been transformed by the introduction of praziquantel, which is effective, generally in a single dose, against all species of the parasite. It is thus of particular value in patients with mixed infections and those who do not respond adequately to other drugs. Other drugs include metrifonate, which is active against *S. haematobium*, and oxamniquine, which is effective against *S. mansoni*. The drugs are described in *WHO Model Prescribing Information: drugs used in parasitic diseases* (*26*). Other formerly used drugs have become obsolete.

19.1.1 *Praziquantel*

Praziquantel is a heterocyclic pyrazine-isoquinoline which is structurally unrelated to other anthelminthics and is highly active against a wide range of trematodes, including all species of schistosome pathogenic to humans. It is well absorbed when taken orally; it undergoes first-pass metabolism and 80% of the dose is excreted as metabolites in the urine within 24 hours. Schistosomes, however, do not metabolize praziquantel. Immediately after exposure the worms contract, lose their anchorage on blood vessels, and gradually disintegrate.

Praziquantel is effective in all forms of schistosomiasis, both in the acute stage and in patients with extensive hepatosplenic involvement. Even when cure is not obtained, egg counts in faeces or urine are often considerably reduced. Praziquantel is of particular value in: intestinal

schistosomiasis due to *S. japonicum, S. intercalatum* or *S. mekongi*, since these parasites are not responsive to oxamniquine; *S. mansoni* infections unresponsive to oxamniquine; and mixed infections with *S. haematobium* and *S. mansoni*, which otherwise require treatment with both metrifonate and oxamniquine.

Praziquantel should be taken after ingestion of food. A single dose of 40 mg/kg is effective in the treatment of *S. japonicum* infection in both adults and children, and the same dose is now recommended for all forms of schistosomiasis. The initial cure rate is usually 60-90% with egg reductions of 90-95% in those not cured. A paediatric preparation is not yet available but would be highly desirable.

When praziquantel is used in areas endemic for cysticercosis, its parasiticidal effect on cysts in the brain or eye can provoke a localized oedematous reaction. Praziquantel has not been shown to be mutagenic, teratogenic or embryotoxic. However, it is preferable to delay treatment until after delivery unless immediate intervention is essential.

Praziquantel is exceptionally well tolerated. However, in patients with heavy worm loads treatment may induce abdominal discomfort, bloody diarrhoea, nausea, headache, dizziness, drowsiness and, rarely, pyrexia, urticaria and rectal bleeding. Tablets should be kept in well closed containers, protected from light.

19.1.2 ***Metrifonate***

Metrifonate is an organophosphorus compound originally used as an insecticide. It has selective schistosomicidal activity against *S. haematobium* resulting from its partial metabolism to a highly active anticholinesterase, dichlorvos. Schistosomal cholinesterase is more susceptible to this metabolite than that of the human host, but transient reductions in both plasma and erythrocyte cholinesterase activity are demonstrable at therapeutic dosage. However, despite early concerns about its potential toxicity, metrifonate is well tolerated and has been used effectively and extensively in mass control programmes.

In adults and children a dose of 7.5 mg/kg on three occasions at intervals of two weeks will cure 40-80% of patients. Even when viable worms remain, egg counts after one year are reduced to less than 20% of pretreatment levels.

Mass chemotherapy should not be undertaken in communities recently exposed to insecticides or other agricultural chemicals with an anticholinesterase action. Treated patients should not receive depolarizing neuromuscular blocking agents such as suxamethonium until at least 48 hours have elapsed from the time of metrifonate administration. Metrifonate has not been shown to be teratogenic or embryotoxic, but it is preferable to delay treatment until after delivery unless immediate intervention is essential. In the absence of information on whether

metrifonate is excreted in breast milk, it should preferably not be administered to nursing mothers. After administration, abdominal pain, nausea, vomiting, diarrhoea, headache and vertigo are common. Cholinergic symptoms rarely occur with currently recommended dosages. Atropine sulfate (for adults, 1 mg intramuscularly every 6 hours) may be used as a specific antidote to relieve symptoms of cholinergic activity. This does not impair the antiparasitic action.

Metrifonate tablets should be kept in tightly closed containers and stored at a temperature not exceeding 25 °C, preferably in a refrigerator.

19.1.3 *Oxamniquine*

Oxamniquine is a tetrahydroquinoline derivative with selective and variable schistosomicidal activity against *S. mansoni.* Oxamniquine is reliably absorbed when administered orally and is extensively metabolized to inactive acid metabolites that are excreted in the urine. It is well tolerated and has been used effectively and extensively in control programmes in South America. Male schistosomes are more susceptible than females but residual female worms cease to lay eggs after exposure and are no longer of pathogenic significance. Resistant strains, which have been reported particularly in South America, have subsequently been effectively treated with praziquantel.

Oxamniquine is used for the treatment of schistosomiasis due to *S. mansoni* both in the acute stage and in patients with hepatosplenic involvement. The effective dose varies between 15 mg/kg and 60 mg/kg given over two to three days, but dosage recommendations should be based on local experience.

Since oxamniquine has been known to cause seizures, epileptic patients should remain under observation for several hours following treatment. Oxamniquine has not been shown to be teratogenic or embryotoxic. However, it is preferable to delay treatment until after delivery unless immediate intervention is considered essential. In the absence of information on whether oxamniquine is excreted in breast milk, it should preferably not be administered to nursing mothers.

Transient dizziness, drowsiness, and headache, usually mild, may occur. Levels of serum transaminases are transiently raised in some patients, but the drug may be safely used in patients with severe hepatosplenic involvement. In Egypt and some other countries within the eastern Mediterranean region some patients have developed transient fever, peripheral blood eosinophilia and scattered pulmonary infiltrates (Löffler syndrome) after a three-day course of treatment has been completed. Capsules and syrup should be kept in well closed containers, protected from light.

19.2 Treatment and retreatment schedules

Periodic treatment is now established as a central component of schistosomiasis control. Experience with community-based chemotherapy to control schistosomiasis has demonstrated that appropriate drug treatment lowers worm burdens and prevents or reverses disease caused by all schistosome species.

Various operational approaches are used with the dual objectives of reducing the prevalence and intensity of established infections and decreasing the intensity of transmission. Treatment of a high proportion of the infected individuals in a locality within a short period of time promotes achievement of both objectives.

Several useful approaches for community-based treatment have been developed to match the epidemiology of schistosome infection and associated disease. They include:

- Mass treatment: treatment of entire populations without regard to individual infection status.
- Selective population treatment: treatment of infected persons identified by a diagnostic survey of the whole population.
- Selective group treatment: treatment of all or of infected members of a high-risk age or occupational group.
- Phased treatment: use of the above strategies in a sequence of progressively greater selectivity.

Epidemiological data indicating a high prevalence of infection at the beginning of a control programme may justify treatment of entire populations without further individual diagnosis. If the response is satisfactory according to predefined goals for coverage of the population and reduction of infection levels, selective approaches are then recommended. Unnecessary treatment is unacceptable; after mass treatment, various minor, transitory side-effects are likely to be seen in the treated population.

In order to increase cost-efficiency, treatment strategies can be adapted to prevalence levels in accessible indicator groups within a community, often 7-14-year-old children. These children are usually easily located at school for stool or urine examination and are also usually the most heavily infected group in the community. Treatment based on this method is empirical and aims to cover most people at risk for minimum cost; one variant may be to treat the entire population if the prevalence in 7-14-year-olds exceeds 50%, all children aged 5-19 years if the prevalence is between 20% and 50%, and all children positive on screening if the prevalence is below 20%.

A little-used strategy is that of targeting chemotherapy to people with high egg counts. However, with the decreasing price of drugs and the recognized clinical improvement in all infected patients, withholding treatment from any infected individual becomes increasingly difficult to justify.

In some endemic countries severe economic constraints may preclude the use of community-based treatment. In such situations morbidity control can be achieved by a passive surveillance strategy which ensures that appropriate drugs are always available at health institutions for the treatment of patients who present with schistosomiasis.

The principal goal of retreatment schedules must be to protect 5-19-year-old children as they grow older and continue to be infected. Retreatment may be required at intervals ranging from one to five years according to the surveillance data. Adults, and particularly those at risk of infection through their occupation, should be treated if and when the intensity of infection increases.

Two drug delivery strategies have been used over the past decade. At the outset, treatment may be given by specialized control units that have identified and mapped transmission sites, assessed the level of morbidity, and educated health workers and the community about the control programme. Every effort should then be made progressively to integrate subsequent diagnostic surveys and treatments into the existing health care system.

In any event, chemotherapy should be available from the start through the general health care system; in low-prevalence areas, this may be the only source of treatment. Trained community health workers, a permanent community-based system for diagnosis of infection, an adequate distribution network for the chosen drug(s), and an informed participating population are required. Community participation makes integration with environmental improvements more likely and improves compliance with all elements of a schistosomiasis control programme. Experience has shown that community-based control programmes are feasible and effective.

Both types of drug delivery system need well defined operational goals and quality control systems to monitor diagnosis and drug treatments. In this regard delivery in the health care system poses special problems related to supervision and repeated in-service training. These arise because health workers involved in primary health care cannot easily develop the same degree of expertise for diagnosis, record-keeping or treatment as those dedicated to these tasks in a vertical programme. Centrally based specialized control programmes are difficult to sustain and do not easily integrate with other important activities such as provision of safe water supplies, sanitation and community education.

19.3 Effects of chemotherapy

In *S. haematobium* infections, reagent-strip urine analysis before and after treatment with metrifonate or praziquantel has shown a significant reduction, up to 95%, in the prevalence of haematuria and proteinuria, especially in children. In some people with heavy infection before

treatment, haematuria and proteinuria persist after treatment, although no eggs can be found. These individuals will require further examination.

Gross haematuria due to *S. haematobium* infection usually disappears after chemotherapy, as do dysuria, frequency of micturition and suprapubic or abdominal pain. The disappearance of bladder granulomas after metrifonate or praziquantel chemotherapy, with subsequent relief of obstruction and resolution of hydroureter and hydronephrosis, has been well confirmed. Along with the improvement of the obstructive uropathy, renal function, as shown by urine concentration tests, phenolsulfonphthalein (PSP) excretion, and creatinine clearance, generally also improves.

Lesions of the urinary tract in children usually resolve after treatment; however, in adults the severe changes with bladder calcification may not regress. In a recent study of the use of metrifonate in *S. haematobium* infection, adult male patients gained weight and their fitness scores improved after treatment, and children showed improvement in anthropometric indices. The activity scores of the treated children increased significantly compared with untreated controls at three- and six-month follow-ups (*3*).

Chemotherapy is generally recognized to be the most important rapid and cheap method to reduce morbidity due to *S. japonicum* infection. After praziquantel treatment, a reduction in size of the liver and spleen has been reported in China, Indonesia and the Philippines. Cerebral schistosomiasis has been successfully treated with praziquantel.

Treatment of infected individuals with oxamniquine or praziquantel diminishes or eliminates excretion of *S. mansoni* eggs, reducing contamination of the environment. In children, hepatomegaly and periportal fibrosis, as assessed by ultrasound and liver biopsy, regress after treatment (*13, 27*) and, in those heavily infected, the development of hepatosplenic schistosomiasis is reversed. Treatment may not resolve large or pedunculate polyps of the large intestine and the associated symptoms. In these cases multiple endoscopic polypectomy may be the treatment of choice. Hepatic schistosomiasis with splenomegaly, with or without ascites, can be safely treated with either oxamniquine or praziquantel.

19.4 Drug resistance

Resistance to antischistosomal drugs in current use is uncommon. It is necessary to distinguish *true drug resistance* from *treatment failure*. There have been no published reports of drug-resistant strains isolated from patients infected with *S. haematobium* or *S. japonicum*. In Kenya, poor cure rates were reported for metrifonate, suggesting that drug-tolerant *S. haematobium* may be present. In Brazil and Kenya, similarly, tolerance of *S. mansoni* to oxamniquine has occasionally occurred. However, tolerance or resistance to praziquantel has not been reported under experimental conditions or in the field. In view of the evidence currently

available, systematic monitoring is only recommended if resources are available to national research institutions. For other parasites, sub-curative doses have been shown to give a biological advantage to resistant parasite strains; thus the need to use standard dosage schedules must be emphasized.

19.5 Treatment of acute schistosomiasis

Oxamniquine and praziquantel have been used for the treatment of acute toxaemic schistosomiasis. The reduced efficacy of these drugs against immature worms in experimental animals has been confirmed in patients with Katayama fever. Clinical and experimental evidence indicate that steroids act synergistically with antischistosomal drugs in the treatment of Katayama syndrome.

19.6 Interaction with other antiparasitic drugs

In most endemic countries schistosomiasis coexists with intestinal and other parasitic diseases. Praziquantel has a wide spectrum of activity against intestinal flukes and there are attempts to expand its range by combining it with other preparations. Drug combinations are being considered for intestinal parasites and schistosomiasis, but require further study before large-scale use.

Progress in control

20. Country experience in control

In its previous report (*1*), the Expert Committee outlined three main phases of schistosomiasis control:

1. *Planning phase.* This consists of: collection of baseline epidemiological data, preparation of a national plan of action with quantitative objectives and definition of operational approaches (see Annex for definition of outcome indices), and allocation of resources.
2. *Attack/intervention phase.* Intensive control operations are carried out according to a planned timetable and are continually evaluated. In this phase a rapid reduction in prevalence and intensity of infection can be anticipated. Preparations for maintenance should be started at the beginning of intervention.
3. *Maintenance.* This is a protracted follow-up period during which measures such as those related to health education, water supplies and sanitation will be maintained. Resources will be used to support established facilities, especially laboratory facilities, and primary health care for surveillance and monitoring.

The information below comes from countries that have operational control programmes in all these phases.

20.1 Countries where *S. haematobium* is endemic

20.1.1 *Algeria*

Urinary schistosomiasis is endemic in one focus in the north of the country and in three foci in the south. The objectives of the national programme are to eradicate the focus of disease in the north, to reduce morbidity in the south, and to train and maintain control staff in the endemic foci.

The strategy of control consists of screening and treatment campaigns as well as health education and snail control by molluscicide and environmental management. The programme is currently in the attack phase in the northern focus and at the preparatory phase in the south. The programme in Djanet in the south is in the consolidation phase.

In Hamiz El Khechna in the north, the proportion of the population excreting over 50 eggs per 10 ml of urine dropped from 4.5% in 1987 to 2.9% in 1988. Infected patients were treated with a single dose of praziquantel at 40 mg/kg of body weight. During the first quarter of 1991 prevalence fell to 1.1%.

Progress in the southern foci has been slower. A survey conducted before 1985 showed a prevalence of over 40% in Tamadjert. The prevalence has dropped to 33% in subsequent surveys. In Djanet, control activities carried out since 1985 have eliminated disease in the indigenous population since 1989. However, occasional cases are reported as a result of population movement in this frontier region.

20.1.2 *Mauritius*

Before 1988 there was no systematic schistosomiasis control programme in Mauritius. The most recent survey at that time dated back to the 1950s when the overall prevalence of *S. haematobium* infection among schoolchildren was found to average 9.2%.

The current programme is centrally managed in coordination with the district health offices. Its aim is to reduce morbidity and it uses urinary egg count as the main indicator of disease. A strategy of single-dose treatment of selected patients with praziquantel has led to a significant reduction in prevalence among schoolchildren as well as in the general population. Follow-up surveys at schools where prevalence had been highest (between 1.2% and 8.2%) all confirmed eradication of the disease. Prevalence in the general population fell from 6.6% in 1988 to 1.9% in 1989 and 1.3% in 1990. Cure rates after single-dose treatment were 93% and 96% in schoolchildren and the general population, respectively.

As a result of the low endemicity of schistosomiasis in Mauritius, there is little public awareness of the disease as a health problem and poor compliance for screening and treatment. However, there has been a marked decrease in prevalence and a reduction in morbidity among schoolchildren over the past three years. The programme will now focus on transmission control in those areas where it persists.

20.1.3 *Morocco*

Urinary schistosomiasis was originally localized in a few rural areas in certain southern regions of the country. The implementation of an extensive programme of water resources development in the late 1960s resulted in the establishment of new foci, particularly in the central and north-eastern parts of the country. About 5% of the total rural population is directly exposed to the risk of infection. Of the several thousand cases reported each year, 80% were from the southern provinces. Children under 14 years old were the most severely affected age group, accounting for 65% of all cases.

A schistosomiasis control programme was established in the mid-1970s with the aim of reducing the prevalence of schistosomiasis. The short-term objective was to prevent the establishment of new foci of transmission in irrigated areas.

The control strategy is based on chemotherapy, with molluscicides being used only as a supplementary measure. The operational basis for this strategy is the existing rural health infrastructure (health centres, dispensaries and laboratories).

Until 1988, people infected with *S. haematobium* were treated with three doses of metrifonate, 7.5 mg/kg of body weight, at two-week intervals. Since 1988, treatment has been with praziquantel alone, in a single dose of 40 mg/kg of body weight. Follow-up examinations are carried out 4 and 12 months after treatment. Cure rates increased from 82% in 1982 to 98% in 1990.

There is a central body responsible for planning, supervision and evaluation of the various control activities. The existing staff of the health units take on the specific tasks of schistosomiasis control in addition to their normal duties.

Extension of control activities to the entire country from 1982 onwards was also accompanied by the establishment of the control-programme information system, which provided the data and the indicators needed for assessing the efficacy of the activities and their impact on the evolution of schistosomiasis. Between 1982 and 1990 the number of patients examined annually ranged from 105 542 to 172 781. The number of cases detected annually since 1982 has ranged from a maximum of 10 628 in 1983 to a minimum of 2568 in 1987. The programme is succeeding in interrupting transmission. Some foci of transmission have been completely eliminated, and others are largely under control. Prevalence fell from 7.8% in 1983 to 2.3% in 1990.

20.1.4 *Tunisia*

The control programme started in 1970 has reduced transmission of schistosomiasis by molluscicide to eliminate the snail intermediate host, *Bulinus truncatus*, and by treating anyone found to be infected. The last cases of infection were recorded in 1982 and, since then, no new infections

have been reported. A permanent surveillance programme exists in order to prevent reintroduction of the snail host.

20.1.5 *United Republic of Tanzania: Zanzibar*

Schistosomiasis is an important public health problem on the two islands of Zanzibar, Unguja and Pemba. It is estimated that at least 45% of the 600 000 population of Pemba and Unguja have urinary schistosomiasis.

The pilot project on the control of schistosomiasis in the Kinyasini area of Unguja was successful in reducing the prevalence from 49.4% to 11.2% between 1981 and 1983 by means of selective population chemotherapy with metrifonate and health education. No further intervention has taken place on Unguja since the pilot project; however, people from the rural areas with signs and symptoms of schistosomiasis have been examined and, if required, treated with metrifonate. Haematuria, an indicator of *S. haematobium* infection, was found in 79.5% of 5-14-year-old children in 1986 and 91.0% in 1990 on Unguja.

The schistosomiasis control programme in Pemba (supported by WHO, the German Pharma Health Fund and the *Direzione Generale per la Cooperazione allo Sviluppo* of the Ministry of Foreign Affairs of Italy) used a similar primary health care approach to the one in Kinyasini. Direct observation and reagent strips were used to detect haematuria. These techniques were systematically evaluated and found to be reliable indicators of infection by comparison with microscopic examination. Praziquantel was used for selective population chemotherapy of children and communities. Control activities within the community were centred on primary health care units (dispensaries), and schools (thus involving the teachers). Public awareness and education of the teachers and health workers were also emphasized. There has been a gradual decrease in the prevalence of schistosomiasis since the introduction of the control programme. Haematuria in schoolchildren fell from 54.1% in 1986 to 16.7% and 10.0% in 1989 and 1991, respectively. Using the primary health care operational base, the control activities are now being expanded to include the detection and treatment of malaria and intestinal parasites.

20.2 Countries where *S. mansoni* is endemic

20.2.1 *Brazil*

In 1990, 30 million people in Brazil were estimated to be at risk for schistosomiasis. Between 1975 and 1980, about 4.5 million drug treatments for schistosomiasis were administered throughout the country. Diagnosis was by stool examination in 7-14-year-olds, who were then given chemotherapy if necessary. Chemotherapy schedules varied according to the prevalence of the disease in the sampled population. *Biomphalaria* breeding sites in impounded water sources were molluscicided intermittently. Basic sanitation was limited to the setting up

of dry cesspools, as well as public water supplies and collective laundries in a few hyperendemic localities.

In 1988, the programme strategy and approaches were reviewed and important changes were implemented with regard to objectives and interventions. The areas covered by the programme were classified in order to allow an approach to control according to regional and local epidemiological conditions. Objectives also differed according to the area, ranging from suppression of severe clinical schistosomiasis in hyperendemic areas, to interruption of transmission in isolated foci and prevention of the disease in vulnerable areas.

Recent evaluations show a declining annual prevalence of schistosomiasis and a reduction in mortality for the whole country. Between 1977 and 1988 mortality fell from 0.67 to 0.44 deaths per 100 000 inhabitants, corresponding to a reduction of 34% over 12 years. Prevalence appears to be rising in some areas of north-east Brazil. With the success of the schistosomiasis control programme come new challenges, not only to maintain what has been achieved but also to improve results still further. More effort must be made to promote involvement of the primary health care system in implementing control measures, in particular by ensuring the availability of diagnosis and treatment. A further challenge is to coordinate efforts with ministries and institutions responsible for education, water supply and sanitation, in order to address the problems of hyperendemic and other areas where different approaches from those of the normal control programme are necessary.

20.2.2 *Burundi*

Schistosomiasis due to *S. mansoni* is endemic in Burundi in the western lowland area of Imbo, including the capital, Bujumbura, and in a small isolated focus around a highland lake. Prevalence varies considerably, from 3% up to 70%, with moderately intense infection. There is considerable intestinal, but limited hepatosplenic, morbidity, and low but detectable levels of transmission. A national schistosomiasis control programme was implemented in 1985. The control strategy was based on selective mass chemotherapy in rural areas and yearly selective chemotherapy for primary-school children in urban areas (Bujumbura, Rumonge). These measures were supplemented by focal snail control and health education. From the start emphasis was also put on water supply and environmental intervention, including public laundries, showers, and foot bridges, and on sanitation (individual and pool latrines). Some 150 000 people have by now been examined and, if positive, treated by mobile and local teams. In different localities, prevalence was reduced by 50%–70%, one to three years after treatment.

Treatment is now integrated with primary health care, but in certain areas the impact of the programme is limited because of poor coverage by health centres; for example, in the Kirundo area, a single health centre serves 45 000 people. After initial selective chemotherapy, further chemotherapy

campaigns will be necessary to maintain control. Widespread health education and programmes to improve water supply and sanitation are in progress.

20.2.3 *Dominican Republic*

Schistosoma mansoni was first reported in the Dominican Republic in 1942. Since 1972 the main endemic areas have been in El Seibo and Higüey in the eastern region. Three new foci in the eastern provinces as well as three foci in the centre of the country were discovered during the 1980s. Prevalence varies from as high as 24.6% in one suburb of Higüey, to 7-10% in the other villages. The mean intensity of infection remains low (5-14 eggs/g of faeces).

The recognized snail intermediate hosts are *Biomphalaria glabrata* and *B. straminea.* Since 1984, a few studies have determined the distribution and extent of disease in the country. Praziquantel is now available for treatment, but the schistosomiasis control section of the Ministry of Health has no systematic plan of action in the endemic areas.

20.2.4 *Suriname*

Since 1974, several epidemiological surveys have been carried out in Suriname, showing a prevalence of schistosomiasis as high as 26% in some communities. The intermediate snail host, *B. glabrata,* has been found beyond the present areas of transmission as far afield as Nickerie district in the west and Marowijne district in the east.

The objective of the schistosomiasis control project, initiated in 1974, was to reduce the prevalence of schistosomiasis to 5%, a level at which control could be integrated into primary health care services. In 1982, a policy statement issued by the Ministry of Health set the stage for this integration to occur. Phase 1 of the schistosomiasis plan of action lasted until 1983, when phase 2 was started. Prevalence continues to fall in most endemic areas. However, in some areas near the capital, Paramaribo, it has not been possible to maintain low prevalence, owing mainly to environmental degradation.

20.2.5 *Venezuela*

Since the beginning of the schistosomiasis control programme in Venezuela in 1943, the prevalence of the disease has steadily declined.

This has been brought about by use of molluscicides for vector control, sanitary education, sanitation engineering (e.g. water supplies, latrine construction, rural housing) and chemotherapy. However, after achieving low prevalence, it has not been possible to eradicate the disease in certain areas, in spite of maintaining the above control measures.

Between 1989 and 1991, important and deleterious social and economic changes occurred in the country, coinciding with a steady increase in prevalence of the disease in children under 10 years old, rising from 0.1%

in 1988 to 0.9% in 1991. In this area of low prevalence and low intensity of infection, both serological testing and the Kato stool examination method have been used to monitor the application of control measures.

20.3 Countries where both *S. haematobium* and *S. mansoni* are endemic

20.3.1 *Botswana*

A control programme, planned and coordinated by the National Schistosomiasis Task Force, was established in 1985 in Ngamiland district, with the objective of developing a national schistosomiasis control programme. By using mobile teams within the primary health care system it was hoped to control *S. mansoni* infection by reducing prevalence by at least 75%, and reducing heavy infection (defined as > 100 eggs/g of faeces in Botswana) by at least 90% among schoolchildren by January 1988.

In some areas a local task force, consisting of members of the district health team, was also set up. The Kato technique was used for diagnosis and treatment was with praziquantel, 40 mg/kg of body weight in a single dose. In all schools of the Ngamiland district, between 1985 and 1990, disease prevalence was reduced from 34% to 6.7%.

Community surveys were carried out by mobile (field) teams after planning with local authorities and health facilities. The aim was to identify and treat adults and children not attending schools (about 30% of the school-age population) who were at risk for the disease. Integration of the control programme into the health services to maintain its achievements is now the major challenge.

20.3.2 *Egypt*

S. haematobium and *S. mansoni* infections are prevalent among the inhabitants of the Nile Delta region in Lower Egypt, and in Giza Governorate to the south of Cairo. *S. mansoni* is now commoner than *S. haematobium* in the irrigated area of the Nile Delta. In Upper Egypt, *S. haematobium* infection is prevalent.

In 1988, the aim of the control strategy was changed in order to control morbidity due to schistosomiasis rather than its transmission. This strategy is based on selective population chemotherapy, snail control (chemical molluscicide), health education and community participation, and environmental sanitation and management.

Praziquantel is used to treat both types of schistosomiasis in a single dose of 40 mg/kg of body weight. Since 1988, praziquantel has been available, free, to all patients with a positive diagnosis at all rural health centres and endemic diseases hospitals throughout Egypt.

Molluscicide is carried out in villages with a high prevalence of schistosomiasis (20% or more) and in sites where water courses are infested with infected snails. Niclosamide is the molluscicide used in the

areas covered by the national programme. In areas where the national programme has not been implemented, copper sulfate is used.

From 1984 to 1990, *S. haematobium* prevalence in Fayoum was reduced from 15.7% to 13.8%; in High Dam Lake from 11.9% to 8.1%; in Middle Egypt from 10.3% to 7.3%; in Upper Egypt from 13.6% to 9.5%; and in Giza from 10.4% to 4.9%. The prevalence of *S. mansoni* in the Suez Canal Zone was reduced from 18.3% in 1986 to 16.7% in 1990, and in Western Nubariya from 46.6% to 3.9%. The total number of infected individuals in Egypt in 1990 was estimated to be 5-6 million.

20.3.3 *Ghana*

The aims of control in Ghana are to reduce prevalence and morbidity. Health education is used to teach communities about schistosomiasis and encourage those with the disease to seek treatment at the nearest clinics.

Urinary schistosomiasis is more common than intestinal schistosomiasis, which is limited to a few widely scattered localities. Large-scale ecological changes and population movements have brought about conditions favourable to the rapid spread of the disease. Many water development projects, such as at Lake Volta and Lake Kpong, the Tono Irrigation Project, the Weija reservoir and other smaller water projects throughout the country, have resulted in new foci of transmission.

In 1989, a simple questionnaire survey on urinary schistosomiasis was carried out throughout the country as part of the Ghana Guinea Worm Eradication Project. It was the first survey of its kind in the country and the results probably underestimate the true situation. Out of the 17 320 villages visited, 5947 (34.3%) were found to have cases of urinary schistosomiasis.

In view of the high prevalence of *S. mansoni* in the Lower Volta District, systematic mass treatment with praziquantel was carried out in all the schools in the area. After one cycle of treatment there was a significant reduction in prevalence among the schoolchildren. Passive treatment of outpatients at hospitals and clinics remains an important component of schistosomiasis control. Inadequate and irregular supplies of antischistosomal drugs and lack of reliable transport persist as major problems.

20.3.4 *Madagascar*

During the 1980s, the results of two pilot projects integrating schistosomiasis control with basic health services raised expectations about the feasibility of a successful national programme. The first project, in Majunga province, conducted by the German Agency for Technical Cooperation (GTZ), achieved a reduction in prevalence of *S. haematobium* to below 20% in three years in a population of 160 000. The second project focused on *S. mansoni* infection in Toamasina province and was implemented through the primary health care system. It achieved a reduction in prevalence from 41% to 28% over three years. Rapid

reinfection has occurred in this area since the project was discontinued because of lack of resources.

Encouraged by the results of these projects, the Ministry of Health has proposed a national control programme, but lack of resources continues to hamper this new initiative.

20.3.5 *Malawi*

Recent surveys indicate that schistosomiasis occurs in all settled areas of Malawi and appears to be more widespread than previously reported. The strategy of control since 1984 has been a combination of chemotherapy, health education, improved water supply and sanitation, and selective snail control. Since 1984 the control programme has been restructured, with the support of the German Agency for Technical Cooperation (GTZ), to emphasize the integration of schistosomiasis control into the primary health care system and the involvement of other sectors related to health. During 1982-1983, pilot studies in an area of mixed *S. mansoni* and *S. haematobium* infection (Nkhoma) showed decreases in prevalence after a single treatment, with wide differences between villages. These decreases were sustained up to eight years after treatment. The overall prevalence was 54% before treatment and 20% four years afterwards. In schoolchildren, the prevalence of *S. mansoni* infection dropped from 71% to 12% four years after treatment.

The reduction in prevalence of *S. haematobium* infection in communities and schools in another area (Zomba) was not sustained more than two to three years, and prevalence has now returned to pretreatment levels.

At this stage of the programme only a small proportion of the population at risk has been diagnosed and treated. The main problems have been a lack of resources to train health workers to implement the programme and the high cost of antischistosomal drugs.

20.3.6 *Mali*

The main endemic areas of urinary and intestinal schistosomiasis in Mali are the Office du Niger, a vast irrigation scheme north of Ségou, and the Dogon plateau; foci of urinary schistosomiasis are found along the Niger river and especially in the Inner Delta. A local schistosomiasis control project was started in 1979 as a health component of a small dam construction project in the Dogon area. In 1982 it was transformed into a national pilot control project, supported by German Agency for Technical Cooperation (GTZ). The main objective of this project was to reduce the prevalence of schistosomiasis to an acceptable level and to integrate control measures into the primary health care system.

Control was based mainly on community chemotherapy implemented by mobile teams. The intervention strategy was mass treatment if the prevalence in a population sample was over 75%, selective treatment if it was between 20% and 50%, and no intervention if it was less than 20%.

Between 1980 and 1987, the project covered 136 villages, with a total population of about 125 000 people, in the four intervention zones.

By 1987 the target prevalence (< 20%) was achieved in 41% of the *S. haematobium* villages, and 26% of the *S. mansoni* villages. The target reduction of intense infections (to less than 5%) was reached in 64% and 22% of the villages, respectively.

Based on the experiences of the project, a national control programme, targeted at the Office du Niger and Dogon Land, was adopted in 1988. A strategy of mass treatment, implemented by the district and local health services, was adopted, based on epidemiological assessment, monitoring and coordination by a central team. By the end of 1990, some 91 000 people had been treated by the local teams.

20.3.7 *Nigeria*

Schistosomiasis is endemic in Nigeria and its prevalence remains high, especially among children aged 6-12 years. A national schistosomiasis control programme was established in 1989, consisting of: (1) a national prevalence survey among children aged 5-14 years; (2) treatment of infected children with praziquantel once every year or two years; and (3) five designated pilot project areas where field operational research could be carried out.

The national prevalence survey among children was carried out in 18 out of 21 states and the disease was found in all 18. Outpatient visits because of complaints related to schistosomiasis have risen steadily, showing a 60% increase between 1989 and 1990. Treatment in general health services is not readily available and the high cost of praziquantel is the main obstacle to the implementation and maintenance of the control programme.

20.3.8 *Saudi Arabia*

In 1967 over a million people were estimated to be infected with schistosomes in different regions of the country. In 1974, the prevalence of *S. mansoni* was 91% in Al Khobar district in Gizan province, and 75% in Kheibar, Madina province. In 1973-1974 schistosomiasis control centres were established in endemic provinces to carry out control programmes based on diagnosis and treatment of infected individuals with the antimony compound stibophen, snail control by niclosamide, and health education.

In 1985 a new control strategy was implemented, based on surveys to determine the exact distribution of the disease, case-finding and treatment of at least 80% of those infected. The strategy aimed at reducing the prevalence of the disease to less than 1% over two to five years. At present, praziquantel is the only drug in use in all endemic areas. Since 1988, schistosomiasis control has been integrated into the primary health care system.

The overall prevalence in all parts of the country fell from 11% in 1983 to 1.9% in 1987. *S. mansoni* was reported in all 12 endemic provinces but *S. haematobium* was predominant in Gizan province in the south-west. The overall prevalence of schistosomiasis in Saudi Arabia is now very low (0.52%) but varies widely between different parts of the country. In 1990-1991, 54.2% of infected people were non-Saudis. In the Madina, Al-jouf and Taif provinces, the number of infected non-Saudis represented 98%, 89% and 77%, respectively, of the total number of those infected. Through use of the primary health care system, the annual coverage of the target population rose from 10.9% in 1983-1984 to 62.7% in 1990-1991, and about one million people were examined in 1990.

20.3.9 *Sudan*

The Gezira-Managil scheme is one of the largest irrigation projects in Africa. Transmission of both urinary and intestinal schistosomiasis occurs throughout the area and has spread into newly irrigated areas.

Since the early 1970s, the prevalence of *S. mansoni* has risen while that of *S. haematobium* has fallen. By the mid-1970s, *S. mansoni* infection was widespread, with a prevalence of about 70%, whereas *S. haematobium* was present focally at a prevalence between 1% and 15%.

The Blue Nile Health Project control programme was started in 1979 with the aim of reducing the prevalence of schistosomiasis to 10%. The project's integrated strategy includes health education and community participation, provision of domestic water supplies and improvement of sanitation, focal molluscicide and chemotherapy for schistosomiasis. Field units implement the comprehensive control strategy which now covers the whole area of the Gezira-Managil and Rahad schemes, lying east of the Blue Nile.

Mass chemotherapy is used in any village where the prevalence among schoolchildren exceeds 40%. If the prevalence is below 40% selective population chemotherapy is used. Throughout the project area a network of trained laboratory microscopists is being built up to help with the diagnosis of both malaria and schistosomiasis as part of the maintenance programme after initial intervention.

The intervention in the study zone began in mid-1982 and since that time the overall prevalence of schistosomiasis has been reduced from about 50% in 1981 in 18 monitor villages, to about 10% in 1988 and 6% in 1989. In the Rahad scheme the prevalence in schoolchildren has risen slowly over the past seven years from 10% in 1982 to 14% in 1989. However, the prevalence in uncontrolled areas is very much higher. Among schoolchildren in the Managil area the prevalence is over 80% and over 60% in the populations of whole villages. Control of schistosomiasis in this economically important area requires a long-term commitment to staffing and maintaining adequate health services.

20.3.10 *Zimbabwe*

Schistosomiasis has remained a public health problem in Zimbabwe, coming within the top 10 causes of attendance at health facilities. From the results of a national survey of 14 614 schoolchildren from 157 schools around Zimbabwe, the country was divided into three zones according to the prevalence of urinary schistosomiasis and two zones for the intestinal form of the disease.

The prevalence of *S. haematobium* infection ranged from 13% to 97% (mean 62%) within the high-prevalence zone in the north-east, including Lake Kariba and the Zambesi Valley. These areas with high rainfalls and high temperatures are ideal for the transmission of schistosomiasis.

The rate of infection with *S. mansoni* was 15.2% in the north and south-eastern parts of the country, but only 1.5% in the rest of the country.

The Government of Zimbabwe has adopted a primary health care-based strategy for schistosomiasis control with the main objective to control morbidity. A multi-component strategy, using snail control, safe water supplies, adequate sanitation, health education and chemotherapy, is to be adopted. All components, except targeted chemotherapy and some aspects of snail control, will be embodied within the primary health care system. Studies have been undertaken on engineering measures to reduce schistosomiasis transmission in irrigation schemes.

A pilot control project, based on primary health care, was started in 1986, incorporating improved water supplies, sanitation, snail control, health education and chemotherapy of infected schoolchildren. From a pretreatment prevalence of *S. haematobium* infection in the pilot area that exceeded 60%, a reduction of about 40% was observed after 18 months, while *S. mansoni* prevalence in the same area was reduced from 17.5% to 8.2%. The pilot project and the Government's strategy for schistosomiasis control, emphasizing intersectoral cooperation and improved water supply and sanitation, should help to bring about further reductions in the prevalence, intensity and morbidity of the disease.

20.4 Countries where *S. japonicum* is endemic

20.4.1 *China*

Schistosomiasis control has been given high priority in public health work in China. By the end of 1989, schistosomiasis was declared to have been eradicated in the municipality of Shanghai, in the provinces of Guangdong and Fujian, and in the autonomous region of Guangxi. Among the 378 counties formerly endemic for schistosomiasis, the disease has been eradicated in 150, is under control in 110 and remains endemic in 118. In the four provinces, municipalities and autonomous regions where schistosomiasis has been eradicated, the prevalence is now zero, and in Zhejiang Province only 202 infected persons were reported in 1989. The average prevalence in the endemic provinces, five in the central lake region and two in the western mountainous region, was 4.6% in 1989.

From the 1950s until the early 1980s, both snail control and chemotherapy were integral components of the control strategy. After praziquantel became available for large-scale use, the major emphasis has been put on chemotherapy, while snail control has been carried out only in areas with a high risk of transmission. Some 16 000 professional staff and even more part-time, trained schistosomiasis control staff are involved directly in the national programme. Moreover, active community participation has played an important role in the control work.

Although remarkable progress has been made in the control of schistosomiasis, China is still facing important challenges to achieve control in the remaining endemic areas. According to a nationwide survey on schistosomiasis in 1989, in a population at risk of 40 million people, 1.5 million are infected and 60 000 have severe clinical disease. In the remaining endemic areas the epidemiological situation has been changing and in some areas the prevalence is going up. Acute schistosomiasis is now reported from cities in the lake region and in other rural areas the prevalence is increasing.

20.4.2 *Indonesia*

The endemic area for *S. japonicum* is limited to isolated localities in the Lake Lindu Valley and Napu Valley in Central Sulawesi, with 12 000 people at risk. Intensive mass treatment was started in 1981, giving two doses of praziquantel at 30 mg/kg of body weight. The prevalence fell from 17% to 2% after six annual treatments in Lindu Valley, and from 33.8% to 2.2% after four annual treatments in Napu Valley. Although chemotherapy was effective, transmission continues and retreatment is necessary to maintain the low prevalence. In 1990 the average infection rate in snails was 2.6% in Lindu and 0.2% in Napu.

Since 1984 the schistosomiasis control programme in Indonesia has included treatment with praziquantel once every six months of all infected persons detected in community surveys and by surveillance, health education and population migration screening. Control of the intermediate snail host is achieved by identifying new snail habitats, molluscicide application at known transmission sites, reducing the snail population and infection rate, and modifying the environment suitable for *Oncomelania hupensis* by means of cutting and burning bushes, drainage and earth filling of water bodies, and changing from wet to dry agriculture. A programme to provide a safe water supply and sanitation is being implemented. Systematic treatment of *S. japonicum* infection in cattle and other domestic animals is part of this control programme.

20.4.3 *Philippines*

S. japonicum infection has been recognized as a serious public health problem in the central and southern Philippines since the 1950s. Ten years ago it was estimated that 700 000 people were infected out of 4 million at risk in 22 provinces. The national Schistosomiasis Control Commission

carried out control based on snail control, environmental sanitation, health education and case detection and treatment. There are now 24 endemic provinces, some resulting from new geographical boundaries.

In 1984 all schistosomiasis control programme activities were integrated with the rural health services under the direction of the provincial health officer. This operational change was based on the more immediate impact of chemotherapy on transmission and morbidity compared with other forms of prevention and control. Accordingly, control measures are now centred on chemotherapy through the peripheral health care system with a substantial health education component. Sanitation and snail control are carried out as supplementary measures whenever resources permit (e.g. foreign loan-assisted projects).

Anybody over one year of age is examined by the modified Kato-Katz (cellophane faecal thick-smear) method in the endemic locality (*barangays*). Infection is treated with praziquantel at a total dose of 40-50 mg/kg of body weight in two doses given four to six hours apart at the local health centre on scheduled days.

The results of schistosomiasis control show an encouraging trend, with the prevalence dropping from a five-year average of 10.4% from 1981 to 1985, to 7.4% in 1986, 6.6% in 1987, 6.2% in 1988, 7.5% in 1989 and 6.6% in 1990. Between 450 000 and 550 000 stool specimens have been examined each year. A fully supported case detection and treatment programme funded by a World Bank loan was started in 1991, and it is hoped to achieve 100% coverage. The target is to reduce the prevalence of the disease to below 5% in all endemic areas by the end of 1994.

20.5 Countries where *S. mekongi* is endemic

20.5.1 *Lao People's Democratic Republic*

Schistosomiasis control began in Khong Island in 1989. The mean prevalence of *S. mekongi* infection was 30% in 869 schoolchildren aged 5 to 14 years, with a prevalence of 100% in some villages. In villages with a prevalence above 50% in schoolchildren, praziquantel was offered to all persons aged 2 to 69 years; in the other villages only children aged 2 to 14 years old were treated. In 1990 mass drug administration was used to cover the remaining population of Khong Island and about 52 000 inhabitants in nearby areas of Khong District. The results obtained in December 1990 showed that the prevalence of schistosomiasis in Khong Island had been reduced from 30% to 5%. In several nearby islands, the prevalence was reduced from 70% to 15%. Treatment with a single dose of praziquantel was also effective against opisthorchiasis, and the prevalence was reduced from 50% to 14% in a study group.

Reinfection with schistosomiasis is related to water contact at the Mekong River. Lack of adequate sanitation causes contamination of the river and maintenance of transmission. Dogs are reservoir hosts for *S. mekongi* but their role in the epidemiology of human infection is unknown.

21. Conclusions

Strategy of control

In recognizing the achievements of control of morbidity due to schistosomiasis in the past seven years, the Committee endorsed greater flexibility to extend the objectives of control. The success of the use of large-scale chemotherapy has revealed areas where the prevalence and intensity of infection were reduced less than had been expected. In areas of high prevalence, morbidity control remains the strategy of choice. If resources and an operational peripheral health care system permit, strategies for transmission control can also be envisaged in all areas.

Integration

The Committee supported the concept that all health services, in particular primary health care systems, and other sectors should have integrated roles in the control of schistosomiasis. National commitment is required to adopt a strategy for control of schistosomiasis supported by a plan of action that defines the roles of all sectors.

Different types of schistosomiasis

Although the biological cycles may be similar, the epidemiology, clinical manifestations and response to treatment are distinct for each type of schistosomiasis. This knowledge justifies a more critical attitude towards the strategies and approaches in the 41 countries with both intestinal and urinary schistosomiasis.

Schoolchildren: a major target

The epidemiological distribution of prevalence and intensity of infection supports the Committee's concern that control programmes should give priority to school-age children, who are the fastest growing vulnerable group in endemic countries. Children bear the greatest parasite burden, which is an important determinant in the eventual development of hepatosplenic and urinary schistosomiasis, with severe clinical sequelae such as portal hypertension and squamous cell carcinoma of the bladder. The harmful effects of schistosomiasis on the growth, development and health status of this vulnerable age group are now recognized to be greater than was previously suspected.

Health education

Health education remains a high priority in control programmes. A health education approach can be developed in all endemic countries, emphasizing personal hygiene and the individual's role in controlling schistosomiasis.

Safe water supplies

The International Safe Drinking Water Supply and Sanitation Decade has focused attention on the felt needs of developing countries endemic for schistosomiasis. This has benefited endemic areas and shown that closer co-ordination between schistosomiasis control and water supply and sanitation

projects would assist in targeting areas with a high prevalence of the disease. Schistosomiasis control programmes are also more sustainable in areas with water supply and sanitation programmes. The use of schistosomiasis rates as reliable indicators of the impact of water supplies on health is endorsed in all endemic countries.

Technology in the field

Advances in general and biomedical technology have been proved to contribute effectively to control. Microcomputers are taking their place in database management at central and peripheral levels. Ultrasound technology is progressing at such a rate that its use at the village level to assess morbidity and the impact of control is now feasible and provides an excellent opportunity for collaboration between curative and public health services. Health education through use of videotapes and television can now reach villages with targeted messages.

Epidemiology

The epidemiology of schistosomiasis is changing with the environment and socioeconomic development. For the first time the Committee was asked to consider the basis for disease eradication, and it was agreed that Japan and Montserrat had now achieved that status. The increase in *S. mansoni* in the deltas of the Nile, Senegal and Volta rivers after dam construction, the increase in urban schistosomiasis in north-east Brazil and in western and central Africa, and the resurgence of transmission in central China show that schistosomiasis remains a constant and undiminishing threat in developing countries. Poverty, marginalized vulnerable groups and unbalanced socio-economic development are contributing to these epidemiological changes.

Water resources development

The Committee noted that health risk assessment was not consistently included in the terms of reference of pre-feasibility and feasibility studies for water resources projects. Measures to prevent and control schistosomiasis and other parasitic diseases are still lacking in these projects. Budgeting and financing to implement appropriate intervention measures need to be coordinated between ministries of health and the development agencies.

High costs

The cost of control remains high. The cost of praziquantel is a major constraint in achieving effective control of schistosomiasis, but this is only one of the costs of control. The diminishing per capita expenditure on health in developing countries should be of concern to the international community.

Long-term commitment

The strategy of control of schistosomiasis requires long-term commitment from the international to the local level. The increasing understanding of the disease, the proof of the effectiveness of available tools for diagnosis and treatment, the increasing capacity of health services, and the increasing emphasis on community involvement and management continue to augur well for progress in control of the disease.

22. Recommendations

The Expert Committee:

1. Encourages all endemic countries to adopt a strategy for control of schistosomiasis according to available resources. A national plan of action is essential for planning, negotiating for resources, and monitoring implementation.
2. Recommends that schistosomiasis control programmes should be integrated into primary health care systems.
3. Recognizes that the cost of praziquantel is a major constraint in achieving effective control of schistosomiasis and endorses the efforts of the World Health Organization and the United Nations Children's Fund to negotiate an affordable price.
4. Recommends that health risk assessment should be included in the terms of reference of pre-feasibility and feasibility studies of water resources development projects. Measures to prevent and control schistosomiasis and other parasitic diseases should be defined and explicitly budgeted at the time of financial planning of projects and negotiations with external agencies.
5. Asserts that effective control of schistosomiasis requires strong intersectoral coordination with participation and support from government and international agencies, particularly those concerned with water supply and sanitation, primary education, water resources and agricultural development.
6. Encourages WHO, its Member States and other agencies to promote national and regional training and technical cooperation between different schistosomiasis control programmes.
7. Recommends strengthening of health services in the least developed countries in order to improve their capacity to initiate and sustain control of schistosomiasis and other tropical diseases.
8. Urges countries affected by urinary schistosomiasis to seize the opportunity to initiate or intensify control efforts by adopting strategies of proven feasibility and effectiveness.
9. Recommends that control programmes give priority to school-age children because of the harmful effects of schistosomiasis on the growth, development and health status of this vulnerable age group.
10. Recommends that research on schistosomiasis and socioeconomic aspects of tropical diseases should continue to receive support through the UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases and other bodies. More collaborative research should be encouraged between ministries of health, WHO Collaborating Centres on Schistosomiasis Research and Control, and national research institutions.

11. Supports efforts to promote training in the use of non-invasive imaging techniques, such as ultrasound, for community-based surveys in order to evaluate morbidity due to schistosomiasis.

Acknowledgements

The Expert Committee wishes to acknowledge the special contributions to its discussions and to the drafting of the report made by the following staff members of WHO, Geneva, Switzerland: Dr P. De Raadt, Associate Director, Division of Control of Tropical Diseases; Mr H. Dhillon, Director, Division of Health Education; Mr H. Dixon, Chief, Epidemiological and Statistical Methodology, Division of Epidemiological Surveillance and Health Situation and Trend Assessment; Dr D. B. Evans, Economist, UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases; Dr S. Litsios, Operational Research, Division of Control of Tropical Diseases; Ms C. Mulholland, Office of the Director-General; Dr I. Nuttall, Schistosomiasis Control, Division of Control of Tropical Diseases; Dr L. Philip, Division of Health Education; and Dr D. Warner, Programme Manager, Community Water Supply and Sanitation, Division of Environmental Health; and by Dr N. I. Neoumine, Regional Adviser, Parasitic Diseases, WHO Regional Office for the Eastern Mediterranean, Alexandria, Egypt; and Dr F. K. Wurapa, Responsible Officer, Prevention and Control of Parasitic Diseases, WHO Regional Office for Africa, Brazzaville, Congo.

The Expert Committee also acknowledges the valuable written contributions from: Dr M. Al Jeffri, Ministry of Health, Riyadh, Saudi Arabia; Dr S. M. Al Saghyer, Ministry of Health, Riyadh, Saudi Arabia; Dr Abdul Rahim M. Ageel, Ministry of Health, Gizan, Saudi Arabia; Dr M. I. Ali, Ministry of Health, Maun, Botswana; Dr V. Andrianaja-Ravaoalimalala, Pasteur Institute of Madagascar, Antananarivo, Madagascar; Dr H. Aroua, Institute of Public Health, Ministry of Health, Algiers, Algeria; Dr C. Balzan, Ministerio de Sanidad y Asistencia, Maracay, Venezuela; Dr R. A. Becker, Ministry of Health, Brasília, Brazil; Dr J. L. Bennett, University of Michigan, Ann Arbor, MI, USA; Dr E. H. Benzerroug, WHO Regional Office for Africa, Brazzaville, Congo; Professor J. I. Bruce, University of Lowell, Lowell, MA, USA; Dr D. A. P. Bundy, Imperial College, London, England; Dr I. M. Cesari, Venezuelan Institute for Scientific Research, Caracas Venezuela; Dr S. K. Chandiwana, Blair Research Institute, Harare, Zimbabwe; Dr L. Chitsulo, Ministry of Health, Lilongwe, Malawi; Dr D. G. Colley, Vanderbilt University, Nashville, TN, USA; Dr C. Combes, University of Perpignan, Perpignan, France; Dr J. Duplantier, French Institute for Cooperative Scientific Research for Development (ORSTOM), Dakar, Senegal; Dr J. Dhunputh, Ministry of Health, Port Louis, Mauritius; Dr O. El Zemaity, Ministry of Health, Agouza, Giza, Egypt; Dr D. Engels, Schistosomiasis Study & Control Programme, Bujumbura, Burundi; Dr D. B. Evans, Economist, UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases, WHO, Geneva, Switzerland; Dr H. Feldmeier, Free University of Berlin, Berlin, Germany; Dr A. Fenwick, Schistosomiasis Research Project, Ministry of Health, Agouza, Giza, Egypt; Dr J. Fiusa-Lima, Ministry of Health, Brasília, Brazil; Dr G. Gazzinelli, FIOCRUZ, Belo Horizonte, Minas Gerais, Brazil; Dr B. Gryseels, University of Leiden, Leiden, Netherlands; Dr H. L. Guyatt, Imperial College, London, England; Dr P. Hagan, National Institute for Medical Research, London, England; Professor G. V. Hillyer, University of Puerto Rico School of Medicine, San Juan, Puerto Rico; Dr M. A. Homeida, Faculty of Medicine, University of Khartoum, Khartoum, Sudan; Dr I. Isrin, Ministry of Health, Jakarta, Indonesia; Dr P. A. S. Johnstone, National Cancer

Institute, Bethesda, MD, USA; Dr C. H. King, Case Western Reserve University, Cleveland, OH, USA; Dr U. M. Kisumku, Ministry of Health, Zanzibar, United Republic of Tanzania; Dr T. K. Kristensen, Danish Bilharziasis Laboratory, Charlottenlund, Denmark; Dr J. A. Kumaresan, Ministry of Health, Gaborone, Botswana; Dr N. Kumwenda, Ministry of Health, Lilongwe, Malawi; Mr M. Laaziri, Ministry of Health, Rabat, Morocco; Dr J. Lambertucci, Federal University of Minas Gerais, Belo Horizonte, Brazil; Dr J. P. Madruga, Ministry of Health, Brasília, Brazil; Dr H. Madsen, Danish Bilharziasis Laboratory, Charlottenlund, Denmark; Mr O. Makura, Blair Research Laboratories, Harare, Zimbabwe; Dr G. H. Manjolo, Ministry of Health, Zomba, Malawi; Mr S. S. Mokgweetsinyana, Ministry of Health, Maun, Botswana; Ms P. Ndhlovu, Blair Research Institute, Harare, Zimbabwe; Dr J. Ndoricimpa, Schistosomiasis Study & Control Programme, Bujumbura, Burundi; Dr B. A. de Noya, Central University of Venezuela, Caracas, Venezuela; Dr O. Noya, Central University of Venezuela, Caracas, Venezuela; Dr B. F. J. Oostburg, Bureau of Public Health, Paramaribo, Suriname; Dr D. Overbosch, Red Cross Hospital, The Hague, Netherlands; Dr L. A. Portillo, Department of Health, Manila, Philippines; Dr T. A. Pule, Ministry of Health, Gaborone, Botswana; Professor A. A. Roman-Franco, University of Puerto Rico School of Medicine, San Juan, Puerto Rico; Dr J. R. Roux, Pasteur Institute of Madagascar, Antananarivo, Madagascar; Dr D. Rollinson, British Museum (Natural History), London, England; Dr V. T. Schall, Oswaldo Cruz Institute, Rio de Janeiro, Brazil; Dr A. C. Silveira, Ministry of Health, Brasília, Brazil; Dr P. Simarro, Spanish Cooperation Agency, Bata, Equatorial Guinea; Dr A. C. Sleigh, University of Queensland, Brisbane, Queensland, Australia; Dr V. R. Southgate, British Museum (Natural History), London, England; Dr L. S. Stephenson, Division of Nutritional Sciences, Cornell University, Ithaca, NY, USA; Dr L. C. Tormis, Department of Health, Manila, Philippines; Dr M. Vargas de Gomez, Autonomous University of Santo Domingo, Santo Domingo, Dominican Republic; Professor G. Webbe, London School of Hygiene and Tropical Medicine, London, England; Dr S. T. Wen, Ministry of Health, Accra, Ghana; Dr T. Wolff, Ministry of Health, Lilongwe, Malawi; Professor Wu Shao-Wu, Human Institute of Parasitic Diseases, Hunan, China; Dr K. Yasuraoka, University of Tsukuba, Ibaraki-ken, Japan; Mr S. S. Yoon, Baltimore, MD, USA.

References

1. *The control of schistosomiasis: report of a WHO Expert Committee.* Geneva, World Health Organization, 1985 (WHO Technical Report Series, No. 728).

2. *WHO Expert Committee on Bilharziasis: first report.* Geneva, World Health Organization, 1953 (WHO Technical Report Series, No. 65).

3. **Stephenson LS.** Urinary schistosomiasis and malnutrition. *Clinical nutrition,* 1989, **8**:256–264.

4. **Tomkins A, Watson F.** *Malnutrition and infection: a review.* United Nations Administrative Committee on Coordination/Subcommittee on Nutrition, 1989 (ACC/SCN Nutrition Policy Discussion Paper No. 5; available from the Technical Secretary, ACC/SCN, World Health Organization, 1211 Geneva 27, Switzerland).

5. **Koroltchouk V et al.** Bladder cancer: approaches to prevention and control. *Bulletin of the World Health Organization*, 1987, **65**:513–520.

6. **Savioli L et al.** Control of morbidity due to *Schistosoma haematobium* on Pemba Island: selective population chemotherapy of schoolchildren with haematuria to identify high-risk localities. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 1989, **83**:805–810.

7. Doumenge J et al. *Centre d'Etudes de Géographie Tropicale/WHO atlas of the global distribution of schistosomiasis.* Presses Universitaires de Bordeaux, Bordeaux, 1987.

8. Hunter JM et al. *Parasitic diseases in water resources development: the need for intersectoral negotiation.* Geneva, World Health Organization, 1993.

9. *World register of dams, 1988 updating.* Paris, International Commission on Large Dams, 1989.

10. Mott KE et al. Parasitic diseases and urban development. *Bulletin of the World Health Organization*, 1990, **68**:691–698.

11. Utroska JA et al. *An estimate of global needs for praziquantel within schistosomiasis control programmes.* Geneva, World Health Organization, 1989 (unpublished document WHO/SCHISTO/89.102; available on request from Schistosomiasis Control, World Health Organization, 1211 Geneva 27, Switzerland).

12. *Health education in the control of schistosomiasis.* Geneva, World Health Organization, 1990.

13. Homeida MA et al. Association of therapeutic activity of praziquantel with the reversal of Symmers' fibrosis induced by *Schistosoma mansoni. American journal of tropical medicine and hygiene*, 1991, **45**:360–365.

14. *Basic laboratory methods in medical parasitology.* Geneva, World Health Organization, 1991.

15. Esrey SA et al. Effects of improved water supply and sanitation on ascariasis diarrhoea, dracunculiasis, hookworm infection, schistosomiasis and trachoma. *Bulletin of the World Health Organization*, 1991, **69**:609–621.

16. De Wolfe Miller F, Steering Committee for Cooperative Action for the International Drinking Water Supply and Sanitation Decade. *Report on IDWSSD impact on schistosomiasis.* Geneva, World Health Organization, 1990 (unpublished document; available on request from Community Water Supply and Sanitation, World Health Organization, 1211 Geneva 27, Switzerland).

17. *The community health worker: working guide, guidelines for training, guidelines for adaptation.* Geneva, World Health Organization, 1987.

18. *Better freshwater fish-farming: further improvement.* Rome, Food and Agriculture Organization of the United Nations, 1986 (Better Farming Series, No. 35).

19. Yoon SS, Mott KE. Global schistosomiasis database: practical considerations in the design of a user-friendly database. *Methods in information in medicine*, 1991, **30**:127–131.

20. Cooper Weil DE et al. *The impact of development policies on health: a review of the literature.* Geneva, World Health Organization, 1990.

21. Development Committee. *World Bank support for the environment: a progress report.* Washington, DC, World Bank, 1989 (No. 22).

22. Mather TH, Bos R. *Policies and programs of governments, bilateral and multilateral agencies and development banks for environmental management in the context of natural resources, agricultural and health development.* Geneva, World Health Organization, 1989 (unpublished document VBC/89.7; available on request from the Division of Environmental Health, World Health Organization, 1211 Geneva 27, Switzerland).

23. *Implications of public policy on health status and quality of life.* New Delhi, World Health Organization (unpublished document SEA/HSD/144; available on request from World Health Organization Regional Office for South-East Asia, New Delhi, India).

24. **Chen MG, Mott KE.** *Progress in assessment of morbidity due to schistosomiasis. Reviews of recent literature: Schistosoma haematobium, Schistosoma intercalatum, Schistosoma japonicum, Schistosoma mansoni.* London, Bureau of Hygiene and Tropical Diseases, 1989.

25. *Meeting on ultrasonography in schistosomiasis: proposal for a practical guide to the standardized use of ultrasound in the assessment of pathological changes.* Geneva, World Health Organization, 1991 (unpublished document TDR/SCH/ULTRASON/91.3 & CTD/91.3; available on request from Schistosomiasis Control, World Health Organization, 1211 Geneva 27, Switzerland).

26. *WHO model prescribing information: drugs used in parasitic diseases.* Geneva, World Health Organization, 1990.

27. **Qurashi MA et al.** Ultrasonographical investigation of periportal fibrosis in children with *Schistosoma mansoni* infection: reversibility of morbidity seven months after treatment with praziquantel. *American journal of tropical medicine and hygiene*, 1991, **44**:444–451.

Annex

Indices for use in schistosomiasis control programmes

The indices below are recommended for use in establishing adequate baseline information, in monitoring operations and in evaluating schistosomiasis control programmes.

Indices based on egg counts

1. *Prevalence of infection:* the proportion of the population with schistosomiasis, i.e. the proportion of individuals with schistosome eggs in their urine or faeces.
2. *Prevalence of heavy infections:* the proportion of individuals with at least 50 eggs per 10 ml of urine for *S. haematobium* infections or with at least 100–800 eggs per gram of faeces for *S. mansoni* infections. The cut-off points for these categories are area-specific.
3. *Intensity of infection:* this is estimated according to the number of eggs per unit volume of urine or weight of faeces. These data may be presented according to egg-count classes.
4. *Incidence:* the rate at which uninfected persons who have never been treated become infected during a given period of time.

For most control programmes, it will be sufficient to calculate only indices 1 and 2. Indices 3 and 4 are more appropriate for special studies within the programme. In this case, to calculate the intensity of infection, it is recommended that a figure for the geometric mean egg output among the infected individuals is obtained as well.

Indices related to morbidity

1. Within a stated time interval, the number of hospital beds occupied by patients with schistosomiasis infections.
2. The number of outpatient visits related to schistosomiasis infections at dispensaries, health units and hospitals.

For S. haematobium infections

1. The proportion of persons with a recent history of haematuria and/or dysuria.
2. The prevalence of gross haematuria at the time of examination.
3. The prevalence of haematuria as detected by chemical reagent strips.

For S. mansoni and S. japonicum infections

1. The proportion of persons with a recent history of haematemesis.
2. The prevalence of hepatic and/or splenic enlargement in school-children (the presence or absence of mesoendemic or hyperendemic malaria should be noted).

Indices related to chemotherapy

1. *Participation rate:* the proportion of eligible persons who have received treatment. Individuals who receive only partial treatment when the drug regimen requires more than one dose should be recorded separately.
2. *Egg-negative rate:* the proportion of infected persons who have been treated and who have no *Schistosoma* eggs in the urine or faeces at a follow-up examination. The diagnostic technique used, the interval since treatment and the number of samples examined must be stated.
3. *Egg-positive rate* (used when individual pretreatment status is unknown): the proportion of people who are positive after treatment. These measurements should be presented according to egg-count classes. A high proportion of heavily infected persons is indicative of intensive transmission.
4. *Reinfection rate* (reserved for use in monitoring schistosomiasis control when individual data are available): the proportion of people who have no *Schistosoma* eggs in the urine or faeces at the first examination at least three months after treatment, but who are again found to be infected at a subsequent examination after six months or more. These measurements should be presented according to egg-count classes. The length of time between examinations should be stated.