Modification of the Environment as a means of controlling Schistosomiasis by Peter R Morgan

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The pattern of schistosomiasis transmission is well known and has been discussed for decades. The solution of overcoming the problem of schistosomiasis has confounded workers for an equal number of years, however, largely because the impossible goal of eradication had been assumed possible. The more realistic current strategy of rejecting impossible goals and aiming for reduced transmission and thus reduced morbidity is a logical and long overdue concept which lies within reach of most developing countries.

Several factors are important in the life cycle of the parasite, the most critical being that both human and snail hosts make contact with the same water. If there were no snails, there could be no transmission and the technique of applying molluscicides has been used for many years as one method of controlling the disease. It is now well established that under certain conditions this form of control is effective, not only at controlling snails but also reducing the incidence of the disease. Jobin reviewed 41 pilot schistosomiasis projects in which chemical control methods were used, and which were supported by adequate data on methods, epidemiology, costs and evaluation. More recently Evans has proved beyond doubt that on well supervised irrigation schemes chemical control can be very effective at reducing the incidence of the disease, especially when an adequate supply of chemicals and the technical expertise are available.

On larger bodies of water, the efficiency of chemical control is much reduced, as freshly applied chemicals may quickly become diluted with open water. Similarly the high density of emergent vegetation in many dams and rivers as well as rivers and streams, make chemical control difficult, simply because the molluscicides cannot penetrate the total environment inhabited by the snail. However, if the vegetation is removed, chemical control becomes much more effective, and this subject is described in greater detail later, as an example of modification of the environment.

Chemical control has its limitations however. In most rural areas of the world, surface waters appear as a complex network of streams, pools, rivers and their backwaters and the number of potential contact points is very great.
The repeated cost and practical difficulty involved in locating all potential contact points makes this form of control quite inappropriate in most rural situations. The study of Clarke et al., which describes the blanket application of mollusicides to the Kyle catchment area in Zimbabwe, followed by successive age prevalence surveys, shows a reduction in incidence, but this proved to be only a temporary solution.

The current strategy of the World Health Organisation rests with using chemotherapy as the main tool for reducing the morbidity due to schistosomiasis. According to recent WHO documentation, dramatic effects on the distribution of schistosomiasis begin to take place after safe effective antischistosomal drugs are given to all the infected persons in an endemic community. High cure rates are common and the number of viable eggs excreted is much reduced. This "chemotherapeutic shock" reduces the risk of infection of the snail and thus the potential for reinfection is much reduced. The simultaneous development of a new simple quantitative parasitological diagnostic test also contributes to the implementation of the strategy of chemotherapy.

Studies on the effect of new antischistosomal drugs on morbidity have not been frequently reported however. Mott et al. have shown that by treating with praziquantel, the prevalence of gross haematuria was reduced by up to 91% in children and 77% in adults, six months after treatment. Studies by Davies et al. show that 6 months following treatment with praziquantel the number of cumulative failures (i.e. the presence of viable miracidia in any one urine sample) was small, but that it increased steadily over a two year period, indicating that reinfections were commonly taking place. More recent studies in Zimbabwe by Dallas show the same trend, namely, that although the number of reinfections was small 6 months after treatment with Praziquantel, it rose to a significant number after 18 months.

These data show that chemotherapy, like chemical control requires constant vigilance and repeated financial support if it is to have any lasting effect on schistosomiasis. It seems the cycle of transmission continues, even if only a few individuals constantly shed viable eggs into a suitable water body. In S. mansoni, for instance, a small proportion of only 6% of the infected population excrete at least 50% of the total number of eggs which contaminate the environment. Most of these heavily infected persons are children between 10-14 years old. The constant mobility of the population and the high cost of drugs present obstacles which are not easy to overcome especially in developing countries. The cost of treatment with praziquantel in Zimbabwe, for instance, amounts to over Z$15 per child, and more for an adult. It is true that metrifonate costs less — about Z$0.5 per treatment, but praziquantel is the drug of choice if S. mansoni is present. However where the economy and the health infrastructure of a country can cope, the near elimination of schistosomiasis is possible, as has been demonstrated in Japan.
Both chemotherapy and chemical control are both frontal attacks on the natural balance found in nature between man, the snail and the parasite. Even when both are used in combination, their effect begins to die away when the "chemotherapeutic shock" they induce is removed and the natural balance begins to be restored again. This must always be the case until the root cause of schistosomiasis itself is confronted that is that man makes contact with the snail hosts in water. For these very obvious reasons, it has been accepted that chemotherapeutic techniques must be considered as a means but not an end to schistosomiasis control.

It is clear however, that a multidisciplinary approach will always be vital in any successful strategy aimed at reducing the morbidity due to schistosomiasis. In the past far too little consideration has been placed on the longterm but vital roles of education and environmental improvement as means of reducing morbidity. By paying more attention to these measures schistosomiasis programmes may have wider reaching impacts on health and possibly attract greater international support, than programmes which base their hopes on the application of chemicals or chemotherapy alone. Improvements of water supplies for instance, can be regarded as permanent improvements to the environment, which when carefully constructed and maintained, have lasting benefits. The introduction of an effective educational component into a national school curriculum, is bound to be long lasting, and likely to have greater impact the more it is used. Like the introduction of an improved and reliable water supply, the ingredients of a sound school curriculum become part of a way of life - which is strengthened as the years pass by. Surely this is a much sounder strategy than one which involves short term improvements alone.

Many workers have drawn attention to the importance of water contact as a target for the control of schistosomiasis and these include Macdonald, Husting, Jordan, Pichford, and many others. As the years of practical experience mount up, one technique in particular shows great promise for the future, namely modification of the environment by the provision of alternative and improved water supplies.

The provision of alternative and improved water supplies, together with an educational component has been studied in detail by Jordan who demonstrated a significant reduction in the degree of contact with natural contaminated surface water and simultaneously a reduced incidence and intensity of infection of schistosomes in the communities studied. Although the study was carried out in a unique situation, where the population was isolated and the new water supplies were sophisticated, it proved beyond doubt that improvements in water supply with a related educational component could have a lasting and meaningful impact on the schistosome without the intervention of either chemical control or chemotherapy. The study also showed that with sustained effort in the educational sphere, it was possible to draw the attention of the children away from the river.
The recurrent cost of maintaining the system at the time of the study, that is the water supply, were less than the cost of mollusciciding in a comparative area, and far more attractive to health personnel since the improved water supply simultaneously reduced the severity of other diseases. The cost of the scheme was very high however, because water was supplied to each family. Improved water supplies are not necessarily expensive to install. In a recent programme of water improvement in Epworth near Harare, Zimbabwe, protected water supplies using drilled tubewells and a simple bucket pump system have been introduced at a cost of less than Z$5.00 per person, and in some areas Z$2.00 per person for the materials with labour recruited locally and at no cost. An estimated 1 500 persons, are served by 15 water points each costing approximately Z$250. Most of the water used for drinking, bathing and cooking is derived from these protected sources - approximately 20 litres being consumed by each person, including children. Even if the upper cost is chosen for comparison, this is still one third of the cost of a treatment with praziquantel for the individual. Since the water facilities are expected to be long lasting and easy to maintain, the recurrent costs are similarly small. The effect of the programme is that much of the contact with other more contaminated supplies of water has been reduced, if not ceased altogether.

What remains clear is that a great single stride can be made simply by removing the necessity for rural folk to make contact naturally occurring water by supplying a safer and attractive alternative which is convenient for their use. In this regard, the global efforts of the International Drinking Water Supply and Sanitation Decade, which emphasises the importance of bringing safe water closer to where people live, will have a significant effect on many diseases in the long term, including Schistosomiasis. The greater the number of protected wells and boreholes that are made and put into use, the lesser the reliance will be placed on the rivers and streams that currently provide the water. The construction of a single well, close at hand, can completely change the pattern of water contact for a community who live nearby. The easier access and related convenience speak for themselves from the users point of view and make the absolute necessity for making contact with more traditional sources of water a thing of the past. A description of improved water supply facilities currently being used in Zimbabwe is appended to this paper.

However, there are at least three other factors which attract rural folk to rivers and streams, even if they have access to protected water nearby. Rivers and streams generally provide large volumes of water, and often the rocky outcrops which make clothwashing more convenient. In case studies carried out by Makura, in a farming area of Zimbabwe, contact with river water was maintained by farm workers for laundry, body washing and for recreation, despite the fact that piped water was available to them in communal standposts. However this trend was modified by the installation of a number of simple washing slabs made of concrete within each village. The study showed that whilst contact with the river continued to increase in those communities without washing slabs (+20%), the number of contacts associated with laundry decreased by 50% after the introduction of slabs in experimental farms. The study shows clearly that much of the contact with the river was due to the inadequacy of the protected piped supply and the facilities associated with it. It emphasises that protected water supplies when provided to communities, must deliver sufficient water, and that it must be close by. The success of Jordans study in St. Lucia is no doubt related to the fact that each household was provided with water, in which case the necessity for contacting other sources was reduced to a minimum.
Two further factors attract people to water - fishing and recreation. In many cases these may be linked, but very often fishing takes place because it may also be a necessity as a means of providing food for the family. Even when school children live in areas which are served with much improved water supplies - their visits to relatives in less well developed areas may mean that they are obliged to make contact with unprotected sources of water for periods of time through the year - where they pick up infections. The importance of a sound educational component has already been mentioned.

The work of Laver has shown that although children are taught about schistosomiasis transmission in schools, they still may have a limited understanding of exactly what happens. In surveys carried out in recent years, many children still believed they caught schistosomiasis transmission in dirty toilets, and did not necessarily associate it with water contact. These facts reflect poor teaching methods and material content. Improved methods of teaching such subjects are now being introduced, but these may take time to replace the myths taught in previous times.

Various techniques have been used to alter the environment and so to lure people away from riverine areas of contact. The work of Pitchford, has shown that it is possible to build cheap swimming pools for children and thus divert their attention away from natural rivers. The washing slabs described by Makura, can also be regarded as lures - which attempt to stimulate attractive features of the environment which cause people to contact water. Similarly the construction of small bridges across streams on well used footpaths can reduce contact, and the construction of small peninsulas which project into dams are popular with fishermen, who might otherwise stand in the water.

A more successful technique is that of providing a protected water source adjacent to the banks of streams and rivers. Observations performed in Chilimanzi, Zimbabwe by Walsh, indicate that contact with water flowing in streams can be reduced simply by providing a protected well quite close to the river. A change in the footpaths, away from the bank and towards the water point is very clear evidence that a small but significant behavioural change takes place as a result of environmental modification. This technique is not foolproof however: at times children still take water from pools, if these are closer than the protected water point - educational programmes obviously take years to have a significant and final impact on behaviour.

Another approach which is always mentioned but seldom put into practice is an improvement in sanitation. The common use of improved latrines, might in the long term have an effect on transmission, although in the short term this is unlikely as people still make contact during times of recreation, when contamination of the water, especially by children, is inevitable.

One interesting development in the latrine programme in rural Zimbabwe, is the common use of improved ventilated pit latrines as washrooms. Sanitation of this type removes the fly and odour nuisance of latrines and makes them far more acceptable as washrooms as well. Indeed many latrines are promoted on the basis that they can double as a washroom. It is perhaps this feature of latrines which may have a more significant impact on schistosomiasis transmission than the isolation of the excreta alone since an acceptable bathing facility near the home offers a very attractive alternative to the river. A description of improved sanitation facilities used in Zimbabwe is appended to this paper.
Various attempts have been made to physically alter the environment in an attempt to induce changes in the transmission potential of schistosomiasis. Several studies have centred around weed clearance as one means and the well documented Lake Volta project serves as one good example. Another attempt to simulate lakustrine conditions which did not favour transmission were carried out on Lake McIlwaine in Zimbabwe between 1972 and 1975 by Morgan.

Each year L. McIlwaine rises and falls, but in the years of study the falls in water level were particularly great. Snails were studied in several environments, notably well vegetated and chemically untreated zones and also vegetated zones that formed part of a resort and were treated with chemicals for the control of snails. The graph depicting snail abundance shows clearly snail populations were less dense in chemical controlled areas but in real terms large numbers of snails were still resident, even in treated water. Even very heavy "blitz" treatments with molluscicide had devastating effects on the number of snails close to the immediate shoreline, but the rate of recolinisation was also significant from areas on either side of the treated zone.

Towards the end of 1972 lake levels became very low and the vegetated zones of Polygonum sp. in both sites were left high out of the water. Resident snails receded to lower levels, but were unable to survive in a hostile environment. In the previously treated zone, the substrate consisted of mainly sandy soils in a bay exposed to the lake. In the well vegetated and untreated sites the substrate consisted of mud with less sand. In both areas millions of snails died - the records show a dramatic decline in snail populations of Bulinus tropicus, the most common species. Both Bulinus (Physopsis) globosus and Biomphalaria pfefferi were present in smaller numbers as well, and these species were subject to the same dramatic fluctuations in both areas.

At the time of the lowest lake level, the environment with the sandy substrate was dramatically changed by artificial means. All the vegetation was cut away and the topsoil removed with a bulldozer. The areas were flattened and formed into distinct bays open to the lake. Herbicide was sprayed on any area where the vegetation seemed likely to reappear. Finally many tons of sand were imported to the beaches and placed on the foreshores.

Whilst the lake continued to remain at a low level, the foreshores remained relatively sterile and snail populations did not increase. In late 1973 the lake rose rapidly. The action of the waves shifted the artificially imported sand, but eroded the natural shorelines and exposed underlying sandy layers which formed new beaches. The area remained relatively sterile, even at high water, and the build up of snails was minimal being restricted to isolated clumps of weed. This reduction of the snail population was sustained for long periods, and was far more effective than the combined efforts of repeated chemical control in previous years, and at a cost which compared favourably with spraying, had this been continued at the resort.

In contrast, the vegetated foreshores in non-treated areas became heavily populated with snails once again as the illustration shows. Populations fell dramatically again in 1974 as once again the lake level fell, but showed signs of recovery again in 1975 as before.

This simple study shows quite clearly how natural or artificially induced changes in the physical environment can dramatically influence the snails hosts of schistosomiasis. In this case an attempt had been made to copy what often happens in the natural world. The foreshores of many natural lakes are sandy and in constant motion because of wave action.
Such shores compared to vegetated backwaters are relatively sterile and snails find it difficult to form an anchorage. The lack of vegetation and exposure to the open lake have significant effects. The currents of the open lake are able to pass freely through the foreshore, not being impeded by any growth of vegetation. These currents greatly reduce the density of both cercariae and miracidia in the environment, and thus a significant effect on the transmission potential of the area. It is clear that sterile shorelines, by their very nature, do not favour the transmission of schistosomiasis.

The evidence presented in this paper suggests that there is some hope that it is possible to influence the behaviour of people so they make less contact with surface water and more contact with protected water. People must change their habits if the level of schistosomiasis in the population is to be reduced in the long term. Such habits can only be changed if more attractive alternatives are made available to the population. Behavioural changes take place slowly, even over generations, but if such changes can be steered so that there is a health benefit, then the efforts will have been worthwhile. It must always be remembered that schistosomiasis rarely occurs in isolation as a disease in the rural environment. It is compounded by other, often more serious health problems, and all too often malnutrition - especially in young children. Efforts at reducing the mobility of schistosomiasis will have greater impact and support if they can fit in with other programmes of health improvement including nutritional, immunisation and health education campaigns. In the long term all improvements in health can only be achieved if the living environment of each individual is itself improved. For when there is knowledge and a healthy home environment, the greatest responsibility for health will finally rest with the individual himself.

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References :


5. Mott et al Studies on an endemic area on L. Volta. (to be completed)


