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Review

Schistosomiasis and the social patterning of infection

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Social, cultural, behavioural and economic factors interact with local environmental and ecological factors to produce extraordinary variation in the epidemiology of schistosomiasis, including with respect to prevalence and intensity of infection and the potential for control. This article reviews the literature on schistosomiasis infection, primarily derived from African studies, to identify its major social themes. Research has demonstrated a strong link between economic development strategies, where irrigation has been introduced to boost agricultural production, and the increased transmission of infection. Water-contact studies have provided the fullest and most detailed descriptions of social risk factors, and have isolated age, sex, religion and occupation as primary risk factors. However, fuller explorations of the social and cultural context of infection have yet to be undertaken. The social context of water-related behaviour and patterns of water use within communities and households, the intersection of social and economic activities, and the significance that people give to these activities, remains poorly explored, and although research papers concerned with community-based interventions refer to poor community understanding of the cause, prevention and treatment of the disease, this domain has also received little scholarly attention. Finally, economic studies have focused primarily on working capacity, and extrapolated these findings to generalise about the impact that this might have on productivity, but have yet to address either household or community costs of schistosomiasis infection.

Key words: Schistosomiasis; Social risk factors of infection; Cultural and behavioral factors; Economic impact; Community

Introduction

Schistosomiasis is a behavioural disease associated with the contamination of snail-infested surface waters, and is exemplary of the relationship between social and economic infrastructure, behaviour, belief systems and the transmission of infection. Lack of safe water supplies, the absence of latrines, personal behaviour regarding defecation, urination and bathing, and a lack of recognition of the links between water contact and infection, all result in continuation of behaviour which sustains the cycle of infection. The infection can be prevented by changes in patterns of water use brought about by the provision of safe water supplies and sanitary facilities, and health education to ensure their use and to encourage more effective health-seeking

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behaviour following recognition of symptoms of infection, but poverty and inadequate infrastructure and services make these changes difficult to achieve.

The complex interactions that are evident in schistosomiasis infection between human behaviour, social and economic organisation, public health provisions and cultural understandings of the nature and cause of disease offer considerable potential for research by anthropologists and other social scientists. Yet social research on schistosomiasis is surprisingly uncommon, and few comprehensive studies exist which explore the social and economic dimensions of the infection (Kloos et al., 1983; Dunn, 1979). The available data are highly variable in terms of objectives, methods, study area, and type of infection (*Schistosoma mansoni* and *S. haemotobium* rather than *S. japonica*). This paper reviews the research on social aspects of schistosomiasis, and to an extent its economic impact, and highlights areas where there is an especial need for further research.

Artificial lakes and the politics of disease

Little attention has been paid to the social, political and economic context of development in studies of the impact on infection of "man-made" lakes and waterways, or to the links between artifical lakes and the transmission of schistosomiasis as examples of what Vaughan (1991: 5–6) has termed the "unnatural history" of disease. However, schistosomiasis is a sensitive indicator disease in this context, since changes in infection rates occur relatively soon after environmental changes, and associated morbidity is also perceived by the infected population.

Changes in the mode and patterns of production, including the development of new agricultural programs and cash cropping dependent upon regular water supplies, have often necessitated the establishment of irrigation schemes sustained by large and complex dams. Where this has occurred, the prevalence of schistosomiasis has increased, with the construction of water impoundments for irrigation and other purposes in areas of endemic water-related disease intensifying community levels of infection and creating new areas of transmission (see, for example, Prescott, 1979; Jack, 1986: 158; Korte et al., 1986: 149; Chandiwana et al., 1988). The available data, predominantly from Africa, provide consistent evidence of increased transmission of infection concomitant with the establishment of artificial lakes and canals and the introduction of irrigation schemes. Favourable conditions for snail breeding are created by stable water conditions, and population increases through immigration which occur with the intensification of agriculture may both expose greater numbers of people and introduce the parasite to new areas (Chandiwana et al., 1988; Jordan, 1975). Data are limited due to the absence of pre- and post-development data or their unsuitability for comparative purposes, and to a reluctance on the part of governments to publish findings that indicate deterioration of the health of local residents or immigrants consequent upon development projects. Even so, the evidence is persuasive.

The earliest is from Egypt. The construction of the Low Dam at Aswan in the early 1930s allowed perennial irrigation in a number of provinces. The development of the dam was followed by an increase of schistosomiasis haematobium in four areas which were investigated, with levels of prevalence which rose from 2–20% in 1934 to 44–75% in 1937 (Khalil, 1949). The new high dam at Aswan, which produced more extensive perennial irrigation, also resulted in a change of schistosomiasis transmission in both Upper and Lower Egypt, and a comparative survey carried out in 1979 in the Nile delta, which matched the village, population size and parasitological techniques of the 1935 study, indicated an increase in the prevalence of *Schistosoma mansoni* infection from 3.2% to 73% over the period (Abdel-Wahab et al., 1979).

Data from Lake Volta, Ghana, provide corroboration of the health costs of development. Large-scale surveys for urinary schistosomiasis undertaken the decade before the Akosombo Dam was built indicated low prevalence rates (about 5–10% in children) in the area which was later impounded. Within a year of the lake reaching its maximum level (1968), prevalence rates of up to 90% and over in children aged 10–14 years were found in lake-side communities, where some 150,000 people were living (Hunter et al., 1982). In the Sudan, irrigation of the Gezira by the construction of the Sennar Dam in 1924 and the extension of the irrigation system after 1950 resulted in a progressive increase in both *S. haematobium* and *S. mansoni* (Hunter et al., 1982; also Amin, 1977).

In Mali, comparable data exist for the Circle de Bandiagara (population 160,000), where a program was initiated to build about 50 small dams; by 1977, about 20 had been completed. Base-line data prior to the erection of the dams was not collected, but the first two surveys indicate an increase in the prevalence of schistosomiasis haematobium from 79.4 to 93.4% from 1976 to 1977 in the same population. In addition, the 1977 survey indicated that *S. mansoni* was being transmitted for the first time. Although the area was endemic for schistosomiasis, the creation of artificial water sources appears to have enhanced transmission, providing substantiation of patterns evident in early studies of changes in the distribution of the vector and patterns of transmission.

This pattern of increased transmission and prevalence is repeated throughout the region. In the irrigated sugar estates at Bacita, northern Nigeria, for example, the prevalence of *S. haematobium* infection increased from 6.5 to 20% and *S. mansoni* infection from 25.4 to 49.1% over a 6 month period (Thomson 1967, see also Pugh and Gilles 1978). In Ethiopia, the government has given high priority to the development of irrigated agriculture and hydroelectric power production, and four medium and many small sized artificial lakes were in operation by 1986. The rapid spread of both *Biomphalaria pfeifferi* (intermediate host) and *S. mansoni* infection in irrigation systems followed. For example, in Wonji Sugar estate, only ten infected labourers were reported in 1964; in 1968, 7.5% of the farm population was infected; by 1980 this had increased to 20%. Similar increases have been documented on other estates and in other populations resident in lake areas (Kloos et al., 1988).

In Asia and Latin America, there is little clear evidence of the adverse effects on health of water impoundment schemes drawn by a comparison of pre- and post-development data on the distribution and prevalence of schistosomiasis. This does not demonstrate the absence of such changes in disease concomitant with development, however, and the factors that account for data limitations in Africa apply elsewhere. In Asia, the major schistosome, *Schistosomia japonica*, causes the most severe pathogenic damage, and well-designed comprehensive studies are needed to document changes in its incidence and distribution, and in other social, cultural and economic aspects of the disease, as the risks in the future of an increased incidence of schistosomiasis in endemic areas, including in the Philippines, Indonesia and

China, remain. In Latin America, there is also a risk of the introduction of schistosomiasis in water impoundment and irrigation projects in areas where endemic foci already exist, as in some effluents of the Parana basin, Paraguay and the Sao Francisco basin, Brazil (Hunter et al., 1982).

Water contact behaviour and schistosomiasis

Water contact studies provide the most extensive data on behavioural and social aspects of schistosomiasis infection (Blumenthal 1985), and indicate the complex ways in which such sociological variables as age, gender, occupation, industry, and patterns of settlement constitute risk factors of infection. Although they have been primarily defined, designed and conducted as epidemiological rather than sociological projects and lack the interpretive framework and theoretical insights that one might expect from a sociological or anthropological study, they point to the value of further social research (Bundy and Blumenthal, 1990).

Sex as a risk factor of infection

An early major study of water contact behaviour in relation to schistosomiasis was reported from Puerto Rico (Pimentel et al., 1961). In three watersheds, questionnaire and faecal sample data were collected from 272 children up to 16 years old in a special survey conducted late 1955. The data revealed the significance of frequency of water contact: "daily water contact", interpreted as exposure through drinking, bathing, or stream washing, resulted in infection rates for schistosomiasis mansoni which increased from 32 to 86% through the range of 0 to 3 contacts per day.

Over the last two decades, water contact studies have become increasingly popular. The first detailed study involving direct observation reported in the Egypt-49 Project Area, recorded water contact activities in four sites, representing typical unprotected water contact points on different types of watercourse in the area. The study covered a period of one year, divided into four seasons, with a total period of observation at each station of 32 h in spring and 44 h in other seasons. The results showed that women had more frequent water contact than men; that women under 25 years old had the most frequent contact, but that men were more active contaminators than women. The most frequent, prolonged and extensive body-surface contact occurred in summer. One-quarter of all exposures (year round) took place between noon and 3 p.m., the period of maximum cercarial load, when the most frequent activities were washing of utensils, bathing and playing, and *wadu* (ritual washing) (Farooq and Nallah, 1966).

Two further influential studies were undertaken in St Lucia and at the Volta Lake in Ghana. In the St Lucia study (Dalton, 1976), 1000 persons were observed over 15 months (105 observation days at 15 contact sites). Water contact was divided into two main types: domestic (clothes washing, the collection of water, bathing and swimming) and economic (fishing, crossing the river to carry bananas from garden plots to the market, the collection of sand and stones for road making). Domestic activities constituted the greatest risk of infection (cf. Farooq and Nallah, 1966). Washing clothes resulted in the highest duration of exposure, although bathing had a higher frequency. The number and duration of daily contacts with water played an important role in determining the relative risk of *S. mansoni* infection and correlated significantly with the number of infected persons. Similarly, Dalton and Pole's study in the Volta Lake region (1978), based on seasonal observations of a population (200) exposed to *S. haematobium*, demonstrated the extent to which sex was predictive of infection. Here, domestic water contact activities and activities associated with fishing canoes, including the arrival, departure and entering the canoes for both economic and recreational activities (Dalton and Pole, 1978: 419), were significantly related to *S. haematobium* infection. The reduced intensity of infection in the older age groups was closely related to lower levels of water contact.

The St Lucia study (Dalton, 1976) is especially important not only for the completeness of the observations, but also because it is one of the few which has provided broader anthropological observations to explain the social patterning of water use. These include the fact that women's activities, particularly, did not occur in isolation. Childcare, personal care and domestic activities were combined, so that small children accompanied their mothers to the river and swam and played in it whilst their mothers washed clothes; women usually bathed after they had finished washing (Dalton, 1976: 594). Women's washing activities increased in frequency with marriage and the arrival of children. Subsequently they turned to their daughters for assistance in various domestic duties, including those that were water related, and thus, as a consequence of patterns of sex role socialisation, young girls assisted their mothers until they in turn established a household. Young boys contributed domestic labour by carrying water for household purposes, but only until around puberty, when male and female economic and related activities became increasingly differentiated, resulting in boys' less extensive water contact (Dalton, 1976: 592). In addition, matrifocal settlement patterns – the clustering of houses of mothers and their adult daughters despite village exogamy – meant that women within families would continue to use common water sources for domestic activities; these common sources provided a meeting place and so served a social as well as economic function (see also Kloos et al., 1983: 560). Men's economic activities involved less water contact and as a corollary, because bathing was a "linked" activity, men also bathed less in total (Dalton, 1976: 590).

Since 1979, studies involving direct observations have been reported from many areas of the world and a variety of ecological situations. A number undertaken in Zimbabwe further highlight the relationship between the sexual division of labour and water contact, hence the association between sex and infection. One study in a citrus estate (Husting, 1983), with water contact observations for a total of 881 h over 19 months, showed that water-related activities (expressed as the rate of arrival) was four times greater for women than men, with three activities – washing dishes, removing water, and swimming or playing – accounting for 67% of all female activities. The prevalence of *S. haematobium* was 50% for women and 30% for men, and *S. mansoni* was 53% for women and 38% for men. However, the relationship between sex and infection in this study is not repeated elsewhere. The findings of a study by Chandiwana (1987a) in a temperate highveld region, in contrast, showed that women dominated in partial contact activities and men in complete contact activities, resulting in the higher prevalence of *S. haematobium* infection in men within this community. These results derived from observations of water contact activities over a 27-month period covering approximately 2000 people and 12 sites, with each site observed for 5 days each month. Contacts were categorised as limited, partial and complete contacts and given a ratio of 1:2:5 according to the body surface area exposed. A further study by Chandiwana (1987b) in the same area looked at the main factors influencing human water contact behaviour, and indicated that water availability (water levels in the stream) and temperature (in the hot dry season when contact increased) were the major factors limiting and governing the patterns of contact. In Kenya (Butterworth et al. 1984), water contact observations also showed a marked difference between men and women in terms of duration and intensity of water contact. In men, contact rose to a sharp peak between the ages of 10 and 14, and thereafter declined, while in women, water contact persisted at high levels for longer periods, with the first peak also between ages 10 and 14, and a second peak between the ages of 20 and 29. However, this difference was not reflected by a higher prevalence or intensity of infection. These findings stress the importance of understanding culturally variable patterns of economic organisation, water use, and the sexual division of labour, although they lack the ethnographic data that provides an explanation of these patterns. Variation in use of water sources on a seasonal basis, indicated as significant in Chandiwana's study (1987b), also highlight the value in exploring community perceptions of water availability and the suitability of sources for different purposes.

In general, studies have indicated that the relationship between sex and risk of infection is equivocal and culturally variable, and subject to a range of other influences. Religion, and the restrictions on the mobility of women that may be imposed according to particular sets of beliefs, is one such influence. In a study undertaken among Muslim communities in the Raivan Sanyi dam area in northern Nigeria, where the seclusion of women was particularly marked and their water contact consequently limited, men were responsible for 98% of activity involving contamination and exposure of *S. haematobium* infection. Boys under the age 21 years – using water for fishing, playing, bathing and swimming – were responsible for more than 77% of environmental egg contamination (Tayo, Pugh and Bradley, 1980), with peak water contact activity occurring in the afternoon and coinciding with the peak cercarial shedding period and urinary egg output. In Upper Egypt, sexual division of labour and the reduced mobility of adult women again reduced women's contact with infected water, and clothes washing represented their main and longest contact (Kloos et al., 1983: 552).

Activity, site and infection

The association of sex with infection is therefore at times contradictory, and its value in predicting risk of infection is poor. In general however, occupational economic and other activities are useful indicators of risk. In South Africa, for example, a study in a rapidly growing community near an industrial area indicated that two types of water contact activity which played a major role in the transmission of *S. haematobium* and *S. mansoni* were swimming and washing of clothes and blankets (Kvalsvig and Schutte, 1986). There was a high correlation between water exposure and the prevalence of *S. haematobium* in the same age-sex category. In the Philippines, three of 29 independent variables proved to be related significantly with higher intensity of *S. japonicum* infection: economic activities (washing farm animals, washing farm tools and equipment, and ditch tending), sex (male), and bathing (Tiglao and Camacho 1983).

However, whilst the use of water is important in terms of risk on infection, a study in Upper Egypt indicated that site alone was an important variable in communities where different types of water body with varying infectivity levels exist, even in areas of high endemicity (Kloos et al., 1983). Such variations in infectivity occur both intraseasonally and across seasons, as well as by time of day, hence compounding the social risk factors of age, sex and purpose of water use. Further, age appeared to be significant not only because of the different kinds of water-contact activities that involve children or adults, but because of the development of immunity to infection into adulthood. The development of immunity in early adulthood is explored in a study in The Gambia (Blumenthal. 1985; Wilkins et al., 1987). In this, data were collected of water use of a seasonal rain-fed pool from direct observations, to calculate an index of cumulative exposure to infection throughout the transmission season. The observed duration of each water contact was multiplied by factors allowing for the variation of cercarial densities by site, month and time of day. A correction factor was then applied to allow for the presumed affect of different forms of water contact activity on the likelihood of cercariae entering the skin, based principally on a consideration of the proportion of the body's surface usually observed to be in contact with water in each activity. The results showed that among groups of subjects with an apparently similar intensity of exposure to infection, reinfection of *S. haematobium* tended to be much heavier in children under 10 years of age than in 10- to 14-year-olds, while only light infections were found in the few adults who became reinfected.

These studies emphasise exposure to infection, rather than the extent to which contaminative activities (i.e., urination and defecation into waterways) vary also within populations, or the relationship between contaminative behaviour and snail behaviour and infection rates. However, surveys of water contact and contamination behaviour in relation to *S. mansoni* infection were made in river and stream sites in Ethiopia (Kloos and Lemma, 1980). Of 30,925 water contacts observed during 7 consecutive days each in the dry and rainy season, 90.6% involved exposure only (fetching water, washing extremities, fording the river, and so on), while the remainder were contaminative (i.e., due to defecation) or involved both exposure and contaminative activities.

Several recent water contact studies in Brazil have used questionnaires rather than direct observations, although there has been relatively little discussion of the comparability of the two methods or of the reliability and validity of questionnaire-based studies (although see Blumenthal, 1989 and Kloos et al., 1982). In one study carried out in Comercinho in south-east Brazil, a standard questionnaire was applied to 290 households and 1208 inhabitants respectively on water contacts that occurred during the previous 60 days (Lima e Costa et al., 1987). The results showed that 75% of reported water contacts were for household activities or body hygiene and 21% occurred during leisure pursuits, all with implied risks for infection. In another study (Mota and Sleigh, 1987), a questionnaire was administered to 69 households, with one or more of the adults providing the information for each family. The results showed that the mean time spent for steam bathing was predictive of the prevalence and intensity of *S. mansoni* infection.

These studies indicate that the risk of being infected may vary with activity, duration of exposure, extent of body-surface exposed and, in view of the diurnal cercarial shedding pattern of the snail intermediate host, on time of the day. Studies highlight differences according to sex, age and exposure, with both sex and age functioning to a degree as determinants of the nature (frequency, time and duration) of water contact. In addition, they draw attention to the complex interactions of the physical and social environments: the focality and seasonality of transmission, and the effects of social structure and economic organisation. Population movements also influence patterns of transmission and infection, both where infected immigrants introduce new infections into controlled areas (Chandiwana and Taylor, 1990: 1134), and where non-infected immigrants acquire infection on moving into endemic areas. In addition, local ecological conditions clearly affect snail vector capacity and such variations occur within villages as well as more widely. Local variation in seasonal transmission of infection, the nature of water sources, and the sexual division of labour and associated water contact activities highlight the difficulty in generalising risk of infection across regions and cultures.

Social and cultural variables

The above summary of the literature highlights the research focus on the social epidemiology of infection. Other studies, summarised below, supplement these water contact studies to draw attention to key sociological variables and highlight in consequence the social basis of infection.

Occupation

A number of studies indicate the association between occupation and prevalence of *Schistosoma* infection. In general, the findings are not surprising: people who work in water are at greater risk than those who do not. A survey in the Egypt-49 project area, for example, indicated high rates of *S. haematobium* and *S. mansoni* infections among fishermen (60.4%) and boatmen (52.0%), although farmers and farm labourers, together constituting half of the population, also had high infection rates (50.6 and 41.6%, respectively). Domestic servants and factory hands had lower rates (31.9 and 31.3%), clerical workers the lowest rate (20.6%) (Farooq et al., 1966a). A study carried out in Brazil similarly showed that manual workers were at greatest risk of infection, with the rate and intensity of infection and the rate of splenomegaly significantly higher in both manual workers and in families whose household heads were manual workers (Lima e Costa et al., 1987).

Education

Level of education might be hypothesised as predictive of risk of infection, due to its association with occupation and industry and because of the presumed association between educational status, knowledge of risk factors of infection, and behaviour. The Egypt-49 study, however, demonstrated that the link between schooling and the prevalence of *S. haematobium* and *S. mansoni* infection was not so clear-cut (Farooq et al., 1966a), and Mota and Sleigh's work in a rural community in Brazil confirmed that there was no significant difference in infection rates between families with or without literate household members (1987).

Religion
Religious practices may significantly affect patterns of water use. We have noted that restrictions on the mobility of women according to religious precepts influence water contact and hence infection rates. In addition, religious rules governing cleanliness and purification may result in greater risks of infection. Farooq and Nallah (1966), for example, found significant differences in "bilharziasis" (either *S. mansoni* or *S. haematobium* infection) between Muslims and Christians. In a village with more than 400 inhabitants, the prevalence rate for the Muslim population was 19.4% and for Christians 6.7%, with higher rates of infection among Muslims consistent for all ages and independent of occupation and literacy. The constancy of this association relates primarily to purification and ritual practices, whereby purification requires the use of flowing, not stagnant, water, hence the preferred use of streams for bathing after urination, even if elimination does not occur in the water. However, ritual ablutions are only one of a wide range of water contact activities within any community, and Kloos et al. (1983), in one of the most comprehensive studies investigating the social context of water contact activities, do not identify this as a notable risk factor of exposure or infection.

Housing and hygiene
Farooq et al. (1966a) also established that the prevalence rate for both *S. haematobium* and *S. mansoni* infections were considerably higher for persons living in houses constructed of mud-brick or mud, compared with those living in houses of stone or redbrick. The authors have suggested that type of house is an easily determined index of the social and economic standard of the population. The data also showed that *S. haematobium* infection was considerably higher in persons without a latrine than in those with one, although the authors did not consider this to be a causal relationship. A study carried out in Brazil (Lima e Costa et al., 1987) drew the same conclusions, that is, the rate of infection was significantly higher in persons living in poorer types of houses or houses without piped water. However, there was no correlation between the rate of schistosomiasis haematobium and households with or without latrines in Zimbabwe (Taylor et al. 1987), and in consequence, the associations between house structure, sanitation facilities and personal hygiene remain unclear and vary according to cultural, social and economic context.

Village size and house location
Although Farooq et al. (1966b) found no definite relationship between the prevalence of schistosomiasis and the size of village, Robert et al. (1989), in a study in the Cameroon, observed the highest prevalence of schistosomiasis mansoni in larger villages (greater than 200 persons) where sanitary conditions were poorest because of crowded living conditions. Mota and Sleigh (1987) found that the relative location of the house and snail-free or snail colonised water sources was the key influence on infection status. Taylor et al. (1987) found a strong correlation between the household washing site and the prevalence of schistosomiasis in the family, but also a clear separation of water sources for different activities which suggests that expediency of choice of water site was not the major factor in selection. In this latter case, water contact patterns may yield to health education to encourage the choice of

more distant, safer water sources for household or other uses. This is not true in other cultures however, where easy access to water may take precedence over such considerations as privacy, perceived cleanliness, or avoidance of infection.

Knowledge and perceptions of schistosomiasis

A number of authors, particularly those concerned with community participation in the control of schistosomiasis, have emphasised the low priority and poor understanding of the infection among communities where incidence is high. The development of appropriate health education material and interventions to reduce transmission through treatment of infected persons and changes in water use presupposes a good understanding of community behaviour, beliefs and perceptions. These include local understandings of the prevalence of the disease, its etiology, and diagnosis and treatment of symptoms. Local knowledge, diagnosis and response to the disease is poorly documented. However, a study undertaken among farmers in Upper Egypt has provided detailed information regarding local beliefs of the transmission and treatment of the disease, and its etiology: as the consequence of contamination with excreta, drinking dirty or infected water, or due to a variety of other reputed pathogens (Kloos et al., 1982: 102). However, these inaccuracies were not important, for on the whole the population was able to identify transmission sites, recognise symptoms of infection, and seek appropriate treatment (Kloos et al., 1982: 105). Similarly, among the Kamba population in Machakos district, Kenya, although schistosomiasis was only rarely recognised as a disease and biomedical explanations do not fit well with local explanatory models of illness, the association between stream water, skin rashes and intestinal illness has resulted in preventive behaviours and treatment seeking by ill persons, and provides a valuable indigenous base upon which to introduce health education and interventions (Kloos et al., 1986).

Elsewhere, poor knowledge of the disease and appropriate treatment appear to be associated with its continued transmission. Patwari and Aneja (1988), for example, surveyed 200 schoolboys aged from 5–18 years with urinary schistosomiasis in Nigeria, and found that ignorance about the disease, its cause and means of transmission (e.g., infection occurs because of sexual intercourse, sleeping in the bed of an infected person, eating too many mangoes) and poor drug compliance were important factors in the transmission of the disease (see also Ekeh and Adeniyi, 1986). While haematuria might be considered as an alarming symptom elsewhere, in these endemic areas repeated and prolonged exposure has resulted in very high prevalence of the disease, such that haematuria is accepted as a sort of physiological process for adolescent boys which corresponds to the onset of menstruation in girls (Bello and Idiong, 1982). Many people regard the symptom as a sign of puberty (Nash et al., 1982), and hence prompt medical attention is not sought. A wider evaluation of local understandings of haematuria, and the utility of its recognition as an indicator of infection and the need for early treatment, is currently being undertaken in a multi-centre study in Africa (see Lengeler, Sala-Diakanda and Tanner, 1992; see also Lengeler et al., 1991). Elsewhere, symptoms of schistosomiasis infection may be recognised as pathological, but the etiology and consequent appropriate treatment strategies differ. In the Lindu Highlands of Sulawesi, Indonesia, for example, people refer to schistosomiasis japonicum as *sakit hantu* (lit. ghost illness), grouping it with other supernaturally caused infections for which biomedical treatment is inappropriate (Widayatun, personal communication).

Interventions, community participation and the control of disease

Early control measures for schistosomiasis and other water-borne diseases were introduced with little attention to community understandings and priorities, and in consequence met with variable success. As early as 1928 in Egypt, a study was undertaken to explore the effect of sanitation improvements, through the provision of bore-hole latrines on parasitic infections including *Schistosoma haematobium*, *S. mansoni*, hookworm and *Ascaris* (Scott and Barlow 1938). The results showed, however, that latrines had little impact on infections levels due, the authors argued, to the fact that the sanitation was installed in the houses, whilst most parasites were transmitted in the fields. They suggested that another generation born and brought up in houses provided with sanitation would, on maturity, be ready to accept and use field sanitation as well, hence reducing parasitic infections. More recent work has shown a reduction in the prevalence of *S. haematobium* – from 41.6% in 1975 to 4.7% in 1979 – with the provision of adequate pipe-borne water in Epe villages of Lagos state, Nigeria (Ejezie, 1983). A Brazilian study has also shown a spontaneous reduction in prevalence of schistosomiasis mansoni in hyperendemic areas following the provision of adequate water and the construction of toilets and bathrooms (Kloetzel and Schuster, 1987).

Poor understanding of the purpose of an intervention, such as the provision of latrines, and lack of community commitment to the intervention, highlight the importance of local involvement from the outset. A number of projects have taken as their starting point the need for community involvement and control if interventions for disease control are to be more effective and sustainable. These projects have built upon an understanding of local social, cultural, economic and political factors, although these are often poorly described in the literature.

The recognition of village priorities by change agents will determine the success of any control strategy at a primary health care level, and the community participation projects concerned with schistosomiasis especially emphasise this fact (Tanner et al., 1986). Since infection does not result in acute symptoms, since there may be a long pre-patent period, and since infected communities are typically also confronted with a variety of other infectious diseases, health problems, and economic difficulties, schistosomiasis is not often regarded locally as a priority (Andrianaja, 1986). To overcome this, schistosomiasis control needs to be incorporated within broader based community health and development programs (cf. Sandbach, 1975). Successful control programs require a period of preparation and planning during which time the knowledge, attitudes and practices of the community, and its broad priorities, are assessed (Davis and Korte, 1986: 176; Kloos et al., 1986: 171; Moir, Tullock and Sibiya, 1986: 169). Community willingness to participate in control activities or behavioural changes presupposes both recognition of the infection as a public health problem and its effects on the community, and hence the ability of a community to participate in control activities typically rests on the delivery of health education. Tanner et al. (1986: 164; see also Tanner and Degremont, 1986; Tanner, 1989a) argue that community participation in primary health-care programs requires structures that are able to "listen to communities" by linking national health services with communities, including through the involvement of village health workers and other local health staff. Community needs are necessarily accorded priority. At the same time, they argue for a pragmatic approach whereby the provision of infrastructure (e.g., a water supply scheme) may "prepare the ground" for health education campaigns to increase the use of latrines, treat infection, clear vegetation, and apply molluscide in infected waters. Without appropriate communication with the community too, including to address its understanding of the relationship between water use and infection, behavioural changes aimed at restricting or modifying domestic or recreational water contact have been unsuccessful. The capacity of communities to participate in such modifications also needs careful assessment, hence the importance of gathering baseline social and cultural data (Andrianaja, 1986; Jack, 1986; Korte et al., 1986; Kloos et al., 1986; Moir, Tullock and Sibiya, 1986).

One example of the integration of schistosomiasis control into primary health care is from Nganuland, Botswana (Sibiya, 1986). This study built upon local understandings of participation and researchers worked with community groups and key individuals, including church, village and other traditional political leaders, schools and Parents' and Teachers' Associations, Village Development Committees and Health Committees, and District Extension Teams. The control program emphasised the supply of clean water and the construction and use of proper toilet facilities, and discouraged contact with polluted water from bathing or other activities. Both the media and personal contact of health workers with community members and organisations were used to impart these basic behavioural messages. Other community participation projects have used voluntary health workers to motivate behavioural change, and again an understanding of community structure and organisation has been a prerequisite to the implementation of these strategies (see Byskov and Ali, 1986; Taylor, 1986; and for a discussion of the use of volunteers, see Manderson, Valencia and Thomas, 1992).

These projects emphasised changes in the use of water sources. A few projects have also sought to involve the community in treatment campaigns. Andrianaja (1986), for example, describes a project in the rural area of Maroway, Madagascar, which aimed to increase the use of health services by those with signs of infection, as well as to introduce behavioural changes to reduce water contamination. In common with other writers concerned with schistosomiasis, Andrianaja emphasises both the need to understand local perceptions of the disease and to provide health education to raise awareness of the means of infection and its impact on community welfare.

Discussions on measures to control infection have emphasised the role of health education in informing the community of the significance of the problem and encouraging their involvement in control measures and behavioural change; it is, Sibiya argues (1986: 169), a prerequisite for community participation. Because of the long pre-patent period and chronicity of infection, schistosomiasis is rarely regarded as a priority within infected communities; broader social and economic concerns, and other more acute health problems, tend to take precedence in community-based programmes (Andrianaja, 1986: 170; Tanner et al., 1986: 165; Tanner, 1989b; Tanner, 1989c).

Community participation and other control strategies must necessarily develop health education strategies to encourage local interest, commitment, and for mass drug administration programs, compliance. Health education has been implemented using a variety of media according to local circumstances and resources and including through community meetings, theatre, posters and pamphlets (Manderson, Valencia and Thomas, 1992; Taylor, 1986: 161; Sibiya, 1986). Other projects have approached the need for health education to raise awareness of the prevalence and importance of infection and the means of transmission through more formal mechanisms. For example, a study concerned with demonstrating the outcome of health education in the control of schistosomiasis, malaria, dracunculiasis, and onchocerciasis was undertaken in secondary schools in Nigeria, with schools divided into two equal cluster groups (five each), experimental and control (Ekeh and Adeniyi, 1988). Baseline data from the two groups were compared and indicated no significant differences in the level of knowledge of causes, prevention and treatment of the four diseases. Dissemination of information to students included talks by teachers, visual aid materials, demonstrations, story telling and role playing. Post-intervention findings after 2 years revealed a significant increase in the knowledge of the four diseases among those in the experimental group over those in the control group, and students in the experimental group no longer visited nearby streams and ponds to wash their utensils or defecate. However, the impact of health education on the prevalence of the diseases was not measured (see also Sibiya, 1986), and in general the effectiveness of health education in introducing and sustaining behavioural changes remains to be studied.

Socioeconomic consequences of schistosomiasis

Only a few studies have been undertaken on the socioeconomic consequences of the disease, as reviewed and evaluated in particular by Prescott (1979). Although both macro- and micro-level economic studies are limited, received wisdom emphasises the costs of infection at the level of the household, community and state.

Macro level

Some attempts have been made to estimate the economic effects of schistosomiasis at the macro level. Early in 1949, Khalil described schistosomiasis as "the most dangerous problem affecting the future of the Egyptian nation" and alleged that the "loss due to bilharziasis in Egypt will be 80 million every year" (Khalil, 1949; cited in Prescott, 1979: 2). A little more recently (1972), Wright has estimated an annual loss from complete and partial disability of US$ 446 million in Africa, US$ 16.5 million in South-West Asia, US$ 118 million in South-East Asia, and US$ 60.5 million for the Americas; his total estimated annual world loss amounts to US$ 642 million. Although this does not include the cost of public health programs, medical care, or compensation for illness, even so the estimates are, he believed, conservative. However, Prescott (1979) has suggested that macro estimates such as these have certain conceptual shortcomings. In particular they assume that schistosomiasis substantially impairs labour productivity in all cases – an assumption which has not been confirmed by empirical research at the micro level (see especially Parker, in press).

Micro level

Physical work capacity

Several authors have attempted to measure differences in the physiological capacity of persons according to infection status, using laboratory tests as a means of estimating work capacity. Omer and El Din Ahmed (1974) investigated some cardio-pulmonary functions and physical fitness of 31 young male nurses passing significant numbers of *S. mansoni* ova in their stools before and after antibilharzial treatment, and found some disturbance of lung function and a reduction in physical condition, parameters which improved significantly after treatment. Collins et al. (1976) tested 194 Sudanese cane cutters and found that submaximal responses to exercises on a stationary bicycle ergometer, oxygen intake, ventilation, tidal volume, cardiac frequency and estimated maximal aerobic power output (a significant determinant of working efficiency) were similar in non-infected and infected groups. However, the intensity of infection of subjects was moderate. In contrast, Awad el Karim et al. (1980) found a statistically significant difference in maximum aerobic power output among 203 Sudanese subjects, amounting to 18% between heavy infected persons and non-infected/light-infected persons, but with no difference apparent between non-infected and lightly infected persons. Ee and Polderman's study (1984) of moderately-infected tin-mine labourers in Zaire also found no significant difference in estimated work capacity depending on infection status. Although these studies present mixed findings, their results give some indication that persons with high intensities of infection will have some reduction in their work capacities.

Short-term effects on productivity

Some authors have attempted to evaluate the impact on actual or potential labour productivity through studying the influence of the disease on labour supply and labour efficiency in actual working situations, by comparing the work performance of infected versus uninfected employees. In general, their findings follow the trends of the laboratory studies. In 1962–1963, for example, a cross-sectional study in a Tanzanian sugar estate was conducted (Foster, 1967), which investigated the effect of schistosomiasis on worker days supplied and on productivity per day worked. No significant reduction was found in infected cane cutters; however, for irrigation workers who had higher intensity infection levels, days supplied were significantly reduced. Eight years later, in 1968–1969, Fenwick and Figenschou (1972), working on the same Tanzanian estate, examined the effect of schistosomiasis mansoni on earnings (directly reflecting the combined effect of days of work supplied and per work daily productivity). They found significant earning differences in a cross-sectional study, and in a time-series study the earnings of infected workers receiving chemotherapy improved somewhat, relative to the earnings of the uninfected workers. On the other hand, Gateff et al. (1971) failed to obtain significant results for a series of hypotheses which measured both labour days supplied and productivity for sugar estate workers in the Cameroon, both in an initial comparison of infected and uninfected workers, and in a subsequent comparison after the subgroup of infected workers received chemotherapy.

Two cross-sectional studies involving rural banana estate workers and female workers in an urban light manufacturing plant in St Lucia, investigated worker productivity according to the following four hypotheses: (1) disease reduces weekly earnings; (2) disease causes workers to shift to physically less demanding jobs; (3) disease reduces productivity per day worked; (4) disease reduces the amount of labour time supplied per week. The results of the study, which drew on household survey and a work-site questionnaire, estate records on worker attendance, physical output and earnings, and infection data, showed no significant effect of schistosomiasis infection on weekly earnings of either men or women, although infection was associated with lower daily productivity for men. This appeared to be offset by increased days worked per week by infected workers, suggesting that male workers compensated for their reduced daily productivity by working relatively more days than non-infected men to maintain earnings. No significant production effects were found for female workers (Weisbrod et al., 1974; see also Weisbrod and Helminiak, 1977, for a follow-up study). However, infection intensity in St. Lucia was only moderate, and the possibility exists that the physiological reserve threshold level – beyond which productivity impacts results – might be exceeded in areas of higher infection intensity.

A study carried out in Pernambuco, north-eastern Brazil, employing a three-stage clinical gradient for infected workers on two sugar estates, produced mixed findings (Barbosa and Pereira da Costa, 1981). No significant earnings differences were found in an initial retrospective study, but in a subsequent study, cane cutters in the third stage of the gradient – "hepatosplenic schistosomiasis" – were found to have 35.1% less productivity (earnings) than those in the first stage of the gradient – "intestinal form". The loss to one of the sugar estates from reduced productivity caused by schistosomiasis mansoni for the harvest season of 1978 was calculated as 0.93% of the estate's total production, or approximately US$135 000. When this figure was extrapolated to the whole state (16 million tons of sugar total annual production), the annual loss in the state was estimated to be US$2 million.

School performance

A number of researchers have investigated children's school performance, including through tests of mental ability, marks, score ranking and attendance. Results are conflicting. Some reports indicate that children seem to be relatively unharmed by the disease (Loveridge et al., 1948; Walker et al., 1970; Goldin and Barclay, 1972; Nkya et al., 1986), whilst others show definite or significant impairment of infected children (Clarke and Blair, 1966; Bell et al., 1973). Others are equivocal (Usborne, 1954; Jordan and Randall, 1962). Further, some authors found that the infected children were more active and sociable than uninfected children, as indicated for example by their membership of the main playground. Kvalsvig and Becker (1988) suggest that this is because children who were active and gregarious were more likely to spend time playing in the rivers, hence at greater risk of schistosomiasis (and other) infections. Weisbrod et al. (1974) found that infected pupils had lower absentee rates than non-infected children, and speculate that this is because the infected children were not sufficiently well to assist in the fields on harvest days, but were regarded as well enough to attend school.

Conclusions

Social and economic studies of infection and disease are still relatively uncommon, but they are especially so for endemic parasitic and other vector-borne diseases such as schistosomiasis. Yet as this review indicates, there is considerable potential for further research which explores the complex interaction of humans, vector and environment.

The available literature provides compelling evidence, especially in Africa, of the impact of water development projects on the transmission and prevalence of schistosomiasis infection, because of environmental changes which favour snail breeding conditions, population changes in development areas in terms of absolute numbers and the number of non-immunes, and because of increased human–water contact due to changes in agricultural production and irrigation. The association of development and the transmission of disease points to the need to integrate disease prevention programs with water development projects, although the politics of disease control and the economics of alternative methods of control or treatment require further research.

The research we have described emphasises social risk factors of transmission and infection, and the predictive value of demographic and sociological variables for infection and intensity of infection. However, the relative importance of these variables – age, sex, occupation and industry, for example – vary culturally and regionally, and according to other environmental and ecological factors: the focal distribution of snails, the selection of water-sites, seasonal variation, and so on. More well-designed studies are still needed, particularly for schistosomiasis japonica, where there is yet no social epidemiological research.

Water contact studies have provided us with the best data to assess the complex inter-relationship between human behaviour and infection. However, a full appreciation of the complex links between social organisation, mode of production, the sexual division of labour, risks of infection, and community understandings of etiology and diagnosis and treatment of symptoms of infection, demands a methodology that brings together a sophisticated combination of quantitative and qualitative methods.

Further, whilst water contact has been relatively well studied, albeit with equivocal findings, little research has been undertaken on other social, cultural and economic factors influencing the prevalence of schistosomiasis. With the exception of the work of Kloos et al. (1982, 1986), there has been virtually no attention to cultural dimensions of the disease. Whilst the possibility of a sociology of the infection emerges from the current literature, an anthropology of schistosomiasis is very much a task for future researchers (although see Parker, 1989). We still do not know – in different cultural settings and for different types of schistosomiasis – how readily people are able to identify symptoms of infection; their ability to differentiate schistomiasis infection from other diseases (e.g. other bloody diarrhoea, or bladder infections); local treatments and patterns of health seeking behaviour, including of available biomedical services as well as indigenous healers; availability and acceptability of current chemotherapy and the distribution of drugs; or understandings of etiology and prevention from avoidance. Nor do we understand the way in which risk activities – that is, water contact behaviour – fit with other aspects of social organisation, kinship relations and the structure of economic life, although the anthropological components of the St. Lucia study (Dalton, 1976) highlight the importance of this.

Much of the research, including water contact studies and socioeconomic studies, has concentrated on the individual, and there has been little work on community use of water and control of water sources, on the changes that occur within communities as a consequence of interventions, or on the impact of infection on communities. Economic research on schistosomiasis has yet to address the household or village, and to date has largely focused on individual work capacity and extrapolated national costs of infection. Community perception of the cost of infection again needs exploration, as a significant determinant of health seeking behaviour and of the reception of any control program.

The lack of information is greatest for Asia and Latin America, but there remains in all endemic areas a need for more comprehensive studies to better understand the dynamics of infection and to gather sufficient, accurate data as a sound foundation for prevention and control. Since schistosomiasis is sustained through the synergy of humans, vector and environment, such comprehensive studies are necessarily interdisciplinary tasks.

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