Available online at www.elixirpublishers.com (Elixir International Journal)

Applied Biology

Elixir Appl. Biology 51 (2012) 11024-11028

ISSN: 2229-712X

An Investigation into the Prevalence, Predisposing factors and Vector transmission of Urinary and Intestinal schistomiasis in Zvishavane District, Zimbabwe

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ARTICLE INFO

Article history:
Received: 28 June 2012;
Received in revised form:
30 September 2012;
Accepted: 20 October 2012;

Keywords
Schistosomiasis,
Predisposing,
Prevalence,
Vector,
S. heamatobium,
S. mansoni

ABSTRACT

Schistosomiasis is endemic in many countries affecting more than 200 million people worldwide mostly those living in rural and agricultural areas. A survey of the prevalence of schistosomiasis, its predisposing factors and snail host species was carried out in Zvishavane district, Zimbabwe, from March to November 2010. Prevalence of urinary and intestinal schistosomiasis was determined from volunteers' stools and urine using the Kato Katz technique. Predisposing factors to schistosomiasis were investigated through the use of questionnaires and field observations. Snail species responsible for the spread of the different schistosoma species in the district were determined by collecting snails from three major rivers; namely Runde, Ngezi and Manjere. A total of 250 patients (130 males and 120 females) participated in the study and a total of 168 were infected (67.2% schistosomiasis prevalence). This was despite the widespread knowledge (95% of the respondents knew about schistosomiasis) of the disease. *S. haematobium* prevalence was higher (60.4%) than S. *mansoni* prevalence (6.8%). Unsafe sources of drinking, washing and irrigation water like dams and rivers were to blame for the high incidence of schistosomiasis. Three snail species were collected; *Bulinus globosus* (12 individuals), *Melanoides turberculata* (9) and *Bulinus tropicus* (9) but only *B.globosus* shed cercariae.

Introduction

Schistosomiasis refers to infection with Schistosoma trematode flat worms or flukes that are transmitted by fresh water snails. The disease is zoonotic and when it occurs in man it is called bilharzia. Blood in urine signifies infection by *Schistosoma haematobium*, a condition called urinary schistosomiasis and blood in stool indicates infection by Schistosoma *mansoni,* a condition called intestinal schistosomiasis. Each schistosome has its intermediate snail host which facilitates the transmission of infective stage to man. The disease is endemic in 75 countries affecting more than 200 million people mostly those living in rural and agricultural areas (Clements, Moyeed and Brooker 2006).

According to (WHO, 1993), about 500 000 to 500 million people are at risk of being infected with schistosomiasis as a result of poverty, inadequate hygienic practices coupled with inadequate water supply as found mostly in the least developed tropical countries of the world. The three most common species of trematode are *Schistosoma haematobium*, *S. mansoni* and *S. japonicum*. All these species have man as their definitive host, but each has a different fresh water snail as its intermediate host. The adult schistome worms, both male and female, live in human mesenteric, portal and vesicle veins, and their life cycle consist of the alternate generations each in its own host. The miracidium hatches from the egg and invades the fresh water snail from which the cercaria are released and invades the human host. They penetrate the skin, where they may cause cercarial dermatitis, then enter a vein via the lymphatic system and eventually reach the liver where they mature. A heavy infection at this stage can cause an acute febrile reaction with hypereosinophilia lasting several days or weeks (Katayema fever). The trematode egg is the main cause of the pathological changes, its antigen leads to the pathological changes, and its antigen leads to the formation of granulomata which consist of epithelioid, plasma and giant cells surrounded by loose fibrous tissue. These granulomata occur in the wall of the bladder, where they often calcify (*S. haematobium*), or in the large bowel (*S. mansoni; S. japonicum*). The ova of all three species of schistosome have been found in the brain and in the spinal cord where lesions may result both from infection of the arterioles and from granuloma formation (Coutinho and Acosta, 2007).

The parasite undergoes developmental changes that enable them to migrate to the liver, where they begin feeding on red blood cells. The worms partner up and move to a particular location in the body, depending on the species of schistosoma helminthes*; S. mansoni* relocate to the mesenteric or rectal veins *and S. haemotobium* relocate to the veins surrounding the bladder, ureters and kidneys. Upon reaching sexual maturity after six to eight weeks, the pairs permanently copulate and begin to produce eggs at a prodigious rate, up to 3,000 eggs per day in certain species of schistosoma (Coutinho *et al.*, 2007).

After the pair of helminthes lay eggs, some eggs remain lodged in the body and some leave the body through stool (in *S. mansoni* infection) and urine (in *S. haematobium* infection) and hatch upon contact with water, releasing free swimming miracidium. The miracidia find and infect the appropriate snail intermediate host where they mature into larvae that are released into the water, completing the cycle of infection. In one life cycle, the parasite passes through both humans, who are the

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primary host, and a non-human vector - freshwater snails, which are the secondary host. Thus schistosomiasis is acquired in bodies of water, where larvae that have matured in freshwater snails attach to and penetrate human skin.

The distribution of schistosomiasis prevalence in Zimbabwe, as stated by Woolhouse and Chandiwana (1990), reflects a close relationship with availability of surface water, especially in northern eastern Zimbabwe, which has the highest temperature and rainfall, and, where most streams have some water all the year round, the prevalence of *S. mansoni* and *S. haematobium* is at its highest. *S. mansoni* is also prevalent along the shores of Lake Kariba and in the lower reaches of the Sabi, Lundi and Nuanetsi rivers in the south-east, which are perennial (Taylor and Makura, 1985). In recent years, over 10 000 small dams and reservoirs have been constructed throughout Zimbabwe. This does not appear to have resulted in high levels of prevalence of *S. haematobium* or *S. mansoni* on a national scale, although the prevalence of *S. haematobium* in medium and low prevalence areas may have gone up as a result of water conservation. There is no difference in prevalence of *S. mansoni* or *S. haematobium* in the western part of Zimbabwe (Taylor and Makura, 1985).

Because of its detrimental effects schistosomiasis prevalence must be closely monitored by treating infected humans, destruction of snail habitat and also treatment of water bodies to curb live cercariae (Clements *et al.*, 2006). Over most of Zimbabwe the transmission is highly seasonal, with the exception of the Zambezi Valley and the south-eastern low-veld, where, because of the warmer climate and the presence of perennial water, the seasonality may be less marked (Shiff 1979, Taylor and Makura, 1985). Zvishavane District lies in the Midlands Province where rainfall pattern is seasonal but the major areas of transmission are reservoirs such as dams and perennial rivers and streams.

According to Zvishavane District hospital records, the recent years (2005-2009) have witnessed a steady increase in cases of schistosomiasis. The year 2010 registered a dramatic increase in infection rates in both adults and children, especially school children seeking medical attention as compared to any other previous years. In the past 5 years, from 2005-2009, there were about 1500 infections recorded and in 2010 alone, there were about 800 infection cases that were recorded which was almost half of the people infected in five years.

Zvishavane district is a mining town that has the majority of its dwellers settled in rural areas. These people are involved in activities such as fishing, farming, gold panning along river banks and dam irrigation. All these activities expose people to high risks of contracting schistosomiasis. People get drinking water from dams, rivers and unprotected wells. These factors and lack of knowledge about schistosomiasis may be contributing to the increased infection by schistomsomiasis. In urban areas there are those who are poverty stricken and engage in fishing in sewer streams for survival thereby exposing themselves to schistomiasis infection. Zvishavane is also one of the hardest hit towns by HIV and AIDS in Zimbabwe and it is possible that compromised immunity is contributing to the high infection rates. Despite the seemingly increasing schistosomiasis prevalence rate in the district, no study has been done to assess the levels of prevalence, the predisposing factors and the identification of snail species which may be acting as the alternate hosts of the schistosomes. This study aimed at achieving this.

Materials and Methods

Study site

The study was carried out in Zvishavane district (20°20'00"S and 30°01'59"E), Zimbabwe, from March to November 2010. Zvishavane district is situated at an altitude of 915m and has a mean temperature of 15°C in the coldest month and 23°C in the hottest month. It receives an average rainfall annual of 569 mm. Schistosomiasis prevalence determination and questionnaire administration was carried out at Zvishavane Referral Hospital and schistosome snail host determination was done in the surrounding major rivers; namely Runde, Ngezi and Manjere.

Ethical considerations

Permission to study was granted by the District Medical Officer and much of the help in the laboratory was offered by the Medical Laboratory Scientist. Consent was sought from the patients who came for treatment at the hospital and volunteered to participate in the survey.

Study Structures

The study population was volunteer patients at Zvishavane Referral Hospital from March to November 2010. In determining the prevalence of schistosomiasis volunteers' stools and urine were collected and analyzed using the Kato Katz technique.

Those who volunteered filled in a questionnaire which sought to have an in-depth understanding of the individual lifestyles in order to deduce the predisposing factors of schistosomiasis. Snail species responsible for the spread of the different schistosoma species in the district were collected from three major rivers in the district namely Runde, Ngezi and Manjere.

Stool examination (Kato-Katz technique)

250 volunteers' stools were collected and put in clean, clearly labeled containers and analyzed using the Kato-Katz technique. Using this technique, for each stool specimen, approximately 1g of faeces was placed on a filter paper (5cm square) and pressed through a 100 mesh (150µm pore size) sieve. The sieved stool sample, suspected to be containing schistosome eggs, was scrapped off the wire surface of the sieve with the edge of a microscope slide and packed into the head of a disposable syringe, previously calibrated to deliver 30mg. This amount was put on a slide, which was then inverted and pressed firmly down on a thick glass cover slip. The diameter of the faecal smear was usually about 25mm.The slide was then examined for schistosome eggs under the microscope lens x40 before drying out occurs-i.e. within 2 hours.

Urine examination

From the same (above stated) patients, 250 urine specimens were collected and put in clearly labeled containers. The urine was slightly shaken and emptied into a 20mm centrifuge tube, centrifuged at 1000 rpm for 5 minutes. Aspirating off the top 9 ml, the remaining 1 ml quantity was resuspended. Using a Pasteur pipette calibrated to discharge 1 ml in 20 drops, one drop of the sample was released onto a microscope slide and placed and covered with a cover slip. The slide was examined for *S. haematobium* eggs and count (if present) under the x10 objective of a light microscope.

Design of Questionnaire

The design of questionnaire considered simple investigative questions, to elicit disclosure of activities that were undertaken by these individuals that exposed them to contaminated water bodies (risk factor), time of the events, frequency of exposure as well as type of clothing worn by these people when undertaking these activities (the day to day activities).

This type of questionnaire also probed for a simple understanding if people at risk are also aware of the dangers they exposed themselves to regarding the diseases.

The combined individual responses led to the choice of rivers that were sampled for snails. The majority of the people lived around and carried out their daily activities in three major rivers of Zvishavane namely Runde, Ngezi and Manjere, and it is from these rivers that snails were collected.

Snail Collection

In collecting snails, ten samples were randomly collected from each of the three different major rivers in Zvishavane District namely Runde, Ngezi and Manjere. From each river, snails were collected from five locations, at places used or near places used by the people for various activities like bathing, fishing, gold panning, etc.

Snail habitats were visually located and a rectangular scoop net was used to collect snails. The scoop-net consisted of millimeter-mesh steel or copper gauze, with a strong iron frame and a large wooden handle made in fitted sections to permit easy transportation. The scoop was used for collecting water plants on which snails may have been feeding, resting or ovipositing, but also for gathering samples at the bottom and in which they may have been burried and from which they may have been freed by gentle agitation of the net just below the surface of the water.

The cercaria shedding method was used to determine if the snails were infected. This method involved alternate exposure of snails to light and darkness eliciting infected snails to shed cercaria which were then examined under the microscope.

All collected snails were then sent to the Natural History Museum in Bulawayo for identification.

Data Analysis

The data was analyzed using analysis of variance (ANOVA) to determine if there were significant differences in Schistosomiasis prevalence among males and females, as well as infection rates by *S. haematobium* and *S. mansoni* among different age groups. Multiple comparison test (Bonferroni) was used to detect between subjects effect on prevalence. Proportion Analysis was used to find out if there were significant differences between age groups of the same gender. Graphs, pie charts and tables were also used for data analysis

.Results

Overall Prevalence of Schistosomiasis

Out of the 250 patients that participated in the study, 130 were males and 120 were females. Of these participants a total of 168 (67.2%) were infected by schistosomiasis (Fig 3).

Fig. 3. Pie chart showing the overall schistosomiasis infection in the District

Patients that were infected by *S. haematobium* were 151 (60.4%) and those that were infected by *S. mansoni* were 17 (6.8%).

Schitosomiasis prevalence by sex

The prevalence of *S. haematobium* among males and females was 32.8% (82 cases) and 27.6% (69 cases), respectively. *S. mansoni* prevalence was found to be 3.2% (8) in males and 3.6% (9) in females (Fig 4).

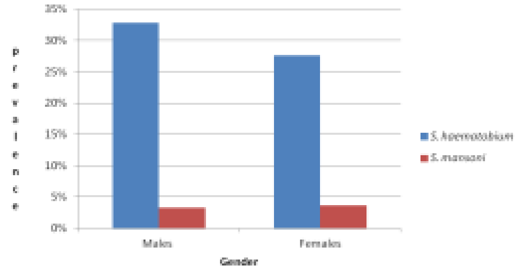


Fig. 4. Graph showing the prevalence rates of *S. haematobium* and *S. mansoni in* both males and females.

S. haematobium infection was higher in both males and females as compared to S. mansoni, with S. haematobium infection being 29,6% and 24% higher in males and females than S. mansoni, respectively.

Prevalence by age group

The prevalence rates of S. haematobium and S. mansoni in different age groups and sexes are shown in Tables 1 and 2 below.

Table 1. Prevalence rates (%) for S. haematobium and S. mansoni in different male age groups

Age group (yrs)	*S. haematobium* (%)		*S. mansoni* (%)		
5-15	90.40[a]		66.70[a]		
16-25	58.30[b]		40.00[b]		
26-35	94.70[a]		0.00[c]		
36-45	33.30[c]		20.00[d]		
46-55	40.00[c]		16.70[d]		

Note:

Prevalence rates in the same column denoted by different letters are significantly different (P<0.05), Proportion Analysis.

The highest prevalence rate recorded for *S. haematobium* was 94.7% in the age group 26-35 yrs followed by the 5-15 age group (90.4%) and the lowest recorded was 33.30% in the age group 46-55 yrs. *S. mansoni* had its highest prevalence rate in the age group 5-15 yrs of 66.70% and its least prevalence rate of 0 in the age group 36-45 yrs.

Table 2. Prevalence rates (%) for S. haematobium and S. mansoni in different female age groups

Age group (yrs)	*S. haematobium* (%)		*S. mansoni* (%)		
5-15	90.40[a]		66.70[a]		
16-25	58.30[b]		40.00[b]		
26-35	94.70[a]		0.00[c]		
36-45	33.30[c]		20.00[d]		
46-55	40.00[c]		16.70[d]		

Note: Prevalence rates in the same column denoted by different letters are significantly different (P<0.05), Proportion Analysis.

In all the age groups *S. haematobium* prevalence rates were higher than those of *S. mansoni*. In the age group 26-35 yrs a highest prevalence rate of 81.30% was recorded in *S. haematobium* while in the same age group zero prevalence was recorded for *S. mansoni*.

Overally there were significant differences observed in the mean prevalences among *S. haematobium and S. mansoni;* between age groups and gender (P< 0.05).

Snail Data

The proportion of the snail species collected from the three rivers and the results of the shedding procedure are shown in Table 3 below. Three species of snails; *Bulinus globosus*, Melanoides turberculata and Bulinus tropicus were identified in the study. Bulinus globosus constituted the highest proportion with 12 individuals (40%) and the two other species Melanoides turberculata and Bulinus tropicus had 9 individuals (30%) each.

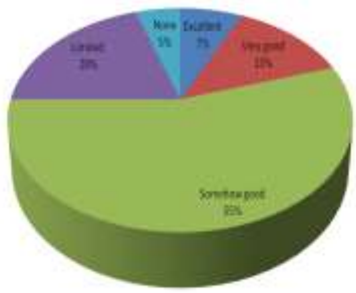
Table 3. Proportions of the snail species collected and the results of the shedding procedure

Species	No of individuals collected	Results of shedding	Species shed	
Melanoides tuberculata	9	-	-	
Bulinus globosus	12	+	*S.haematobium*	
Bulinus tropicus	9	-	-	

Bulinus globosus had the highest number of snails collected (12) and was also the only one which shed cercariae. The shed cercariae were of the species S. heamatobium. The other snail species Melanoides tuberculata and Bulinus tropicus had the same number of snails collected (9) each and didn't shed any cercariae.

Pre-disposing factors

From the questionnaire survey it was discovered that quite a number of individuals (55%) had somehow good knowledge of schistosomiasis and a small proportion (5%) knew nothing about schistosomiasis. The pie chart below (Fig 5) shows the proportions of different levels of knowledge on schistosomiasis of the people in the district.



Fig, 5. Pie chart showing proportions of people's knowledge about schistosomiasis

The overall questionnaire revealed that 80% of the respondents claimed to have seen promotional information about schistosomiasis especially in clinics and hospitals. Observations done in most public places of the districts like clinics, shops, halls, etc, reveal that information about schistosomiasis (bilharzia) alongside cholera and HIV have been promoted on awareness reasons to the public.

The majority of individuals (45%) used river water for drinking and only a small portion (10%) of the population used tapped water (Fig 6).

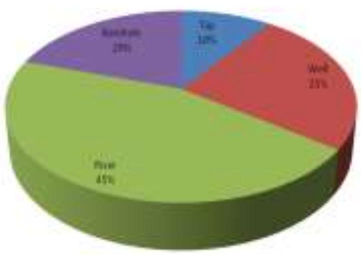


Fig. 6. Pie chart showing the different proportions of drinking water of the people in Zvishavane District

Observations also revealed that common occupations and activities are farming (canal irrigation) and fishing. Children also play barefoot along river banks and even swim in the water as they bath (Fig 7) below.

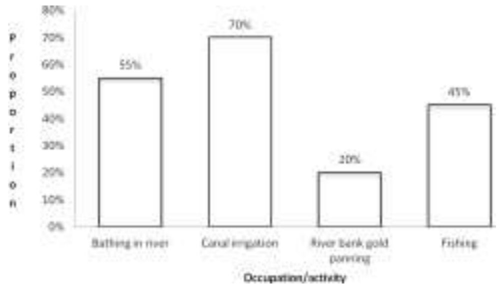


Fig. 7. Graph showing different proportions of the factors that expose people to schistosomiasis infection.

Discussion

Schistosomiasis is a multifactorial disease, prevalent in impoverished and often vulnerable people living in conditions that favour transmission, without proper access to health care or prevention measures. The survey of prevalence of schistosomiasis in Zvishavane District revealed that the overall schistosomiasis prevalence rate was 67.2% with the associated prevalence rates of *S. haematobium* and *S. mansoni* being 60.4% and 6.4% respectively. Unexpectedly high prevalence rates of *S. haematobium* were observed among age groups, 5-15 and 26-35 years, having prevalence rates of 90.4% and 94.7% respectively.

The activities associated with these age groups can be the contributing factors of such high prevalence rates. As WHO (2002) reported that the young population under 15 years old because of their interaction with unsafe water and lack of immunity against schistosomiasis make them vulnerable to schistosomiasis infection. The high prevalence in the under 15 age group also confirm Chandiwana and Christiansen's (1988) results who noted that the prevalence of schistosomiasis and the force of infection in the high-veld of Zimbabwe for *S. haematobium* are at their highest for the age group 7–20 years.

Loss of the once acquired immunity due to other factors such as HIV infection may have contributed to the high prevalence of urinary schistosomiasis in the 26-35 years age group. In a research done in western Kenya when assessing susceptibility to reinfection by schistosomiasis in the car washers, it was observed that persons with HIV-1 infection and reduced CD4+ T cell counts were more susceptible to reinfection than were persons not coinfected with HIV-1, suggesting that host resistance to parasite reinfection may be dependent on CD4+ T cell help (Karanja, Hightower, Colley, Mwinzi, Galil, Andove, Secor 2002). However, this cannot explain the occurrence of zero intestinal schistosomiasis infection in the same age group.

Moderately high prevalence rates were observed throughout the other age groups but males had generally higher prevalences as compared to females. Socially dictated gender roles especially in the rural areas may have caused such differences. The responses to the questionnaire showed that men in most of the age groups were more infected because most of them were exposed to infected water bodies while undertaking masculine activities such as farming (canal irrigation) and river bank gold panning. Women were less infected as they spent most of their time at home cooking and caring for the kids and doing other things that lessened their exposure to contaminated waters. These results are in consonance with those obtained by Chandiwana and Christiansen (1988) who observed that the infection in males generally exceeds that among females. This is further confirmed by Mason, Patterson and Loewenson (1986) who noted that differences in the prevalence of *S. haematobium* and *S. mansoni* also indicate a variation in frequency of water contact.

S. haematobium was seen to be the most predominant and more prevalent schistosomiasis species in the district while *S. mansoni* was even below the minimum prevalence rates that can raise alarm. In some age groups there were even zero infections and no *S. mansoni* snail vectors could be retrieved from rivers which bring to attention if some of the people diagnosed were even from the same region as those who were diagnosed of *S. haematobium*. On the contrary failure to retrieve any *S. mansoni* vector snails may have been due to the lack of proper and sufficient equipment, as only the scoop nets were used to collect snails from rivers.

The snail vector largely responsible for the spread of *S. haematobium* was *Bulinus globosus* which had a highest proportion of 40%. The other snails that were retrieved which are *Melanoides turberculata* and *Bulinus tropicus* are non-vectors. The heavy presence and high proportions of actively shedding *S. heamatobium* host snails (*Bulinus globosus*) thus explains the high prevalence of urinary schistosomiasis in the district. The absence of *S. mansoni* host snails is difficult to explain in view of the occurrence of this condition in the district. It is possible that the few cases of intestinal schistomiasis could be a result of people coming from neighboring districts as this is a big referral hospital.

It was observed that even if most people knew about sources and activities that led them to being infected, economic factors led these people to continue engaging in activities such as canal irrigation, bathing and washing in rivers and also river-bank gold panning. The majority of people have no access to tapped water as it is costly for most of them. So a large population resorts to using river water for drinking purposes. Boreholes and wells serve as alternative sources of safe drinking water. This lessens the transmission of schistosomiasis but the boreholes are separated by prohibitive distances and hence some populations resort to drinking unsafe water from rivers. Most of the villagers use Blair toilets but the problem of increased *S. haematobium* prevalence is probably becausewhen both adults and children swim or bath they urinate in the water.

In conclusion it can be said that Schistosomiasis, like other neglected diseases, is a disease of poverty. The study revealed a high prevalence of the disease despite the fact that the majority of the people, about 95%, knew or had an idea of how shistosomiasis was transmitted. Infected water bodies in which people frequented for washing, drinking and irrigation water was the source of spread of schistosomiasis. Young children in the age group 5-15 yrs were affected as they played in water for longer periods of time thereby increasing risk of exposure. The second highest prevalence in the 26-35 age group may be attributed to compromised immunity.

This study clearly showed that the risk of schistosomiasis infection increases with activities that require frequent contact with cercariae-infected water sources. It is also evident that lake of portable water can bring about activities that would promote the transmission of schistosomiasis. Therefore it is advocated that development planners in the district take into cognizance the desirability of providing adequate sources of portable water for such communities that are in hard to reach and remote settings. Also to help in the control of schistosomiasis the rural community can help in the reduction of snail vectors by using different ways which include the use of chemicals i.e. molluscides, biological and environmental methods.

Acknowledgements

We are grateful to the laboratory staff at Zvishavane Referral Hospital who helped in providing materials and space for this study to be a success. We are also grateful to Dr. P Makoni of the National University and Science and Technology (NUST) who helped in identification of the snails.

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