URINARY SCHISTOSOMIASIS SURVEILLANCE IN PRIMARY HEALTH CARE IN SOUTH AFRICA

by

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"**In theory**, every country with endemic schistosomiasis could initiate specific public health and inter-sectoral activities directed towards control of the disease. **In practice**, the major challenge over the next decade will be to promote the development of strategies with feasible objectives in those countries without active control programmes." (WHO Technical Report Series 830. 1993. pg4)

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"The **ANC** is committed to the promotion of health through prevention and education."(ANC. 1994. pg9)

Figure above: Testing urine samples for micro-haematuria using chemical urinalysis strips.

Figure below: Community Education Programme at Mpolweni Mission, KwaZulu-Natal.

PREFACE

The experimental work described in this dissertation was carried out in the Department of Zoology and Entomology, University of Natal, Pietermaritzburg, under the supervision of Professor Chris Appleton.

These studies represent original work by the author and have not otherwise been submitted in any form for any degree or diploma to any University. Where use has been made of the work of others it is duly acknowledged in the text.

ABSTRACT

A multifaceted *Schistosoma haematobium* study aimed at assessing five different diagnostic techniques of surveillance was conducted. Their use in varying operational circumstances with particular reference to Primary Health Care was conducted in three areas of varying prevalence of disease namely; Mpolweni Mission (44.1%), Empangeni (30.3%) and Verulam (72.0%), KwaZulu-Natal, South Africa. This study incorporated both theoretical and applied components. The theoretical components included freshwater snail surveys, review of literature of *S. haematobium* diagnostic techniques and an assessment of five diagnostic techniques with particular emphasis on diagnostic performance and cost analyses. Added to these components was migration and the assessment of the prevalence of disease amongst occupants of informal settlements in and around the greater Pietermaritzburg city centre. The applied component included the initiation of a holistic *S. haematobium* control programme based along the World Health Organisation Guidelines.

The study provided insight into several of the countries health issues relevant to both schistosomiasis and other diseases and highlighted weaknesses that may hinder the successful implementation of the current National Framework for Parasite Control. The presence of urban schistosomiasis was noted for the first time in the city of Pietermaritzburg. The present schistosomiasis distribution could be influenced by the rural-urban migration that is impacting upon major metropolitan areas. Without intermediate host snail surveys and schistosomiasis prevalence surveys amongst members of the population, the real geographic distribution of the disease will not be known.

The diagnostic methods that were compared included sedimentation, filtration, three brands of chemical urinalysis strips, urine colour scales and an indirect questionnaire. Sensitivity, specificity, positive predictive, negative predictive and efficiency values were determined. Using these values, diagnostic performance ranges were established. The ranges were influenced by the cut-off values used, technique and prevalence and intensity of infection of the study area. The chemical urinalysis strips at cut-off 10erythrocyes/μl (73.7% - 93.2%) were highly sensitive whereas urine colour scales (97.1% - 99.4%) and indirect questionnaire (80.4% - 90.3%) were highly specific. The relationship between the community prevalence rates measured by all five techniques varied significantly. A cost-analysis of the techniques/sample demonstrated a wide price range (20c - R4.32). Therefore their use would be dictated more by the availability of funding than by any operational advantages each individual technique may have demonstrated.

Within the public health services a need for: (1) staff training programmes, (2) core staff based within the PHC system that is dedicated to parasite control and (3) a strengthening of infrastructure was demonstrated. These may be achieved via workshops, improved communication, education courses, specific time allocation to parasite programmes i.e. parasite week, project co-ordinators and the designation of tasks.

DEDICATION

This dissertation is dedicated to my:

Grandfather

and

late Dad

Thank you for your support, inspiration and belief in me.

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I wish to acknowledge the following people, without whom this research project would have been a great deal more difficult.

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INTRODUCTION

Schistosomiasis endemic countries rarely rank control of the disease among their top public health priorities. Many of these countries have not implemented national control programmes. South Africa has been such a country but is now faced with the problem of how to implement a programme within its available human and financial resources.

The South African Health Care System is presently undergoing major changes since the adoption of the African National Congress Health Plan (1994). These changes are based on the philosophy of Primary Health Care (PHC) which aims to reduce inequalities in access to health services, especially in the rural areas and deprived communities. Under the plan, everyone has a right to achieve optimal health. A relevant aim of the communicable disease policy is to foster continued epidemiological analysis of reliable, opportune and comprehensive data for planning and management of various control programmes. The policy sets out to achieve this in two ways; firstly, vector control activities will be reinforced through multisectoral approaches and secondly, Epidemiological Units at provincial and national levels will be strengthened. The latter will be done by producing and deploying qualified health personnel, and appropriately allocating resources to ensure both continued epidemiological work and surveillance (ANC 1994). One major limiting factor which will influence the health changes is the availability of finances needed to implement the various programmes. It is hoped that under this new ANC Health Plan, a national schistosomiasis control programme will be initiated and implemented.

The first record of schistosomiasis in Sub-Saharan Africa was made by Dr John Harley (1863). He discovered *Schistosoma haematobium* eggs in the urine of a patient from Uitenhage, South Africa. Since then, the distribution of the disease was mapped in 1934 by Porter (1938) and more recently by Gear, Pitchford and van Eeden (1980). Small scale control programmes were implemented in South Africa since the late 1950s but the bulk of research into control was conducted in the 1970s and 1980s (Meyling *et al* 1959). During this time, Pitchford was advocating control of the parasite in rural areas by Environmental or Rural Management. This form of control aimed at managing the environment of the free-living stages of the parasites' life cycle and thereby reducing transmission. Management measures included the provision of swimming baths for children, laundry slabs, latrines, piped water and bridges. These methods were only adopted later by Jordan (1985) with the St Lucia project. Despite all the research that was being conducted in South Africa, urinary schistosomiais was never classified as a notifiable disease, nor was any statutory control programme established.

In 1985 it was estimated that two million people in South Africa were infected with schistosomiasis with the majority of them being asymptomatic (Schutte 1985). Researchers warned that there was no reason for complacency and that serious disease does occur. In the short term it may not be a killer but it is a definite health debilitator which reduces efficiency and output at all levels and contribute to a low standard of living. Despite this warning, public health authorities have given this disease a low priority because schistosomiasis is generally not regarded as significant cause of death (Schutte 1985).

Since the late 1980s the amount of schistosomiasis research conducted in the country has declined. A result of this decline is that knowledge of prevalence levels within the endemic areas has remained as it was in 1980 and has not become any clearer. Compounding the problem is the mass rural-urban migration phenomenon and the establishment of informal settlements in and around city centres. The movement of populations has led to increases in the spread of schistosomiasis. Infection may be introduced into an area by infected immigrants while non-infected immigrants may contract the infection in their new environment (Wurapa *et al* 1989). These population movements and the establishment of informal settlements may have altered previous schistosomiasis distribution patterns. However, there are no studies to confirm or dispute this.

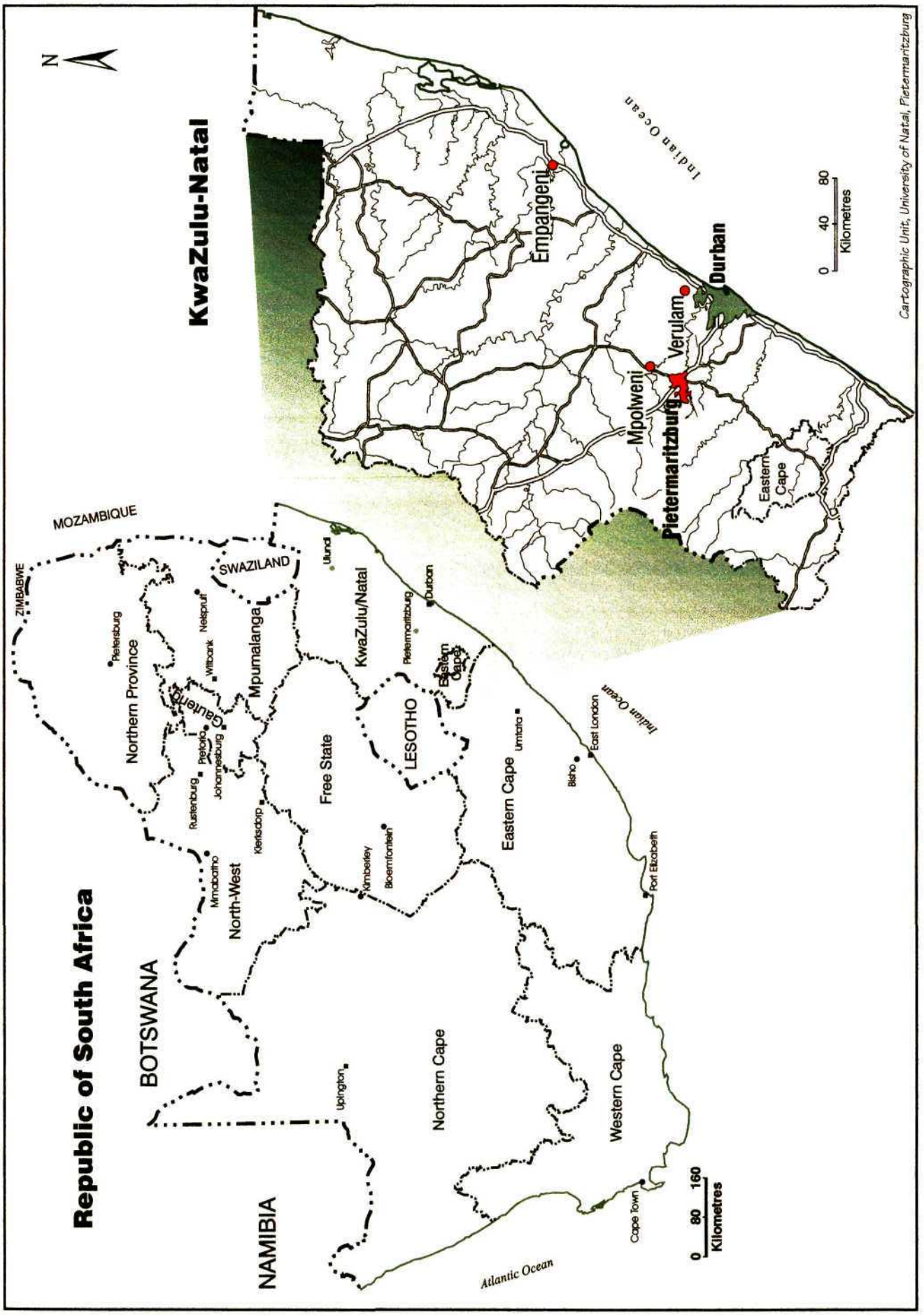
In 1995 a National Framework for Parasite Control was drafted at the request of the National Health Department. However, there has been no indication as to whether or not it was accepted. The fact that it was requested and the existence of the ANC's National Health Plan (ANC 1994) suggests that parasitic diseases other than malaria, i.e. schistosomiasis, will be receiving a new emphasis. A detailed knowledge of the epidemiology of schistosomiasis in the targeted for control areas and collaboration between interested parties carrying out surveys are two important pre-requisites for the implementation of the schistosomiasis control framework. An epidemiological study would have to incorporate both the parasite and human host and include an understanding of the life-cycle and transmission pattern of the parasite in that area. Prevalence data for both hosts and parasite would be required as would intensity of infection data for the human host.

A key factor in investigating the epidemiology of schistosomiasis in a target area is having the ability to determine who is infected and who is not. Several screening methods, both quantitative and qualitative, are presently being used around the world for *Schistosoma haematobium* surveillance. However very few studies have been conducted in South Africa

and one of the important questions to be asked is: What method would be best suited for South Africa?

It was with this background that the present study was initiated. The intention was to assess six different methods of *Schistosoma haematobium* surveillance and their use in different operational circumstances with particular reference to PHC. These included snail surveys, urinalysis strips, urine filtration, sedimentation, colour scales and questionnaires. Much of the focus of the study is based around Pietermaritzburg, KwaZulu-Natal. This dissertation is divided such that chapter one covers the topics of snail surveys, the issue of migration and infection prevalences in informal settlements in and around the greater city area. Chapter two is a review of literature on diagnostic techniques for urinary schistosomiasis which are suited to field surveillance. Chapter three assesses five of these techniques in three areas of differing prevalence levels. The areas studied include Pietermaritzburg, Mpolweni, Empangeni and Verulam (Figure 1.1). Chapter four describes a pilot schistosomiasis control programme incorporating the previous findings. This control programme provided a unique opportunity to gain first hand experience in running a holistic schistosomiasis control programme within the PHC system.

Figure 1.1: Relative position of the four study sites: Pietermaritzburg, Mpolweni, Empangeni and Verulum in KwaZulu-Natal, South Africa.



CHAPTER 1.

RURAL-URBAN MIGRATION AND ITS IMPACT ON *SCHISTOSOMA HAEMATOBIUM* TRANSMISSION IN THE GREATER PIETERMARITZBURG AREA

1.1 INTRODUCTION

Disease and mobility are two factors that have been neglected in epidemiology despite there being both current and historical evidence that human movement has led to the spread of diseases. Population mobility has not only contributed to the spread of both schistosomiasis and malaria, but has also influenced control and eradication programmes. Prothero (1977) emphasised that greater attention needed to be paid to the nature and variety of population movements and to their differing impacts upon disease and health. More recent research has highlighted the need for greater monitoring of population movements (Ofoezie *et al* 1997). Population movements have led to increases in prevalence and intensity of schistosomiasis infection in endemic areas of Africa, South America and Asia (Iarotski & Davis 1981). Migrants entering north-eastern Kwazulu-Natal, South Africa, from Mozambique have contributed to an increase in the number of malaria cases being reported and the acceleration of the spread of chloroquine-resistant malaria (Herbst *et al* 1985; Appleton *et al* 1996). Further studies on the migrants showed them to have a *S. mansoni* prevalence which Appleton (1996) noted could have public health implications by encouraging transmission in a non-endemic area.

Migration of schistosomiasis carriers on both large and small scales has altered the distribution and prevalence of the disease. The infection can be introduced into an area by infected immigrants while non-infected immigrants may contract the infection in their new environment (Wurapa *et al* 1989). Overcrowding, water contact activities and recreational activities are some of the factors responsible for the spread of the disease (Wurapa *et al* 1989). On a large scale, African slaves introduced into Brazil between 1550 and 1646 are presumed to be responsible for the importation and resulting high prevalence of the disease in the country (Machado 1982). On

a smaller scale, as populations in Brazil migrated out of the endemic coastal areas, new foci of transmission were established inland (Machado 1982).

Populations move as a result of civil unrest, socio-economic deprivation or, in nomadic peoples as a cyclical cultural practice (Wurapa *et al* 1989). Prothero (1977) realised the need to differentiate between the different types of migratory patterns that may occur. He categorised people on the move as either migrators or circulators. Migrators are defined as people who move away from their area of residence and do not return to it. Reasons for their move may include violence, marriage and obtaining work. Circulators are defined as people who move from their residence but return after various time intervals, i.e. daily, seasonally or annually. Reasons for circulating include moving to an area to attend school, working in another area, visiting friends and relatives, collection of water and food. Migration and circulation occur on different spatial and temporal scales.

In South Africa, estimates of total number of people infected with schistosomiasis range from two million (Gear & Pitchford 1977), three million (Annonymous 1981) to four million (Doumenge *et al* 1987). Since the publication of the first urinary schistosomiasis distribution map by Porter (1938), urinary schistosomiasis has spread to cover an estimated area of 320,000km^2 (Doumenge *et al* 1987). Intestinal schistosomiasis is found in a superimposed area of 60,000 km^2. Gear and Pitchford (1977) indicate that the geographic spread of urinary schistosomiasis may be decreasing. This can be seen in the apparent reduction of transmission in the Eastern Cape. A national survey conducted by the Department of Health, MRC, SAIMR and Potchefstroom University resulted in the publication of the *Bilharzia Atlas of South Africa* in 1980 which indicates that *S. haematobium* is endemic in 67 magisterial districts with its distribution extending from Northern Province, eastern half of North Western Province, Gauteng, Kwazulu-Natal lowlands, and northern coastal areas of Eastern Cape. The areas of highest prevalence are in the east between Messina and Port Shepstone (Doumenge *et al* 1987).

Average *Schistosoma haematobium* prevalences range from 23% in the southern areas to 90% in the northern areas of Kwazulu-Natal (Doumenge *et al* 1987). Gear and Pitchford (1977) pointed out that in areas with very high prevalence values, almost the entire rural population over the age of five years was or has been infected with the disease. In the past, schistosomiasis has been perceived as a disease of rural communities. However, this perception will need to be changed as a result of the mass-rural urban migration which is currently occurring within South Africa.

The African continent has one of the highest urbanisation rates in the world and this has resulted in the development of a migrant fringe around most African cities (Wurapa *et al* 1989). In South Africa, mass rural-urban migration has led to rapid urbanisation and the establishment and growth of informal settlements in and around major centres. This growth has implications for health maintenance and monitoring. Schistosomiasis is one disease that must be considered together with other threats that impact on urban public health (WHO 1993) and it needs to be monitored. Transmission of schistosomiasis has already been recognised in major metropolitan areas of north-eastern Brazil (WHO 1993), Tanzania (Sarda *et al* 1985a), Zambia (Mungomba & Michelson 1995), Nigeria (Arene *et al* 1989) and central China (Tien-Hsi Cheng 1971). Studies in north-eastern Brazil and central China have shown that when rural migrants with a high prevalence of schistosomiasis move into peri-urban areas, there is a high risk of disease transmission. This is due to the contamination of natural and artificial water bodies that results from poor sanitation, inadequate sewage/refuse disposal, over-crowding and unsound personal hygiene practices (WHO 1993). One of the major problems resulting from urban foci of schistosomiasis transmission is that naïve individuals are placed at an increased risk of exposure to infection (Whittaker 1994).

In the last few years, Pietermaritzburg, Kwazulu-Natal, has experienced an increase in mass rural-urban migration and the consequent development of many informal settlements in and around the city centre. The census figures for 1991 estimated that 1 578 people were living in informal settlements. A count conducted by the Pietermaritzburg City Health Department in March 1995, estimated this informal population had grown to 25 630. These figures are estimates and are increasing each year.

In order to assess the impact that this influx of migrants may be having on the health situation in the Pietermaritzburg area, certain initial baseline data are needed. These include the prevalence of *S. haematobium* amongst occupants of informal settlements as well as permanent dwellers in the area, intermediate host snail distribution and prevalence of larvae *S. haematobium* infection amongst them. Information detailing the waterways that are used by both permanent and informal settlement occupants and the type of migration that is occurring is also important. Distribution data on the schistosomiasis-carrying snails are important to any public health programme because schistosomes tend to be host specific so that their presence serves as an indicator of potential transmission sites. The measurement of infection rates in field snail populations has been used for many years in epidemiological studies of schistosomiasis (Sturrock *et al* 1979). The presence of the parasite can be confirmed via the collection and screening of snails of the genera *Bulinus* and *Biomphalaria* (Pesigan *et al* 1958; Chu & Dawood 1970; Sturrock *et al* 1979). Knowledge of the waterways that are used by people are important

as they may become active schistosomiasis transmission sites. The types of activities that are conducted are important because certain activities, e.g. swimming, promote transmission. This is because swimming involves both total body exposure and usually for extended periods of time. Also, it is common for children to urinate after entering the water. If the child is infected with schistosomiasis, eggs will be released into the water column and transmission will be maintained. The combination of schistosomiasis-infected people, a water source near to their homes and the presence of infected intermediate host snails are important guides for the identification of actual and potential transmission sites.

Without this initial base-line data, potential sites of transmission cannot be detected, nor can the impact of the migration of potentially infected informal settlement residents into the area be estimated. It is quite probable that the mass rural-urban migration in South Africa could lead to changes in transmission patterns and the widespread establishment of urban schistosomiasis (Whittaker 1994) which has not been documented here.

Previously in South Africa, several Provincial Health Departments initiated snail host and parasite survey programmes. However, none of them were maintained despite the presence of schistosomiasis and other trematode cercariae having been documented in South African freshwater snails (Cawston 1916; Porter 1921; Porter 1938; Faust 1926; Pitchford, Gear & Van Eeden 1980; Schutte 1984; Appleton & Brock 1985). The current snail distribution data is based on several studies, none of which have recently been updated i.e. Cawston 1916; Porter 1921; Brown 1980; Gear, Pitchford & Van Eeden 1980; Schutte 1984; Appleton 1996.

As a result of this lack of general surveillance by Health Departments in South Africa, the current status of *S. haematobium* prevalence amongst occupants of informal settlements and permanent dwellers is not known. Nor are host snail distributions or the prevalence of larval schistosome infection amongst them known. Thus a collaborative survey conducted of the central and greater Pietermaritzburg areas was initiated. It involved the Kwazulu-Natal (Environment Division) and Pietermaritzburg Departments of Health and the University of Natal (Pietermaritzburg) and had several aims:

1. to determine the prevalence, distribution and intensity of *S. haematobium* amongst informal settlement occupants,
2. to establish the distribution and prevalence of both infected and non-infected snail hosts, i.e. *Bulinus africanus, Biomphalaria pfeifferi* and in other freshwater snails,
3. to identify the active *S. haematobium* transmission sites in the Pietermaritzburg central area and thus confirm the presence of urban urinary schistosomiasis,

4. to collate data regarding areas of origin and present occupation of migrants, type of migrants (Prothero 1977), host snail distribution and active transmission sites and formulate a schistosomiasis control strategy for the area.

1.2 MATERIALS AND METHODS

1.2.1 INFORMAL SETTLEMENT SURVEY

1.2.1.1 SETTLEMENT DESCRIPTIONS

At the time of this survey (July 1995), there were 40 informal settlements in and around central Pietermaritzburg. Of these, the occupants of 16 (40%) settlements formed part of the urinary schistosomiasis survey. The settlements were chosen for their strategic positions along urban waterways. Settlements were situated on both council and private land. Council land was the responsibility of the City Health Department whilst private land as the responsibility of the land-owner. The settlements sampled are listed in Table 1.1 and their positions indicated on Figure 1.2.

Table 1.1: Informal settlement population structures and available facilities for the central Pietermaritzburg area. The settlement numbers correspond to the numbers on Figure 1.2 and indicate the position of the settlements. Abbreviations used include: M - municipality, C - council, F - flies, m - mosquitoes, R - rodents, O - odour, H - health education programme, VC - vector control education programme.

Settlement	Existing Structure (n)	Incom. Structure (n)	Adult (n)	Children (10-15yrs) (n)	Stand-pipes	Refuge removal	Latrine	Problem	Educ. Prog.
Tembalihle Council land (11)	390	30	1950	50	8 (M)	2 skips (M)	96 (C) 16 (M)	F, m,R,O	No
Mustang Drive Council land (9)	95	48	331	40	1 (M)	No	23 (C)	F,m,R,O	No
Nkululeko Council land (1)	21	2	100	30	fire hydrant	No	3 (C) bush	Litter	No
Peaceful Centre Council land (6)	189	17	600	260	Spring, Neighbours	No	52 (C)	F,m,R,O	H, V C
Ash Road Council land (3)	52	55	245	30	Neighbours, Dorpspruit River	No	7 (C)	F, R, O	No
Marryvale Council land (4)	55	16	184	15	1 (M)	No	7 (C)	F,m,R,O	No
Azalea Council land (5)	430	80	2200	80	10 (M)	4	32 (M) 70 (C)	F,m,R,O	No
Happy Valley Council land (2)	164	0	1148	50	5 (M)	5	8 (M) 33 (C)	F,M,R,O	H, V C

Table 1.1. (continued)

Shortie's Farm Private land (7)	80	6	166	not known	Streams Neighbours	No	6 (C)	F,m,R,O	No
Jesmondene Council land (8)	1001	17	1000	25	Fire hydrant	No	5 (C)	F,m,R,O	No
Happy Pola Council land (10)	161	4	323	not known	Yes privately serviced	No	15 (C)	F,m,R,O	No
Fitzsimmons Rd Council land (12)	545	15	2725	25	2 (M)	2	4 (M)	not known	No
Phola Park Council land (13)	73	?	400	30	Northdale Stadium, Neighbour	No	7 (C)	F,m,R,O	H, V C
Hollingwood Council land (14)	90	15	450	32	Umsimduzi R, Neighbour	No	5 (C)	F,m,O	No
Nhlalakahle Council land (15)	365	21	1095	50	Fire hydrant	No	29 (C)	F,m,R,O	H, V C
Skomplaas Private land (16)	190	4	760	70	Neighbour	1	5 (C) bush	not known	No

1.2.1.2 QUESTIONNAIRE AND URINE COLLECTION

The survey was conducted over three consecutive days, 10-12 July 1995, in collaboration with the Pietermaritzburg City Health Department. The targeted settlements were visited and a contact person met. Request to conduct the survey was made to the contact person who later granted permission on behalf of the community. On a stipulated day, the settlements were re-visited and a loudspeaker was used to notify the community of our arrival. The target group were children aged between 6 to 15 years. This is the age group in which peak infection occurs. However, all children that arrived were given a labelled 500ml-honey jar and total bladder contents were collected. Urine collections were made between 11am and 2pm. Urine samples were taken to the laboratory for analysis using urine colour scales, chemical reagent strips and sedimentation diagnostic techniques.

1.2.1.2.1 QUESTIONNAIRE

A total of 730 questionnaires was administered. The questionnaires were administered via a structured interview whilst the bottles were collected. Several people were used to administer the questionnaire, all were fluent in Zulu and had been briefed previously regarding the format, procedure and purpose of the questionnaire administration. The questionnaire was drafted in

zulu and contained a mixture of closed and open-ended questions. Its aim was to obtain basic demographic data as well as more detailed information regarding the migration activities of the informal settlement dwellers (see appendix 1.1). Questions 1, 2, and 3 aimed to get basic information regarding name, age and sex. The questionnaires were not anonymous, enabling infected individuals to be treated in a follow-up chemotherapy programme. Questions 4, 5, and 6 aimed to provide information regarding the movement patterns of the informal settlement dwellers, i.e. where did they come from, when and why? Question 7 aimed at obtaining information regarding the swimming activities of the informal settlement occupants. Questions 8 and 9 aimed to eliminate any female candidates who may have had blood in their urine due to menstruation. Questions 10 and 11 aimed at measuring the prevalence of visible haematuria in the informal settlement occupants' urine both on the day of study and previously and to assess their admission of the presence of visible haematuria. Question 12 aimed at assessing the informal settlement occupants' knowledge of schistosomiasis. If the respondent was too young to answer the questionnaire or did not know an answer their care-giver was asked to answer the questionnaire.

The overall aims of the questionnaire were threefold: firstly, to determine the prevalence of schistosomiasis infection amongst informal settlement occupants; secondly, to locate swimming areas which may become schistosomiasis transmission sites; and thirdly, to locate areas of origin which may be the source of the infection. This information was considered important for schistosomiasis control purposes as it would enable the treatment of high intensity infections in the Pietermaritzburg area. It would locate the source of infection thereby highlighting areas for further investigation. It would identify possible transmission sites which would need to be monitored.

1.2.1.2.2 URINE COLOUR SCALES

The presence of macro-haematuria was recorded using urine colour scales. The urine samples were categorised according to their colour using four urine colour scales namely clear, cloudy yellow, cloudy brown and red (Rutasitara *et al* 1984; Mott *et al* 1985; Sarda *et al* 1986). The colour red constituted gross haematuria. Colour analysis was conducted by the same person on each occasion.

1.2.1.2.3 CHEMICAL URINALYSIS STRIPS

The presence of micro-haematuria was recorded using three brands of chemical urinalysis strip, namely Lenstrip-5® (Benmore Diagnostics), Ecur-4® (Boehringer Mannheim), Labstix® and/or Multistix 9® (Ames). The strips were dipped into the urine samples for one minute and any colour changes on the haematuria parameter was recorded. The Ecur-4 and Lenstrip-5 haematuria parameters were recorded as: negative, ca. 5-10 (erythrocytes/μL), ca. 50 (erythrocytes/μL) and ca. 250 (erythrocytes/μL). The Labstix and Multistix 9 haematuria parameter scale recorded: negative, ca. 10 (erythrocytes/μL), ca. 25 (erythrocytes/μL), ca. 80 (erythrocytes/μL) and ca. 200 (erythrocytes/μL). All samples were analysed within three hours of collection.

1.2.1.2.4 SEDIMENTATION

Samples were sub-divided into 10ml bottles and were fixed by means of 1ml 10% formalin containing 1% merthiolate. The samples were centrifuged and the number of eggs recorded per 10ml urine. The study population was then divided into four categories as proposed by Cooppan et al (1987) according to intensity of infection, namely negative (no ova in the urine), lightly infected (1-200 ova/10ml), moderately infected (201-1200 ova/10ml), and heavily infected (>1200 ova/10ml).

1.2.2 SNAIL SURVEY

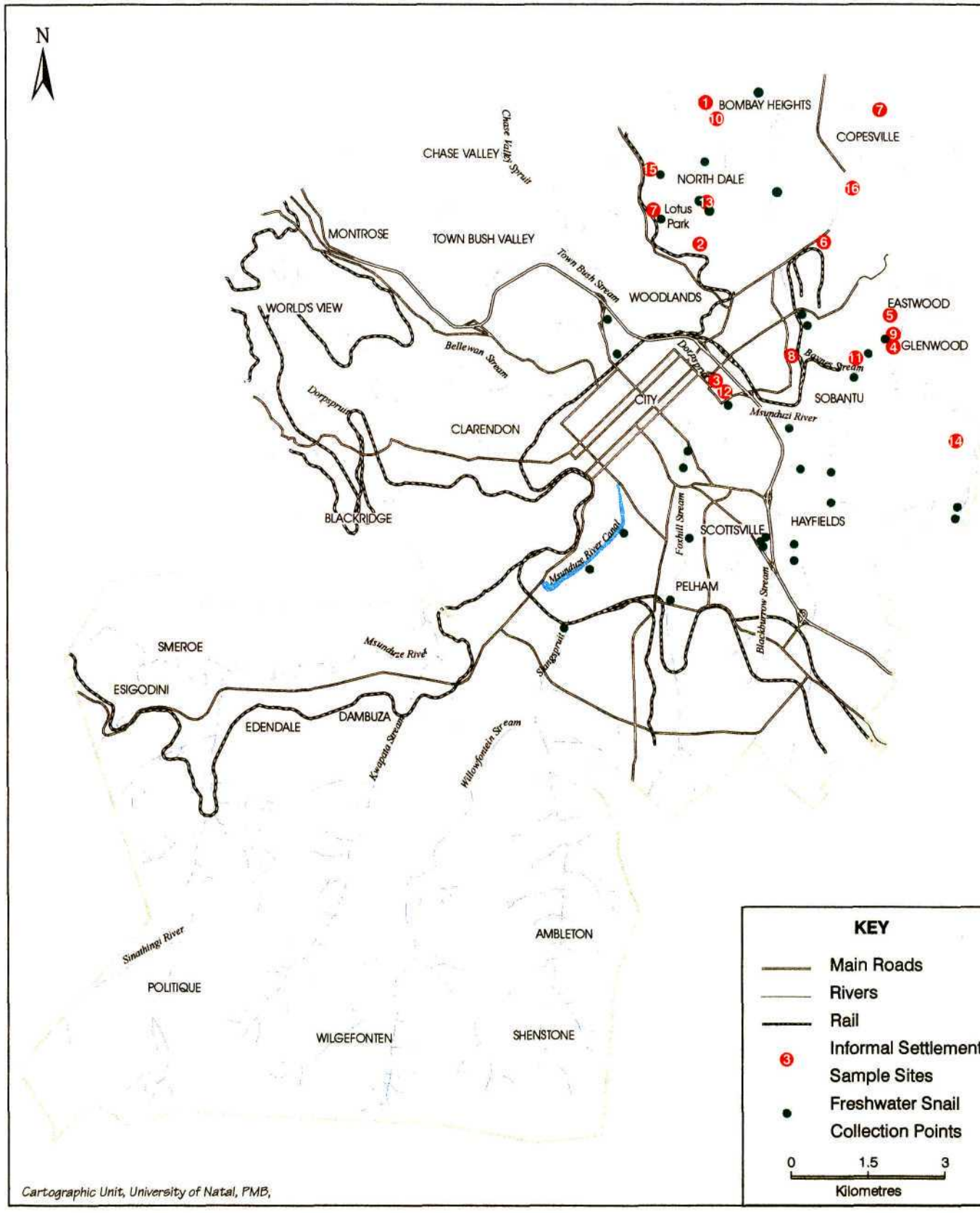
1.2.2.1 Pietermaritzburg City Health Department Survey of the Central City area

A workshop was held to train workers in collection methods and snail identification. Workers were given data sheets (Appendix 1.2) and were asked to complete them after each sampling session. The workers collected snails from January 1995 - August 1995 as part of their routine surveillance work. Collection sites included those that were accessible via bridges and roads, close to informal settlements and those which had been used by the City Health Department as routine mosquito and snail surveillance sites during the 1980s, e.g. bird sanctuary, golf course and Lotus Park. A follow-up snail survey was conducted in March 1996, three months after the December 1995 floods.

1.2.2.2 KwaZulu Health Department - Environment Division

A snail survey of the greater Pietermaritzburg area was conducted over a period of 10 days in May 1995. Due to the Health Departments' greater knowledge of the area and time constraints, only sites previously sampled by department were used. Those collection sites along the river were chosen for accessibility, convenience and nearness of a resident human population. All collectors wore plastic gloves and gum boots to avoid exposure to the potentially infested water. Visible snails were collected using forceps. For less accessible habitats a metal scoop net (1.5 - 2.0mm stainless steel mesh fitted inside a 300mm^2 steel frame with a 1.4m aluminium handle) was used to collect snails, i.e. from vegetation along the banks. Snails from different collection points were placed in separate labelled bottles. Leaf litter and pollution items, e.g. cans, were over-turned and examined. River courses were not searched for snail egg packets, due to time constraints. After collection, snails were taken to the University laboratory for identification, measurement and screening for the presence of larval trematode infections. Once in the laboratory, the snails were housed in freshwater tanks in constant environment rooms and fed on commercial fish flakes. A Vernier Caliper was used to measure snail length to the nearest 0.5mm. Length was measured from the shell apex to the ventral margin of the aperture. Snails were examined for patent infections by placing them individually in test-tubes and exposing them to a light source for 2-3 hours. Shed cercariae were examined and identified with aid of a microscope. Snails were screened over four consecutive weeks to allow pre-patent infections to mature rather than crushing them after collection (Sturrock *et al* 1979).

Figure 1.2: Informal settlement *S. haematobium* prevalence survey sites and freshwater snail collection points in the Pietermaritzburg magisterial district.



1.3 RESULTS

1.3.1 QUESTIONNAIRE

The informal settlement population under study had a sex ratio of 47.5% (347) males to 52.4% females (383) (Table 1.2a). The age range extended from 2 to 17 years of age with the greatest frequencies occurring between 6 to 13 years (Table 1.2b). The skewed age distribution resulted from the target group being between ages 6 to 15 years.

The informal settlement occupants originated from other areas of Kwazulu-Natal, Free State and Guateng (Figure 1.3). Reasons for moving included violence, financial problems, school attendance, work and visiting friends/family (Table 1.2c). Fifty-two percent of the migrants moved as a result of violence. Twenty-one percent of the respondents answered they had moved as a result of finding a new place. This answer may reflect a lack of knowledge of the true reason for moving or an inadequacy in the wording of the question. Due to the age group of the respondents, it more likely reflects a lack of knowledge.

A moderate proportion of 32.2% (235) answered "yes" to swimming in a local river or dam whilst 6.4% (47) swam in a swimming pool. This figure is low as not everyone has access to a swimming pool. Imbali is the only area that has a public swimming pool. Nobody swam in both a swimming pool and river/dam. This indicates that where a swimming pool facility is available, it is the preferred venue.

Twelve females answered "yes" to menstruating on the day of sampling, whilst seven of these came up as strip positive. These samples were removed from the database.

Nine percent (65) answered "yes" to having blood in their urine on the day the questionnaire was administered whilst 12.6% (92) answered "yes" to having had blood in their urine beforehand.

Sixteen percent (115) knew what schistosomiasis is. This knowledge came from school and parents but their understanding of the disease was not investigated further.

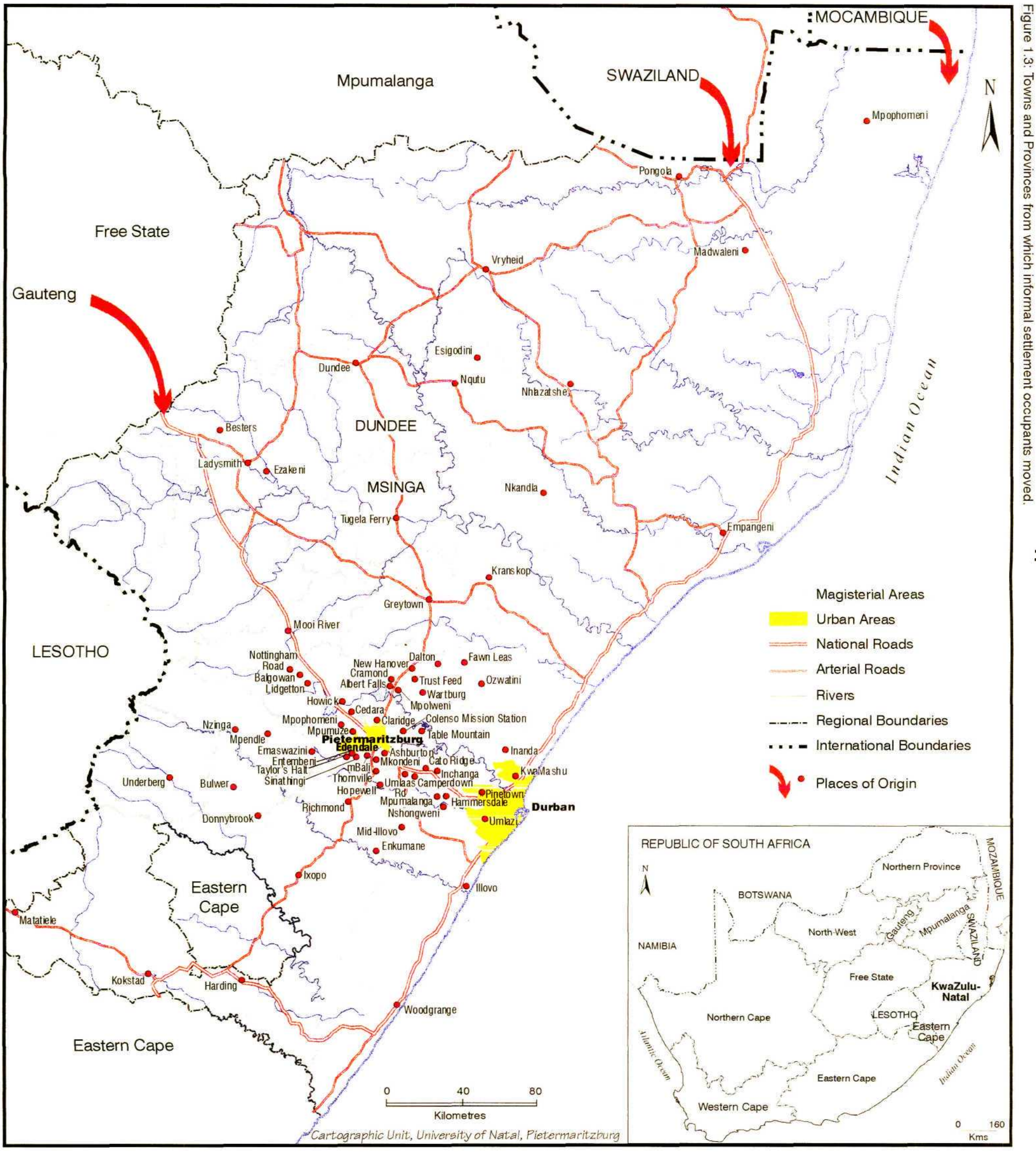


Figure 1.3: Towns and Provinces from which informal settlement occupants moved.

Tables 1.2a - 1.2c: A summary of results obtained from the Pietermaritzburg informal settlement questionnaire.

Table 1.2a : Answers for questions 3, 7, 10, 11, 12.

	Q3		Q7		Q10		Q11		Q12	
	Freq (n)	(%)	Freq (n)	(%)	Freq (n)	(%)	Freq (n)	(%)	Freq (n)	(%)
Male	347	47.5	-	-	-	-	-	-	-	-
Female	383	52.4	-	-	-	-	-	-	-	-
Did not answer	-	-	2	0.3	1	0.1	1	0.1	1	0.1
Yes	-	-	235	32.2	65	8.9	92	12.6	115	15.8
No	-	-	493	67.5	664	91.0	637	87.3	615	84.1
Total	730	100.0	730	100.0	730	100.0	730	100.0	730	100.0

Table 1.2b : Age structure of the Pietermaritzburg informal settlement respondents.

Age (yrs)	Frequency (n)	(%)	Cumulative Percentage
2	2	0.3	0.3
3	4	0.5	0.8
4	6	0.8	1.6
5	17	2.3	4.0
6	111	15.2	19.2
7	71	9.7	28.9
8	91	12.5	41.4
9	73	10.0	51.4
10	92	12.6	64.0
11	63	8.6	72.6
12	71	9.7	82.3
13	64	8.8	91.1
14	36	4.9	96
15	28	3.8	99.9
16	0	0	0
17	1	0.1	100.0
Tot	730	100.0	

Table 1.2c : Reasons given by the residents for their move to the settlement.

Reason for the move	Frequency (n)
Choice	1
Evicted	2
Farm sold	3
Live with relative	3
Mother married	1
Married her/himself	1
Found a new place	94

Table 1.2c: (continued)

Reasons for the move	Frequency (n)
Rent problems	20
Attend school	9
Violence	232
Visiting	59
Work	3
Total	448

Prothero (1977) differentiates between migration (leave place of residence and don't return) and circulation (leave place of residence temporarily for varied periods of time). This typology of mobility proposed by Prothero (1977) was applied to the Greater Pietermaritzburg area (Table 1.3) using the reasons provided by the occupants for their move to the settlements (Table 1.2c). Activities which have an asterisk are those which could promote directly or indirectly the transmission of bilharzia. The collection of water, washing and recreation, e.g. swimming, are activities where exposure to infested water could directly result in schistosomiasis infection.

Table 1.3: Typology of human mobility for the Greater Pietermaritzburg Area [based on Prothero's (1977) typology of mobility].

	Circulation			Migration	
Space	Daily	Periodic	Long term	Regular	Irregular
Rural-Rural	Collect water* Visit* Recreation* School* Washing*	Visit*		Planned settlement* Marriage	Violence*
Rural-Urban	Work Visit	School* Visit* Events	Work School*	Work	Violence*, Financial problem
Urban-Rural	Work Visit*	Work Events* Visit*	Work	Retirement	
Urban-Urban	Work Visit Collect water* Washing*	Visit*		Change address	Financial problem, Eviction

1.3.2 URINE ANALYSIS

A total of 608 urine samples was analysed. The prevalence was 7.15% (43). Infected people came from 10 settlements namely Thembalihle, Happy Valley, Balhambra Way, Fitzsimmons Road, Paulo Park, Merryvale, Mustang Drive, Shortie's Farm and Peaceful Centre (Table 1.4).

Table 1.4: Pietermaritzburg informal settlement *S. haematobium* survey.

Settlement	Adult pop.	Child pop.	Pop. June 1994	No. tested	No. infected
Ash Rd	215	30	144		
Azalia	2120	80	1324	97	5
Eastwood					
Fitzsimmons Rd	2700	25	320	53	4
Happy Valley	1098	50	860	82	2
Woodlands					
Hollingwood	450	not known	140	25	0
New England Rd					
Jesmondene Rd	985	25		22	0
Merryvale St	169	15	238	3	1
Mustang Dr	418	32	224	23	1
Glenwood					
Nhlalakhle	1045	50	772	42	3
Balhamabra Way					
Nkululeko	70	30	88	17	0
Regina Rd					
Peaceful Centre	340	260	402	43	12
Woodlands					
Phola Park	370	30	not known	20	4
Badrodeen Rd					
Shorties Farm	220	not known	not known	32	2
Copesville					
Skomplaas	690	70	390	26	0
(Natal Crushers)					
Tembalihle	1900	50	1124	134	9
Total				608	43

The overall prevalence was 7.2%. Mild infections comprised 6.4% (39), moderate infections 0.49% (3) and heavy infections 0.16% (1). The geometric mean egg output was 11.6 eggs/10ml. People with heavy and moderate infections came from Durban, Hammersdale and Table Mountain (Table 1.5, Figure 1.3).

Table 1.5: Intensity of infection categories in the study population and area of origin.

Intensity of infection	Number (%)	Area of origin
Negative (no ova)	611 (93.2%)	refer to Figure 1.2
Light (1-200)	40 (6.1%)	refer to Figure 1.2
Moderate (201-1200)	3 (0.46%)	Durban, Hammersdale, Table Mountain
Heavy (>1200)	1 (0.15%)	Table Mountain
Total	655	

The micro-haematuria prevalence levels are shown according to the cut-off value of the strip and the brand of the strip in Table 1.6. The prevalence of 10 (erythrocytes/μL) ranged from 49.9% to 57.4 (erythrocytes/μL), whilst the 250 (erythrocytes/μL) ranged from 8.6 to 12.8 (erythrocytes/μL).

Table 1.6: Micro-haematuria prevalence of informal settlement occupants.

	Frequency (n)	(%)
Lenstrip-5 (10 ery/μL)	360	49.9
Lenstrip-5 (50 ery/μL)	94	13.0
Lenstrip-5 (250 ery/μL)	62	8.6
Ames Labstix (10 ery/μL)	380	52.7
Ames Labstix (25 ery/μL)	164	22.7
Ames Labstix (80 ery/μL)	130	18.0
Ames Labstix (200ery/μL)	72	10.0
Ecur-4 (10 ery/μL)	414	57.4
Ecur-4 (50 ery/μL)	134	18.6
Ecur-4 (250 ery/μL)	92	12.8

The majority of the urine samples were clear (i.e. no colour) (425/567). Only one urine sample was red indicating that infections were low in intensity (Table 1.7).

Table 1.7: Categories of urine colour, namely: clear, cloudy yellow, cloudy brown and red.

Clear	Cloudy yellow	Cloudy brown	Red
425	124	17	1

1.3.3 FRESHWATER SNAIL SURVEY

1.3.3.1 PIETERMARITZBURG CENTRAL AREA SURVEY

Localities along the Umsimduzi, Slangspruit, Dorpspruit Rivers ; Blackburrow spruit; Baynes stream and Lotus Park were sampled for freshwater snails (Figure 1.2 and Table 1.8). A total of 2417 snails was collected and screened. Species collected were *Biomphalaria pfeifferi, Bulinus africanus, Bulinus tropicus, Lymnaea columella, Lymnaea natalensis , Physa acuta,* (Table 1.8). Trematode cercariae belonging to the Echinostomatidae, Strigeidae, Spirorchidae and both mammalian and avian Schistosomatidae were identified from infected *B. africanus, B. tropicus* and *L. natalensis* (Tables 1.8, 1.9, 1.10).

Table 1.8: Pietermaritzburg snail and parasite survey 1995-1996

1-*Bulinus africanus*
2-*Bulinus tropicus*
3-*Biomphalaria pfeifferi*
4-*Lymnaea natalensis*
5-*Lymnaea columella*
6-*Physa acuta*
7-*Helisoma duryi*

Date	Place	Snail species (n)	Trematode Parasites (snail species)-parasite-(n)	Total number snails collected
26/01/95	Lotus Park	1 (57)	1-Echinostome (1) 1-Schistosome (7)	57
28/01/95	Lotus Park	1 (49)	1-Echinostome (2) 1-Schistosome (6)	49
6/02/95	Lotus Park	5, 6	0	
16/02/95	Dorpspruit	5, 6	0	25
20/02/95	Lotus Park	1 (42)	0	42
23/02/95	Golf Course	1 (38), 2 (1)	0	39
23/02/95	Dorpspruit	1 (3), 2 (3), 4 (2), 5(35)	4- Avian Schistosome (1)	42
23/02/95	Bird Sanctuary	1 (44), 4 (1), 5 (2)	1-Echinostome (5)	46
24/02/95	Dorpspruit	1 (2) , 2 (3), 5 (50), 6(5)	1-Echinostome (1)	59
28/02/95	Dorpspruit	1(20), 4 (3), 5 (1), 6(15)	1-Echinostome (1)	48
28/02/95	Dorpspruit	1 (13), 2 (2), 5(2), 6 (4)	1-Echinostome (1)	20
28/02/95	Lotus Park	1 (20), 2 (14)	2- Echinostome (3) 1- Schistosome (2)	34
1/03/95	Lotus Park	1 (221)	1-Schistosome (4)	221
3/03/95	Northdale	1 (8), 4(2), 5(3), 6(29)	0	52
10/03/95	Lotus Park	1 (59), 2 (2)	0	61
13/03/95	Baynespruit	1 (9), 2 (1), 4 (1), 6 (21)	0	32
13/03/95	Baynesdrift	1 (10), 2 (2), 6 (50)	0	62

Table 1.8: (continued)

13/03/95	Newholme Way	1 (65)	cysts	65
23/03/95	Slangspruit	2 (226)	2-Echinostome (12)	226
			2-Strigeid (1)	
27/03/95	Scottsville	1 (13), 2 (53), 4 (3), 6 (5)	0	74
28/03/95	Golf Course	1 (2), 2 (19), 3 (5), 5 (2)	2-Spirorchid (1)	28
29/03/95	Lotus Park	1 (41), 2 (7)	0	48
3/04/95	Bird Sanctuary	1 (20)	0	20
3/04/95	Trim Park	1 (21)	1-Strigeid (1)	20
3/04/95	Umsunduzi	5 (91)	0	91
3/04/95	Golf Club	5 (50)	0	50
18/04/95	Umsunduzi-Darville	1 (2), 2 (77), 5 (4)	0	83
19/04/95	Umsundusi-Boscoff	1 (1), 6 (1)	0	2
19/04/95	Slangspruit-Umsunduzi	2 (136), 5 (1)	2-Echinostome (8)	129
23/04/95	Northdale (1)	1 (10), 2 (1), 5 (1)	1-Schistosome (1)	12
23/04/95	Olympia Way-Daphne Rd	1 (79)	0	79
23/04/95	Northdale (2)	1 (30)	0	30
23/04/95	Norhdale Dash Rd	1 (7)	0	7
23/04/95	Lower Lotus Park	1 (30), 2 (1)	0	31
23/04/95	Slangspruit	2 (3)	2-Echinostome (3)	3
17/05/95	Mustang Rd	5 (5), 6 (1)	0	6
17/05/95	CB Downs	5 (3)	0	3
17/05/95	Hollington	4 (4)	0	4
17/05/95	Slangspruit	2 (46)	2-Echinostome (3)	46
23/05/95	Newholme Way	1 (98)	1-Echinostome (5) 1-Schistosome (1)	98
24/05/95	Ohrtmann Rd	1 (86), 2 (5), 5 (12), 6 (5)	0	108
24/05/95	Darville	1 (3), 2 (19), 5 (13)	1-Echinostome (1)	35
24/05/95	Blackburrow	1 (1), 2 (2)	0	3
24/05/95	Foxhill	2 (30), 4 (24), 5 (2), 6 (2)	0	58
15/08/95	Dorpspruit	1 (1), 5 (5), 6 (5)	0	11
15/08/95	Slangspruit	2 (20), 6 (10)	0	30
16/08/95	Umsunduzi Above refuse dump	1 (35), 2 (1), 6 (9)	0	45
16/08/95	Umsunduzi motorcross	2 (10), 6 (4)	0	14
26/09/95	Umsumduzi Esigodini	1 (53), 2 (1), 5 (1)	0	55
27/09/95	Umsumduzi CHD	1 (12), 2 (1), 5 (1)	0	14

After the December 1995 floods in Pietermartizburg, the same areas were re-sampled. In some smaller streams where damage to bank vegetation was not severe, several snail species namely

Bulinus africanus, Bulinus tropicus, Biomphalaria pfeifferi and *Lymnaea columella* were found. In rivers where bank vegetation had been removed, no snails were found (Table 1.7). No patent trematode infections occurred in the snails collected.

Table 1.9: Snail collections from the follow-up snail survey conducted in Pietermaritzburg after the 1995 floods.

1-*Bulinus africanus*
2-*Bulinus tropicus*
3-*Biomphalaria pfeifferi*
4-*Lymnaea natalensis*
5-*Lymnaea columella*
6-*Physa acuta*
7-*Helisoma duryi*

Date	Place	Snails collected (n)	Trematode Parasites found	Total number snails collected
26/03/96	Lotus Park	1 (51)	0	51
26/03/96	Northdale (1)	1 (4)	0	4
26/03/96	Northdale (2)	1 (52)	0	52
27/03/96	Golf Course	1 (5), 2 (7), 3 (12), 5 (1)	0	25
29/03/96	Bird Sanctuary	1 (18)	0	18
29/03/96	Newholme Way	0	0	0
29/03/96	Lindup Rd	0	0	0
29/03/96	Camps Drift	0	0	0
29/03/96	Blackburrow Rd	0	0	0
29/03/96	Olympia Way	0	0	0
29/03/96	Old Bishopstowe Rd	0	0	0
29/03/96	Duzi	0	0	0
29/03/96	Ohrtmann Rd	0	0	0
29/03/96	Grimthorpe Rd	0	0	0

Table 1.10: Abundance and diversity of trematode cercariae in snails collected

Snail species	Total collected (n)	Number infected (n)	Parasites found
B. africanus	1205	35 (2.9%)	Mammalian Schistosome, Echinostome, Strigeid
B. tropicus	686	31 (4.5%)	Echinostome, Strigeid, Spirorchid
L. columella	286	0	-
L. natalensis	40	1 (2.5%)	Avian Schistosome
Physa acuta	188	0	-
B. pfeifferi	5	0	-

1.3.3.2 GREATER PIETERMARITZBURG SURVEY

A total of 259 snails was collected. Their localities and larval trematode infections are listed in Table 1.11. Mammalian schistosomes and echinostomes were collected and identified from

patent infections in the snail species *B tropicus*, *B africanus*, and *Biomphalaria pfeifferi* (Table 1.11).

Table 1.11: Greater Pietermaritzburg snail and parasite survey

1-*Bulinus africanus*
2-*Bulinus tropicus*
3-*Biomphalaria pfeifferi*
4-*Lymnaea natalensis*
5-*Lymnaea columella*
6-*Physa acuta*
7-*Helisoma duryi*

Location	Population June 1994	Snails present (n)	(snail species)-parasite - (n)	snails collected (n)
Albert falls nearby farm dam	156	1 (66), 5 (11)	0	77
Edendale	152 500	area not surveyed		
Hopewell Mlazi River	don't know	1 (25)	1-Schistosome (8) 1-Echinostome (1)	25
Howick	15 400	area not surveyed		
Indaleni Illovu River	don't know	No snails found		
Imbali	40 000	area not surveyed		
Lidgetton Lion's River	don't know	No snails found		
Granny Mouse Lion's River		3 (5)	3-Schistosome	5
Midmar-lower Umgeni River	1020	3 (21), 5 (1), 6 (1)	0	23
Mpolweni Mpolweni River		1 (3), 2 (1), 3 (13), 4 (1), 5 (10), 6 (31)	not known	69
Mpophomeni Lower Midmar Dam	16 000	2 (7), 5 (19)	2-Echinostome (3)	26
Pietermaritzburg	199 699	1, 2, 3, 4, 5, 6	Schistosome-human and avian Echinostome Strigeid Spirorchid	
Sobantu	12 000	area not surveyed		
Swayimane Umgeni River		1 (19), 5 (2)	0	21
Table Mountain Umgeni River	10 000	5 (2), 6 (7)	0	9
Vulundlela Nobanda River	200 000	2 (2), 5 (2)	0	4

1.3.3.3 SNAIL SIZE CATEGORIES FROM BOTH THE GREATER AND CENTRAL PIETERMARITZBURG

1.3.3.3.1 Infected snails

The greatest abundance of infected *B. africanus* (8) occurred in size category 9 (12.0 - 12.9mm) whilst the highest infection rate in *B. tropicus* (7) was in size category 5 (8.0 - 8.9mm) (Figure 1.4a, 1.4b).

1.3.3.3.2 Uninfected snails

The greatest abundance of *B. africanus* (284) occurred in size category 7 (10.0 - 10.9 mm) whilst *B. tropicus* (308) occurred in size category 4 (7.0 - 7.9). The greatest abundance of *L. columella* (31) occurred in size category 7 (10.0 - 10.9 mm) whilst *L. natalensis* (9) occurred in size category 6 (9.0 - 9.9 mm). The greatest abundance of *B. pfeifferi* (46) occurred in size category 2 (5.0 - 5.9). The greatest abundance of *P. acuta* (27) occurred in size category 7 (10.0 - 10.9 mm) (Figures 1.5a, 1.5b, 1.5c).

1.3.3.3.3 Shell shape

Bulinus africanus shell varied considerably in colour and shape. This variation could be problematic for inexperienced persons conducting freshwater snail surveys and lead to confusion in species identification.

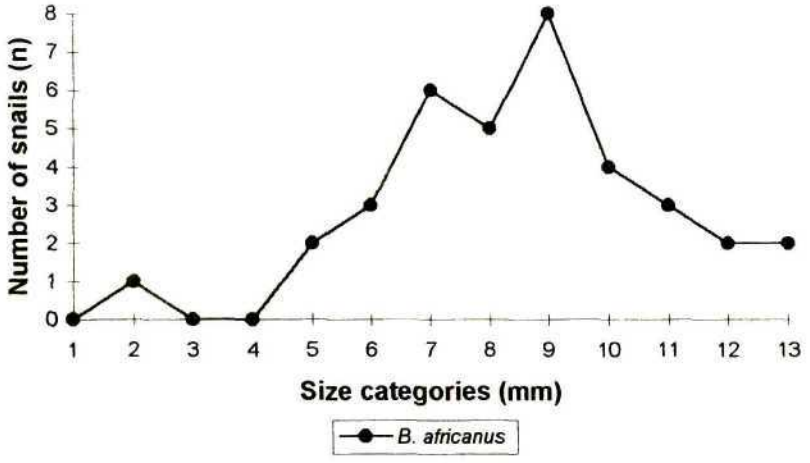


Figure 1.4a: Shell length of digenean trematode-infected *B. africanus*. Length measured from the apex to the ventral margin of the aperture (mm).

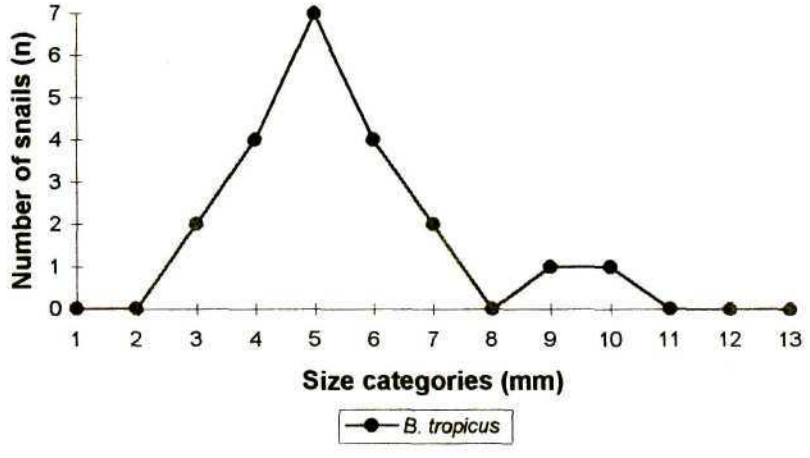


Figure 1.4b: Shell length of digenean trematode-infected *B. tropicus*. Shell length measured from the apex to the ventral margin of the aperture(mm).

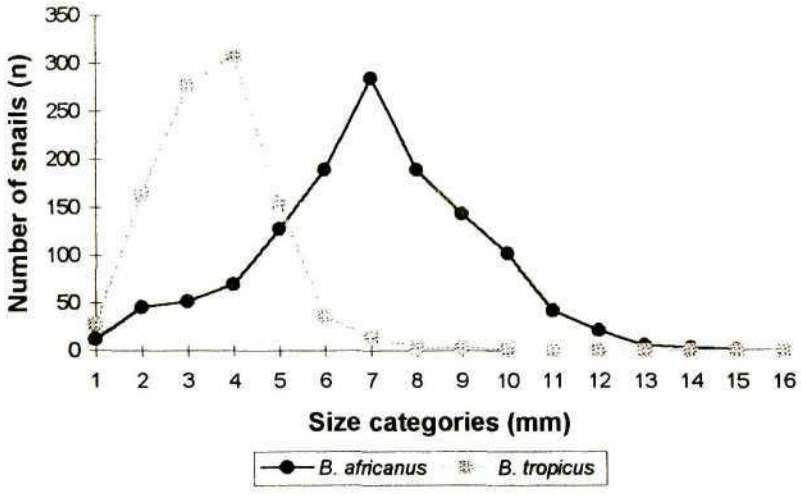


Figure 1.5a: Shell length of uninfected *B. africanus* and *B. tropicus*. Shell length measured from the apex to the ventral margin of the aperture (mm).

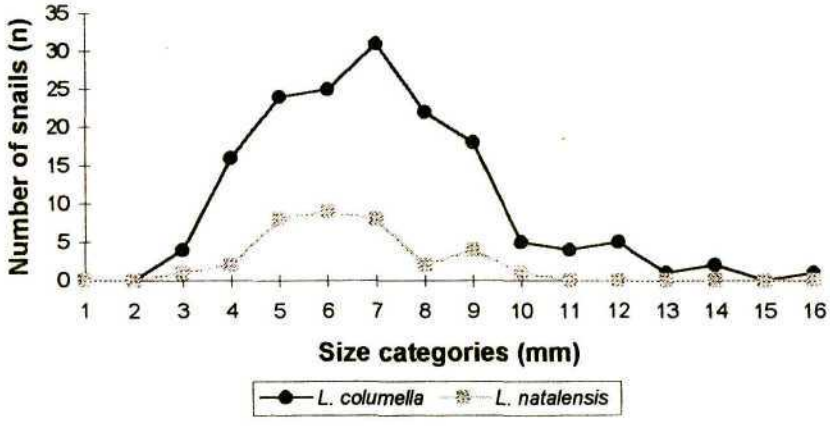


Figure 1.5b: Shell length of uninfected *L. columella* and *L. natalensis*. Shell length measured from the apex to the ventral margin of the aperture (mm).

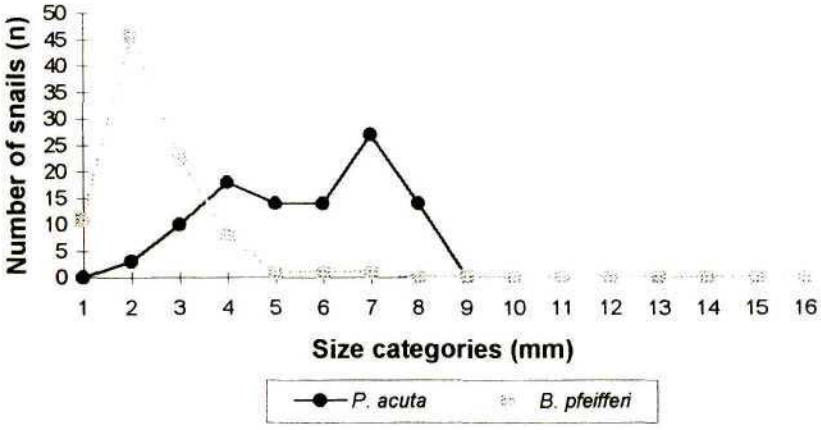


Figure 1.5c. Shell length of uninfected *P. acuta* and *B. pfeifferi*. Shell size measured using shell length measured from the apex to the ventral margin of the aperture (mm).

1.3.3.4 POTENTIAL SCHISTOSOMIASIS TRANSMISSION SITES IN THE CENTRAL PIETERMARITZBURG AREA

In Pietermaritzburg, Lotus Park and certain localities along the Baynespruit are potential schistosomiasis transmission sites (Table 1.12).

Table 1.12: Locations of settlements, nearest water sources, occurrence of infected snails and infected people

Location	Nearby river/pond	Infected snails yes/no	Infected people (n)
Ash rd	Dorpspruit	no	0
Azalia, Eastwood	Baynespruit	yes	5
Fitzsimmons Rd	Dorpspruit	no	4
Happy Valley, Woodlands	Lotus Park	yes	2
Hollingwood, New England Rd	Usmunduzi	no	0
Jesmondene Rd	Baynespruit	no	0
Merryvale St	Baynespruit	no	1
Mustang Dr, Glenwood	Umsunduzi	no	1
Nhlalakhle, Balhamabra Way	Lotus Park	yes	3
Nkululeko, Regina Rd	Baynespruit	no	0
Peaceful Centre, Woodlands	Lotus Park	yes	12
Phola Park, Badrodeen Rd	Umsunduzi	no	4
Shorties Farm, Copesville	dam - Baynespruit	no	2
Skomplaas, (Natal Crushers)	dam - Baynespruit	no	0
Tembalihle	Baynespruit	no	9
Total			43

1.4 DISCUSSION

South Africa is experiencing rapid urbanisation caused by migration (Katzenellenbogen *et al* 1997). Rural people have been and are still flocking to the towns due to socio-economic and political factors. This statement is re-enforced by the results obtained from the questionnaire administered in the Pietermaritzburg informal settlements which revealed that violence was the cause of 52% of the migration cases. This migration has led to the establishment and rapid growth of informal settlements in and around major centres. According to figures released by the Department of City Planning and the Pietermaritzburg Municipality, the population of a developing settlement doubles annually.

Pietermaritzburg is experiencing an influx of migrants and the consequent rapid growth of informal settlements in and around its centre is leading to problems in both health maintenance and monitoring. Problems experienced include flies, mosquitoes, rodents, litter, unpleasant odours, lack of water, latrines and poor education. All of these are a recipe for the encouragement of diseases like cholera, hepatitis, schistosomiasis and various helminthic infections.

The prevalence of urinary schistosomiasis in occupants of informal settlements in and around Pietermaritzburg was 6.7% (44/655) with the majority of infections being of a low intensity (Table 1.5). This pattern of infection conforms to the negative binomial distribution pattern that schistosome and other helminth infections usually follow (Warren 1973; Fine *et al* 1977; Hoffman *et al* 1979). The consequences of this are that a small percentage of the population (the relatively small number of individuals harbouring heavy infections) is responsible for a high proportion of egg output, environmental contamination and disease in the Pietermaritzburg community (Hoffman *et al* 1979, Wilkins 1987a). Studies in Ethiopia revealed that 50% of the eggs obtained came from only 5% of the community (Polderman 1979). Once infection is established it can be maintained by minimal amounts of contamination and this has public health importance because treatment needs to be systematic, regular and supplemented by other intensive measures (MacDonald 1965).

Schutte (1984) conducted a parasitological survey of school children from four schools situated in the upper and lower Umsimduzi Valley. The overall *S. haematobium* prevalence for the valley was low (16.5%) with most of the positive infections (86%) being light. As the lower valley had a higher prevalence than the upper valley he postulated that transmission was occurring there but perhaps in surrounding dams rather than in the Umsimduzi River itself. It may also

have been imported from surrounding areas. In the current survey of settlements along the Umsimduzi Valley, the lower areas of Schutte (1984) were not included due to political complications. If the survey had of included the lower part of the valley especially the Edendale area, the prevalence levels obtained may have been comparable to those of Schutte (1984). The low prevalence levels obtained in this study could indicate that transmission is occurring outside of Pietermaritzburg and that the infections are mostly imported cases. This statement is supported by data recorded in the *Bilharzia Atlas of South Africa* which placed the *S. haematobium* prevalence rates between 1-70% for areas surrounding Pietermaritzburg (Appendix 1.2). Transmission may be minimal in Pietermaritzburg itself due to lack of suitable sites, i.e. shallow water-ways and canalised areas. Areas where urinary schistosomiasis intermediate host snails were found were shallow waterways which are not suitable for swimming or bathing - the two activities which are most likely to promote transmission of the disease.

The low prevalence levels recorded in this study may be a reflection of the true situation of the sampled sites or could indicate analytical error on three accounts. Firstly, analysis of a percentage of the specimens was problematic due to a reaction between the formalin and 10ml plastic bottles which resulted in the formation of a thick precipitate. Several specimens had to be discarded whilst others were difficult to analyse. Secondly, only one 10ml microscopical analysis was conducted on each specimen which is problematic when the infections are light. In such cases the whole urine sample should be analysed. This is critical in large-volume urine samples and low prevalence areas. Thirdly, only one specimen was obtained from each subject which is unlikely to reflect the true intensity of the infection because of day-to-day variation in a subject's egg count (Wilkins & Scott 1978, Lwambo *et al* 1997). Ideally duplicate samples taken on consecutive days should be examined. This was not possible due to the mobility of people and their inaccessibility. All three errors may have resulted in positive samples being missed and inaccurate intensity reports. Results from the chemical strip analyses support the fact that the sedimentation technique underestimated the prevalence of infection and that analytical error did occur. The Lenstrip 5®, Ames labstix®, and Ecur-4® placed prevalences of infection at 49.9%, 52.7% and 57.4% respectively.

In urban communities there may be variation in prevalence between different districts of the same town which is related to variation in socio-economic status and provision of piped water (de Lima e Costa 1985). In Pietermaritzburg the settlements sampled were all of low socio-economic status where variations included access to standpipes and the quality and quantity of toilets. None of the settlements had piped water, yet 10 out of the 16 settlements sampled had infected occupants. This variation in both distribution and quantity of infected occupants highlights the

focal distribution of schistosomiasis transmission and is less a result of socio-economic conditions.

The Pietermaritzburg study highlighted the fact that within endemic areas, variation in the prevalence and intensity of schistosomiasis infections occurs over short distances (Wilkins 1978a; Guyatt *et al* 1993; Lengler *et al* 1991a). Transmission tends to be concentrated in particular areas because it is affected by factors such as population density, migration, distance of dwellings from and frequency of using infected water and the degree of concentrated contact with such waters (Schutte *et al* 1981,Chitsulo *et al* 1995). There is a direct relationship between levels of infection and distance of dwellings from the infection site (Schutte *et al* 1981). Water is made unsafe by pollution with human excreta which in turn occurs through ignorance, overcrowding, indiscriminate urination, defecation and poor siting of settlements (WHO 1993). People come into contact with unsafe water when swimming, fishing, crossing water, bathing, washing clothes and fetching water (WHO 1993). Water contact studies are a useful means of determining the principal human activities that create a high risk of exposure to infection in endemic areas (Dalton & Pole 1978) Time constraints prevented a water contact study in the Pietermaritzburg study but it was assumed that there was a high degree of water contact due to the lack of facilities within the settlements. Many of the Pietermartizburg waterways are not suitable for activities such as swimming due to their small size, steep banks and lack of riverine vegetation, all of which reduce the likelihood of transmission becoming established. This patchy distribution of contact sites reflects the limited number of transmission sites and contrasts with the more uniform distribution of diseases spread by highly mobile vectors such as mosquitoes (Wilkins 1978a).

Both the central and greater Pietermaritzburg surveys revealed the presence of six species of freshwater snails namely: *Bulinus africanus*, *Bulinus tropicus*, *Lymnaea natalensis*, *Lymnaea columella*, *Biomphalaria pfeifferi* and *Physa acuta*. Both *Lymnaea columella* and *Physa acuta* are exotic species, whilst the other four are indigenous. The occurrence of all six has been documented previously in the area (Cawston 1916; Porter 1921; Faust 1926; Brown 1980; Gear, Pitchford & Van Eeden 1980; Schutte 1984; Appleton & Brock 1985). The snail species varied in distribution. The intermediate host for *S. haematobium*, *B. africanus* occurred at most sampling sites over much of the survey area. Its occurrence at the majority of these sites had previously been documented in the Atlas (1980). However, its occurrence at the lower Midmar Dam, Lidgetton and Swayimane had not been documented (Appendix 1.2). The wide distribution of this freshwater snail indicates the potential for the creation of several active transmission sites. The percentage of infected snails obtained is usually used as an index of schistosomiasis transmission. Hoffman *et al* (1979) showed that the absolute number of infected snails and

transmission risk can remain roughly constant even during substantial fluctuations in the total snail population. They suggest that another technique, e.g. cercarial density detection, would be a better index of transmission. An alternative may be to utilise a model to present a qualitative picture of transmission (Macdonald 1965).

The ability of various snail species to tolerate 'urban conditions' has implications for the control of snail-borne diseases. Both *B. pfeifferi* and certain species of *Bulinus* are able to withstand physical disturbance, pollution and flooding making them 'ideal' urban species. Bulinid snails exhibit ecological plasticity in growth rate and reproduction both between different habitats and in different seasons (Southgate & Rollinson 1978). The abundance of *B. africanus* in the central Pietermaritzburg area, both before and after the floods supports this statement. *Bulinus africanus* was often observed on pieces of rubbish, cans and bottles floating in the river. Brown (1980) showed that *P. acuta* had a wide distribution in Nairobi, Kenya where it occurred exclusively in heavily polluted areas. In Pietermaritzburg an increase in *P. acuta* occurrence may act as an indicator of urban water pollution levels.

The Echinostomatidae, avian and mammalian Schistosomatidae and Strigeidae infections obtained in the Pietermaritzburg area have been documented by Appleton & Brock (1985). The Spirorchidae infection was not previously recorded. *Bulinus africanus* is host to cercariae from three trematode families, namely mammalian Schistosomatidae (2.3%), Echinostomatidae (1.4%) and Strigeidae (0.1%). *Bulinus tropicus* is also host to three families, namely Echinostomatidae (4.6%) Strigeidae (0.1%)and Spirorchidae (0.1%). *Lymnaea natalensis* was found to host one family of trematode cercaria namely an avian Schistosomatidae (2.4%). Avian schistosomiasis occurrence has been documented in KwaZulu-Natal (Appleton 1984; Appleton 1986a; Appleton & Brock 1985) as well as its effect on mammalian skin (Appleton 1984; Appleton & Brock 1986). The finding of an avian schistosome in this study acts as a reminder of its presence and the need for further investigation of its epidemiology. Schistosome infection rates in snail populations rarely exceed 10% and are generally nearer 2% (Appleton & Donnelly 1983). Super-infection is the general rule where few snails are heavily infected (MacDonald 1965) and each one sheds many hundred cercariae (Cheesbrough 1992). Schistosome infection rates recorded in *B. africanus* in this study conform to these levels of infection with a prevalence of 2.5%. Other trematodes, particularly echinostomes, may be expected to be more common and multiple infections involving different types of larval trematode are probably more frequent than the approximately 1% that has been documented (Appleton & Brock 1985). No multiple infections were observed in this study. This could be due to failure to identify the less common partner species.

Bulinus africanus occurred widely in the survey area, yet the prevalence of patent infections was low and patchy (3.7%). Factors influencing patchiness are related to spatial and seasonal distributions of aquatic vegetation, water contact sites, temperature, rainfall and host distribution (Hoffman *et al* 1979; Machado 1982; McCullough 1986; Woolhouse & Chandiwana 1989). Sturrock *et al* (1978) demonstrated that repetitive screening of snails is more effective than a one off screening as it detects pre-patent infections as they mature. Anderson & May (1979) suggest that patent infections may account for only half the true prevalence for a given area, thereby highlighting the importance of pre-patent infections. It was not always possible to screen snails over an extended period of time due to their low survival rate in the laboratory tanks. This may have led to several pre-patent infections having been missed which would have resulted in low prevalence estimates.

Sampling procedures for the collection and detection of snails may lead to errors in the reported abundance of snails and prevalences of infections. These problems include: firstly, areas of high snail density may not be accessible and some species may go undetected. Secondly, snails migrate up and down riverine vegetation and may be missed if the survey is limited to surface vegetation. Thirdly, infected snails may be missed due to low prevalence levels and the parasites' over-dispersed nature of distribution. Fourthly, surveys covering large areas may not be comprehensively done due to financial and manpower constraints. Fifthly, the main transmission season may be missed if the study is not conducted over a sufficient length of time. All these above-mentioned problems were experienced with the Pietermaritzburg survey and may have influenced the freshwater snail and trematode prevalence density data.

Studies on malaria and schistosomiasis in Tanzania show that disease and their main signs and symptoms are often well recognised and perceived by community members and this knowledge offers an important source of information for the setting of local priorities and for disease monitoring (Lengler *et al* 1991a). Health interviews relying on community-based questionnaires provide valuable information for health care management and should lead to more targeted activities that may improve the health status of the population (Lengler *et al* 1992). The questionnaire administered to the local population in the present study was a community-based one. The recommended "indirect" health interview procedure of Lengler *et al* (1992) was not used for five reasons: firstly, the poor infrastructure of the informal settlements would have hindered the collection and distribution of the questionnaires; secondly, the population is very mobile; thirdly, correlations between the source of infection and infected individuals could not be made due to lack of information; fourthly, more details which are outlined below were required and fifthly in order to ensure rapid treatment, the questionnaire could not be anonymous as treatment would have to follow without any further diagnoses. The questionnaire aimed to give

information on sex, age, swimming behaviour, presence of blood in urine on the day, ascertain knowledge of schistosomiasis, reasons for movements, type of migrant, i.e. migrator or a circulator (Prothero 1977), and very importantly - their area of origin.

Both migrants and circulators entering Pietermaritzburg originated from other areas of Kwazulu-Natal as well as Free State and Gauteng. The majority of newcomers to Pietermaritzburg are classified as "migrators". Most (52%) have left their original homes due to violence and rarely return. A smaller group (17%) comprises the "circulators". They are either attending school in the area, visiting, working or living with a relative. For schistosomiasis control purposes, "circulators" may have a higher impact on a control programme as they have repeated contact with infected and non-infected areas more than once. Once having been treated in an area, they have the potential to move to another, get re-infected, return to the place of treatment and re-infect the treated area thereby impacting the control programme there. This problem was documented by Evans (1983) in Hippo Valley, Zimbabwe where dependants of employees in the control area travelled to and from their traditional homes. These dependants provided a constant source of re-infection in the control area.

The questionnaire revealed that the moderate and heavily infected people came from three areas namely Durban, Hammersdale and Table Mountain (Figure 1.3, Table 1.4). Control programmes target high intensity individuals occurring within a certain area with the aim of reducing the intensity of infection through treatment and reduction of transmission rather than the eradication of worms in individuals (Hoffman *et al* 1979). Rarely is the source of infection determined and people there treated. If the source of the infection could be determined and people there treated, it would reduce the transmission of the disease in more than one area. The combined knowledge of the source of infection and the nature and variety of human movements, i.e. migrators/circulators, can greatly facilitate schistosomiasis control programmes.

Results from the questionnaire showed that 32% of the children swam in nearby dams and rivers. Swimming is one of the water contact activities which carries with it a high risk of infection (Kvalsvig & Schutte 1986). Children urinate in the water whilst swimming, thus establishing and maintaining transmission. Knowledge of these dams and river localities would be useful for control programmes as they could be targeted for further snail intermediate host surveys. Thus the schistosomiasis problem could be attacked from both the chemotherapy and snail control angles. Knowledge of the activities of people on the move is as important as the type of "mover" they are. This point is highlighted by a study conducted by Pitchford & Schutte (1967) where it was concluded that temporary migration to endemic areas, where transmission is seasonal, is not an important factor in causing high infection rates in non-endemic areas, or in

maintaining high infection rates in controlled endemic areas. However, they did not do any water contact studies to obtain a relative risk value of infection from activities such as swimming. As schistosomiasis transmission is dependent on contact with infected water, it is not sufficient to conduct only a migration analysis if one is trying to ascertain risk of infection and transmission.

The number of children with a knowledge of schistosomiasis and the source of the knowledge has implications for education programmes. Only 16% knew what schistosomiasis was. They obtained their knowledge from schools and their mothers. This highlights the importance of including schistosomiasis in the formal education curriculum and empowering mothers with knowledge as they have more interaction with their children than any other person of influence. The extent of the children's knowledge was not investigated and should be an area of emphasis in a future study.

This Pietermaritzburg study revealed a positive *S. haematobium* prevalence rate amongst the informal settlers which was coupled with the occurrence of infected and shedding host snails obtained from rivers located alongside the settlements. This confirms the presence of active transmission sites in and around Pietermaritzburg and the presence of urban schistosomiasis which has not previously been documented in the country. Schistosomiasis is present in Pietermaritzburg and if not properly monitored could become a problem as more urinary schistosomiasis carriers move into the area and more transmission foci become established.

1.5 SUMMARY

Rural-urban migration is occurring in Pietermaritzburg and has led to the establishment of informal settlements in and around its centre. The rapid growth of the informal settlements has public health consequences which need to be addressed and monitored. Urinary schistosomiasis is present at low prevalence and intensity levels amongst the informal settlement dwellers. However, the low prevalence levels may be underestimates due to analytical and sampling errors. Prevalence was patchy in distribution highlighting the focality of transmission. These patchy prevalences may be a result of migration, especially as levels are low. Six species of freshwater snails were collected in the Pietermaritzburg area. The freshwater snails harboured patent infections of several trematode families, of which urinary and avian schistosomes were the most medically important infections. Active urinary schistosomiasis transmission sites occurred in Pietermaritzburg confirming the presence of previously undocumented urban schistosomiasis. A structured interview questionnaire was administered to the informal settlement occupants and revealed that violence caused 52% of the migration cases and that the

migrants with high intensity infections came from three main areas. Few of the migrants had any knowledge of schistosomiasis. All these findings have implications for any schistosomiasis monitoring and control programme in the greater Pietermaritzburg area. They also highlight the importance of schistosomiasis monitoring in the area.

1.6 SCHISTOSOMIASIS CONTROL AND SNAILS SURVEYS - PROBLEMS AND SUGGESTIONS

Well co-ordinated and efficient snail control programmes are essential for effective schistosomiasis control programmes (Ndamba *et al* 1990). Snail control involves both the monitoring of the presence of infected freshwater snails and their reduction or eradication. Snail control may be achieved via physical, biological or chemical measures. Physical measures include the draining or filling or ponds, the straightening of streams, deepening of marginal areas, the removal of bank vegetation and the canalisation of waterways. Biological control makes use of biological agents such as predators or competitors of the host snails (Chimbari *et al* 1997). To date chemical measures have been the most effective. Before any snail control programme can be implemented careful consideration needs to be given to the basic options of "desirability/feasibility" (McCullough 1986). Certain activities e.g. molluscicide, may be desirable but not feasible due to lack of finances or poor infrastructure thus limiting the sustainability of the programme.

Snails have an explosive biotic potential which poses limitations on the use of snail control to reduce transmission and highlights the importance of continued, regular surveillance programmes (Hoffman *et al* 1979). Snail surveys are very time consuming and rewards are small. Therefore, extensive survey work should be conducted over a few days, annually, by all available workers in a given area as opposed to making it a routine weekly or monthly task. Snail surveys should be conducted in the early summer before the rainy season and should follow directly after bank vegetation clearance, e.g. grass cutting, has taken place. Freshwater snails adhere to the cut, floating vegetation and are highly visible. Areas which were previously inaccessible are made more accessible following clearance of the banks.

Current strategies show that potential snail host control operations must be closely associated with population based chemotherapy schedules (McCullough 1986). Snail control operations should only be conducted in areas where there is evidence that schistosome infection is giving rise to detectable morbidity. The identification of the most important transmission sites and prediction of the main seasons of transmission are crucial initial tasks for control programmes

(McCullough 1986). Brown (1980) suggests that health workers should be taught to identify snail intermediate hosts, detect transmission sites of epidemiological importance and conduct an ecological diagnosis which would include the snail habitat. This would place health workers as central role players in the surveillance and control of schistosomiasis. As they have close, frequent community contact and are trusted by community, they would be ideal in this role. In South Africa however, this is not the case at present. Many health workers do not appear to have the appropriate skills, knowledge, motivation or experience to play such a vital role. As the Environmental Health Officers' (EHO) curriculum covers all the relevant material to equip EHOs for this important role, why is it that they do not seem able to fulfil tasks like schistosomiasis monitoring. It would seem that much of the blame for the apathetic attitude of the EHOs lies within the hierarchical system within the Health Department where people feel there is not much scope for promotion. Staff are not encouraged to use their own initiative when they perceive areas of need and often end up doing mundane, routine jobs, e.g. clearing vacant plots. Schistosomiasis has traditionally been given a low priority and not much importance was ever placed on its surveillance. As a result there is a lack of staff to conduct such programmes. Laboratory facilities for analytical work are also lacking. Poor communication and co-operation amongst primary health care nurses, academics and health workers makes holistic control programmes problematic. Given these problems, the Health Department may have difficulty playing a leading role in schistosomiasis control in South Africa. The sooner these difficulties are addressed, the sooner a workable Primary Health Care driven schistosomiasis control programme can be implemented.

Several problems were experienced whilst conducting the present survey. A largely random sampling strategy was adopted and several locations harbouring snails may have been missed. Aerial photographs should have been examined for potential snail habitats prior to the study. This would have led to a more thorough and extensive survey. On location of a particular species of freshwater snail, the information should have been recorded using a hand held Global Positioning Sensor (GPS). This would lead to accurate positioning of snail habitats for later surveys.

Problems regarding the condition of snails which were brought into the laboratory were experienced. Often the snails died shortly after being brought into the laboratory by the EHOs or were dead on arrival. This led to difficulties in screening the snails for patent infections. There was little consistency regarding the number of snails brought in following a sampling session. On occasions only one or two snails of a particular species were brought in for examination. Possibly there was only one snail of that particular species at that particular location but in such cases the study should have been extended up or down-river.

Time and language constraints were another constant problem. The workers who scanned the rivers for the snails could not speak English and despite being shown and explained in their own language what they were looking for, did not seem to remember when questioned later. Time constraints may have led to inefficient sampling as the EHOs had to assist me whilst also doing their routine work. As snail collection is very time consuming, it would have been better to conduct and finish an intensive survey over a 10 day period without interruptions. This intensive survey strategy may however pose problems with the screening of snails for patent infections. Ideally, days for collecting snails should alternate with days for screening of snails.

Workshops should play an important role in freshwater snail surveys. The workshops would offer a platform from which knowledge, ideas and skills could be exchanged. Academics, EHOs and field workers all have something to offer. Workshops also promote communication which is very important at all levels of a control programme. The majority of the problems and mistakes discussed could be minimised by better planning, communication and skill transfer between all parties involved in the programme.

CHAPTER 2.

DIAGNOSTIC TECHNIQUES FOR *SCHISTOSOMA HAEMATOBIUM* WITHIN THE PRIMARY HEALTH CARE SYSTEM - A REVIEW

2.1 INTRODUCTION

Schistosomiasis is a chronic, debilitating disease which can cause a high degree of morbidity and leads to economic loss in endemic areas. It is a major health problem in many developing countries where it is believed to affect about 200 million people. Africa is home to nearly 90% of all schistosomiasis cases with it being prevalent in all countries on this continent except Lesotho.

As schistosomiasis is transmitted focally, infections within and between countries show differences in their distribution, prevalence and intensity (Chitsulo *et al* 1995; Red Urine Study Group undated). Knowledge on the local epidemiology of these diseases provides an essential background for planning appropriate and cost-effective control programmes (Ahmed *et al* 1996). The epidemiology of *Schistosoma haematobium* has been described in terms of age-specific prevalence and in quantitative terms based on intensity of infection as measured by egg output (McCullough & Bradley 1973). Quantitative techniques thus provide an important indication of the intensity of infection. Information on infection intensity or morbidity as well as prevalence data is useful both to plan the prevention and control of urinary schistosomiasis and to assess progress in control programmes (Mott 1987).

The current understanding of the epidemiology, morbidity, treatment and control of schistosomiasis is based on the quantification of schistosome infections (Peters *et al* 1976). Quantitative diagnostic techniques for urinary examination in urinary schistosomiasis were introduced by Scott (1957). They have repeatedly been recommended during the past 20 years by the World Health Organisation for epidemiological studies and control programmes (Savioli *et al* 1990). Due to the usefulness of the additional information provided by the quantification of egg output, quantitative techniques have replaced qualitative procedures in most community-based studies of schistosomiasis (Bradley 1965, Mott & Cline 1980).

Advances in the methodology of epidemiological research on schistosomiasis are based on the growing recognition of the acceptability of quantitative techniques in the field. Likewise, as the

emphasis of schistosomiasis control programmes altered, so did the requirements of a diagnostic technique. Initially, schistosomiasis control programmes were managed independently from the general health delivery services. Many programmes were pilot studies in small populations for a limited time with finite resources at high cost. Analyses of samples were conducted at great expense in laboratories by staff who were specialised personnel trained to undertake single tasks.

Two major conceptual shifts resulted in changes in the emphasis of control programmes (Hoffman *et al* 1979). The first shift was an economically driven one and resulted in the current trend of integration of control programmes into the general health delivery system. This conceptual shift resulted from the Declaration of the International Conference on Primary Health Care held at Alma Ata, U.S.S.R. in 1978. A second major conceptual shift altered the aim of interrupting transmission, and so stopping it, in favour of achieving control by a reduction of transmission to a level where it no longer causes morbidity. Intensity of infection should be reduced through treatment and reduction of transmission rather than total eradication (Hoffman *et al* 1979). Estimates of the severity of the disease in public health programmes are made either by measuring the intensity of infection or the prevalence of clinical disease in endemic populations.

Both these shifts altered the requirements of a diagnostic technique. Techniques had to become cost-effective, time-saving and require less skilled manpower than before. In order to effectively control schistosomiasis within a PHC programme, the development of simple, rapid, sensitive, specific and quantitative field detection techniques was very important for early and easy control of the disease (Koech 1986). Detection and quantification of infection are critical for the application of some of the newer approaches to control, e.g. targeted mass chemotherapy and follow-up surveillance during and after control efforts (Hoffman *et al* 1979).

Quantitative techniques include both direct and indirect methodologies. Direct methodologies focus on the presence/absence of eggs and include miracidial hatching, sedimentation and filtration. Indirect methodologies focus on the presence of macro or micro-haematuria and include urine colour scales and chemical urinalysis strips. Qualitative techniques, e.g. indirect questionnaires, are being incorporated into control programmes and provide useful information.

Despite the emphasis of research being placed on PHC- based qualitative and quantitative techniques, laboratory-based techniques still play an important role. Several investigators are currently involved in the investigation of techniques which are serologically based (Voller 1984; Gunderson *et al* 1992; Van Lieshout *et al* 1992). These methods are used to detect antibodies to

various schistosome antigens and have proved more sensitive and specific than other tests having an immunological basis such as immediate and delayed hypersensitivity skin reactions. Antibody-based assays may show more discrepant results than the immunologic detection of circulating antigens especially after chemotherapy. However, currently used assays in serodiagnosis of schistosomiasis are antibody based. These tests include CFT (complement fixation test), COPT (Circumoval precipitin test), IFAT (Immediate type skin hypersensitivity test and a cercaria fluorescent antibody test), radioimmunoassay (RIA) and ELISA (enzyme-linked immunosorbent assay). ELISA testing has replaced all of the above except the IFAT. Criticisms regarding these methods include: they are open to abuse, they do not indicate the parasite species, reactions are slow to develop and remain positive after successful cure and cross-reactions occur between antibodies produced after exposure to non-human schistosome cercariae.

2.2 FIELD DIAGNOSTIC TECHNIQUES FOR *SCHISTOSOMA HAEMATOBIUM INFECTION*

Infection with urinary schistosomiasis is characterised by the presence of terminally-spined eggs and macro and/or micro-haematuria in the urine. Both direct and indirect methods of detection are used to diagnose the presence of these eggs and the haematuria (Figure 2.1). Each of these is reviewed below.

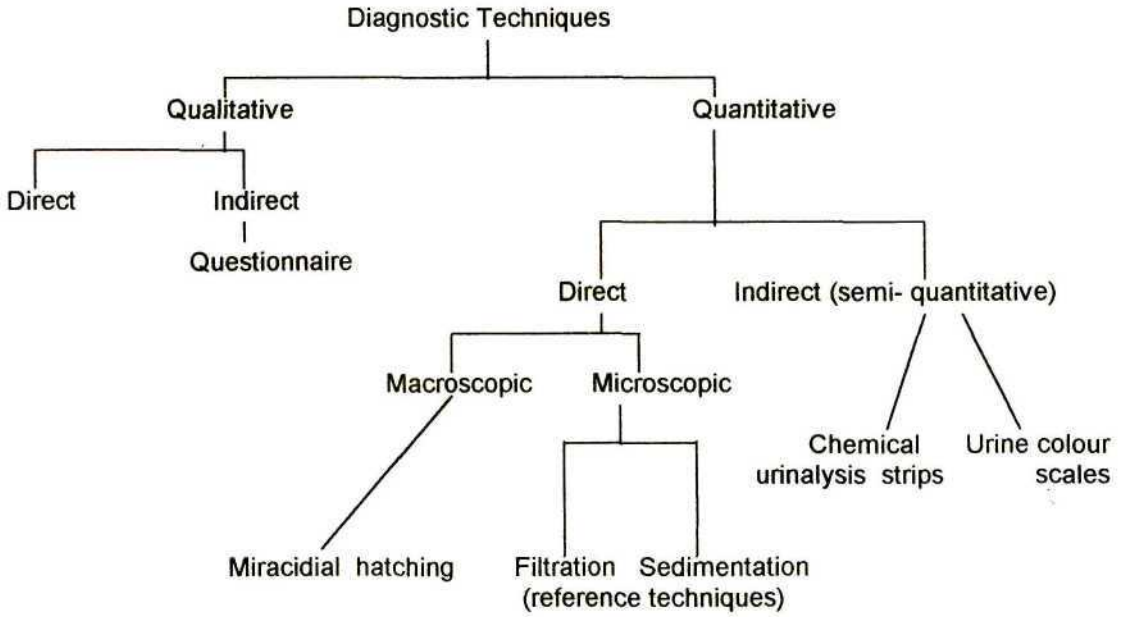


Figure 2.1: *Urinary Schistosomiasis* flowchart depicting field diagnostic techniques

2.2.1 QUANTITATIVE TECHNIQUES

2.2.1.1 DIRECT METHODS OF DETECTION

The parameter of egg output has become a requirement in most epidemiological studies on schistosomiasis following the realisation that the number of schistosome ova in the excreta of man could be used as an indication of the intensity of infection and that most studies have found a direct relationship between this intensity and morbidity (Schutte *et al* 1994). These findings also apply to the urinary form of the disease where the only certain way of diagnosing it is to find the characteristic eggs in urine samples (Fripp 1995).

For many years, counting eggs in urine samples was the only specific and quantitative diagnostic tool for schistosomiasis (Hoffman *et al* 1979). This tool has been widely accepted as the only method with diagnostic accuracy and is used as the "gold standard" in comparative methodological studies. Examination by field workers of 10ml aliquots of whole urines taken between 10h00 and 14h00 usually provides data suitable for use as an index of community egg-output (McCullough & Bradley 1973).

2.2.1.1.1 URINE SEDIMENATATION

Eggs are sedimented by centrifugation (Scott 1957) or gravity.

Methodology

A urine sample consisting of total bladder content is collected in a 250ml sample bottle and then fixed by the addition of one of the following: 4% formalin (Schutte *et al* 1994), a few drops of 10% formalin (Mott *et al* 1985b), 1ml 10% formalin containing 1% merthiolate (Cooppan *et al* 1987), 2 drops (approx. 0.1ml) of 10% v/v formol saline, 1% v/v domestic bleach (50-100ml urine)(Cheesbrough 1991) or 10ml carbolfuchsin added to a 10ml aliquot (Richards *et al* 1984). Following fixation the urine specimen is thoroughly mixed and a 10ml aliquot is obtained from it. The sample is centrifuged at slow to medium speed (1500 - 2000 rpm). In urine samples with gross haematuria, a drop of acetic acid may be added to the deposit to lyse the red blood cells (Patwari & Aneja 1988). Following centrifugation, the supernatant is removed and the sediment examined under a microscope. Sucking off supernatant is recommended over pouring it off (Gilles *et al.* 1973). If a centrifuge is not available, the 10ml sample should be left to stand in a dark place for one hour to allow the eggs to sediment by gravity (Cheesbrough 1991). The

sediment is then examined under a microscope and the eggs counted and reported as eggs/10ml urine. Despite the need for the standardisation of an egg counting technique, little progress has been made on this (Mott & Cline 1980).

The main advantage of microscopy is that it detects infection, irrespective of intensity level (Pugh *et al* 1980). The main disadvantage of this method, however, is that it is unpleasant, labour-intensive, best suited to laboratory conditions and may only be good for small sample sizes. Thus, it is unsuitable for large-scale epidemiological and control purposes (Koech 1986).

The method has been used for a control programme in Morocco (WHO 1986) and to evaluate clinical profiles of the disease in school children in Nigeria (Patwari & Aneja 1988).

2.2.1.1.2 URINE FILTRATION

Bell (1963), Bradley (1964) and Visser & Pitchford (1972) developed various filtration techniques. Later Peters *et al* (1976) introduced a technique in which urine samples were passed through transparent polycarbonate filters (Nucleopore® 13mm diameter, 8μm pore diameter) filters by means of 10-ml syringes. This method allowed for the rapid and accurate quantification of *S haematobium* eggs in urine and was well suited to field studies (Peter *et al* 1976). The main problem with the technique was its high cost which acted as a barrier to its use in areas of endemic schistosomiasis. The non-profit organisation Programme for Appropriate Technology in Health (PATH) made available low cost polycarbonate filters.

In place of the polycarbonate filter membranes, Pugh (1978) suggested the use of filter paper discs (Whatman No.541 or No. 1). To improve visibility of the eggs on the filter membranes, Lugol's iodine was passed through using a syringe. The discs were then placed on glass slides, two drops of supersaturated fresh ninhydrin solution added and the eggs were incubated for 10 minutes in an oven at 180°C oven. This incubation procedure produced optimal staining and the purple-black eggs showed up distinctly under the microscope.

To reduce the cost of the filters, Klumpp & Webbe (1983) recommended that 12 μm pore diameter polycarbonate membranes be purchased in 8 in. x 10 in. sheets and the filter discs stamped out using a 25 mm-diameter metal punch and a flat headed hammer. A 25mm-diameter disc with 12μm diameter pores was recommended to alleviate two problems commonly encountered: firstly, the 13mm diameter filters clogged easily when 10ml urine samples were passed through them and secondly, egg counting was difficult when the number of eggs on the filter was greater than 10^3. These filters have been used in Egypt (Abdel-Wahab *et al* 1992, El-

Sayed *et al* 1995), Kenya (King *et al* 1991) and Jordan (Saliba *et al* 1997). Braun-Munzinger & Rohde (1986) recommend the paper filters as the most appropriate *S. haematobium* diagnostic technique when specimens are sent by post or public transport to a central laboratory for quality control purposes.

Mott *et al* (1982a) introduced a less expensive polyamide (Nytrel®) woven filter (12mm diameter and 20μm pore size). The eggs are viewed against fibres which makes them hard to read. To enhance visualisation they thus need to be stained. A solution of 50% Lugol's iodine, methylene blue or 50% glycerine-malachite green using the El Zogabie modification may be used (Sarda 1986). Richards *et al* (1984) demonstrated that when carbolfuchsin-stained/preserved urine was passed through a Nytrel® filter it produced the highest egg count per 10ml of urine when compared to Whatman® and Nucleopore® filters. WHO (1985a) recommended that these Nytrel® membrane filters be used for the qualitative and quantitative diagnosis of *S. haematobium* infections. They have been used in Cameroon (Robert *et al* 1989), Pemba Island (Savioli *et al* 1990) and Sudan (Elias *et al* 1994; Ahmed *et al* 1996).

Another method was devised by Feldmeier *et al* (1979) who assessed egg excretion in urine both qualitatively and quantitatively by the filtration, Trypan blue staining technique. This method enables very low concentrations of eggs in urine to be detected.

One way of reducing the cost of the filters would be to re-use them. Thus the main question became - Can they be washed ? (Rohde *et al* 1985). There was increasing evidence that the Nytrel® membranes could not be re-used (Klumpp & Southgate 1986) whereas the Nucleopore® membranes could. A WHO Guide (1983a) endorsed the use of Nytrel® filters which were claimed to be re-usable if properly washed and re-examined before reusing. This statement was criticised by researchers who argued that the washing procedures were inadequate (Rohde *et al* 1985; Klumpp & Southgate 1986; Braun-Munzinger 1986; Wilmott 1987). In response, Mott (1988) recommended a more detailed washing procedure for the re-use of the filter membrane and provided field assessments where washing had been successful in Zanzibar, Malawi, Zimbabwe, Zanzibar, Pemba Island, Ethiopia and Mozambique. The successful washing procedure in Zimbabwe included soaking the filters in 10% potassium hydroxide for at least 30min before washing in the normal manner (Taylor *et al* 1990).

The multiple use of Nucleopore® filters was still producing false positives which led Mshinda *et al* (1989) to further compare various washing techniques. They concluded that polycarbonate filters could be washed using a simple method. This method required the filters to be bulk

washed in 500ml water for one minute, soaked overnight in water, boiled in fresh water for five minutes and shaken in a sequence of four 500ml containers of : one cycle of water, two cycles of detergent and one cycle of water for one minute each. This washing sequence gave a 100% egg elimination i.e. freed the filters of all residual eggs. Lengeler *et al* (1993) followed a simpler procedure which involved washing the filters and then boiling them for 5min. A study in Egypt (Anonymous 1987) highlighted the point that not everyone may be prepared to spend the time and effort in trying to clean used Nytrel® filters. Richards (1984) points out that it may not be the filter membranes that were the problem but the filter holders. Peters *et al* (1976) washed both the filter holders and syringes in a solution of detergent (Teepol), followed by two rinses in clear water. Syringes and filter holders were monitored for contamination following every fifth sample analysis. Mott (1988) commented that perhaps the solution to the filter re-use problem lay in the efficiency and adequacy of the washing procedure coupled with the amount of effort by the washer and not the type of filter membrane that is used.

These membrane filters became very popular and were used in many epidemiological and control studies. Filtration was recommended because it has been shown to be the simplest, most sensitive, rapid and reproducible method for detecting and quantifying eggs in urine (Peters *et al* 1976; Mott 1982b; WHO 1983a). It has also been used as the reference technique in comparative methodological studies (Sarda *et al* 1985a; Lengler 1993; Jemaneh *et al* 1994; Mafe 1997).

Methodology

A urine sample consisting of total bladder content is collected in a 250ml sample bottle, thoroughly shaken and then a 10ml syringe aliquot is extracted. Removing the plunger and filling the syringe is recommended in preference to sucking up the urine as a plastic tube attachment at the end of the syringe is not needed and the air which passes through the membrane after the urine helps to stick the eggs to the filter (Cheesbrough 1992). A drop of eosin may be added to the sample to improve subsequent staining and reduce the development of urine odour (Pugh 1978). If filters become clogged, a 3% v/v acetic acid solution can be passed through the filter. Where egg concentrations are less than 10 ova/10ml, whole measured urine volumes should be filtered (Feldmeier *et al* 1982).

Various studies have indicated that filtration of a single urine aliquot is not very sensitive and although used widely to evaluate the sensitivity and specificity of reagent strips (Wilkins *et al* 1979; Pugh *et al* 1980; Mott *et al* 1983; Stephenson 1984; Murare & Taylor 1987), it is probably unsuitable for light infections. Scott *et al* (1982) demonstrated that 30% of *Schistosoma haematobium* infections with 2 eggs/5ml (highly endemic area) of urine would go undetected by

examination of a single urine specimen using the filtration diagnosis technique. In comparison, Lengler (1991b) showed that detection of 80.0% of positives could be obtained when using replicate filtration tests on two days. The low sensitivity of a single urine aliquot filtration can attributed to daily *S. haematobium* egg output fluctuation (Savioli *et al* 1990; Gryseels 1996; Lwambo *et al* 1997). Savioli *et al* (1990) collected urine samples from subjects over six consecutive days. They demonstrated that a single urine filtration detected only 50% of those persons who had >50 eggs/10ml of urine at least once during the study period. This day-to-day variation in *Schistosoma haematobium* egg counts raises questions as to the appropriateness of using egg count limits based on single filtration results for indirect morbidity grading (Hatz *et al* 1990). Despite these findings that a filtration of a single urine aliquot is not very sensitive, a study conducted in Kenya (Warren *et al* 1979) found that it was sufficient.

With the objective of integrating schistosomiasis control activities with PHC, it has been proposed that urines should be collected and filtered at local level by village health workers or visiting nurses. This was done in Mali and was a proposed strategy for Morocco (WHO 1986). The filters were examined at the nearest reference centre equipped with a microscope. Stained filters can be stored without particular precautions for a certain time before being examined. This allows the health worker to send the collected samples weekly or at even longer intervals to the reference centre for examination (Werler 1986). Quality control by a central laboratory is especially important when samples are examined at a local level by health workers. Specimens can be sent to the laboratory by post or public transport. Egg loss or transfer on the filter membranes whilst being transported is a risk. Braun-Munzinger & Rohde (1986) developed a method for filter paper transport which minimised this risk. It involves sticking the air dried filter onto a piece of adhesive tape so that eggs are fixed between the filter paper and the filter. The filter number needs to be visible for later identification. The strips of tape are then stuck onto an A4 plastic sheet and are ready for transportation to the central laboratory. On arrival at the laboratory, the pieces of tape with the filters are removed from the plastic sheets and a drop of 10% iodine tincture is added to the reverse side of each filter. The pieces of tape are then stuck to a glass slide and scanning and counting can be carried out.

2.2.1.1.3 MACROSCOPIC DIAGNOSIS

An egg hatching technique for the detection of *Schistosoma mansoni* miracidia was first described by Dr. Friederick Fülleborn in 1921 (Weber 1973). Fülleborn noted that the diagnosis of bilharziasis could be carried out without the use of a microscope (Weber 1973). Further development of the technique occurred in the late 1940s at the Blair Research Laboratory in present-day Zimbabwe. Over the next 25 years the technique was improved and found to be of value in incidence and prevalence surveys and in drug trials. Meeser *et al* (1948) described the construction of a special examination rack (miracidiascope) enabling hatched miracidia from schistosome eggs in urine to be observed speedily and easily with no other aid than a simple 10x hand-lens.

In a comparative study of macro and microscopic methods of diagnosis, Weber (1973) showed that 211/1300 specimens were diagnosed as positive by both methods, separately. However the macroscopic method picked up 35 cases which were not picked up microscopically. In comparison the microscopical analysis picked up 88 cases where no miracidia hatched.

The advantages of the macroscopic method include the minimal need for equipment and its suitability for field analysis. It should be possible to diagnose active urinary schistosomiasis cases in any population group with no more equipment than urine collecting jars, examination racks, a hand-lens, centrifuge tubes and a hand centrifuge. This method is best suited to routine surveillance by school medical officers whilst doing their routine examinations. It would not be suited to mass examination conducted at any one time.

Methodology

Terminal urine is collected in a glass jar, the lid is removed and the bottle allowed to stand for 30min. The supernatant urine is drawn off leaving behind 10-15ml of urine which is centrifuged. The supernatant is again removed and fresh hatching water added to the remaining urine in the centrifuge tube. The tube is placed in a rack facing the sunlight where the temperature is allowed to rise to about 38 °C. The specimens are then ready for miracidiascope viewing (Weber 1973).

2.2.1.1.4 INFLUENCING FACTORS AFFECTING URINE EXAMINATION TECHNIQUES

There are several important factors to consider which could alter the outcome of results when conducting urine examinations for the presence of *S. haematobium* eggs. These include firstly, the day to day variation in subjects egg count (Wilkins & Scott 1978, Savioli *et al* 1990, Gryseels 1996, Lwambo *et al* 1997) and the seasonal variation in egg counts (Wilkins & Scott 1978). This variation in egg output can be minimised by conducting two replicate samples collected on consecutive days. Secondly, samples should be collected during the period of peak egg excretion and when variation is at its minimum (McCullough & Bradley 1973a). Ideally samples should be examined over a 24hr period whereby the volume of urine is reported in ml and number of eggs/24hr sample. Thirdly, the urine flow rates are important as they will influence the number of ova in a given volume of urine (McCullough & Bradley 1973a; Wilkins 1977). Fourthly, at low intensities there is an increased likelihood of false negatives (Wilkins 1987a). Fifthly, the WHO set a cut-off count of > 50 eggs per 10ml of urine as the threshold for risk of *S. haematobium*-induced morbidity (WHO 1985b). Despite this recommended cut-off count, there is little agreement on an infection intensity categorisation which varies from study to study (Table 2.1). Lastly, single parasitological examinations have limitations and should be accompanied by an indirect indicator of infection (Savioli *et al* 1990).

Table 2.1: Classification categories for number of eggs/10ml that researchers have used.

Negative	scanty	light	moderate	heavy	severe	Reference
0	-	100	101-350	>350	-	Doehring *et al* 1985a
0	<20	21-50	51-150	151-500	>500	Patwari 1988
0	-	1-200	201-1200	>1200	-	Cooppan *et al* 1987
0	-	1-29	30-40	>50	-	Janitscheke *et al* 1989
0	-	1-99	100-399	> 400	-	King *et al* 1991
0	-	1-10	11-100	>100	-	Abdel-Wahab *et al* 1992
0	-	1-50	51-499	500-1499	>1500	Elias *et al* 1994

2.2.1.2 INDIRECT METHODS OF DETECTION

The development of indirect techniques will help enable schistosomiasis control activities to be incorporated into Primary Health Care which is especially important for underdeveloped nations. Many of the direct techniques developed to date are impracticable as they involve expensive equipment and trained personnel (Briggs *et al* 1971). A widely recognised clinical feature of *Schistosoma haematobium* infection is gross haematuria. The passage of eggs through the

bladder wall produces both haematuria and proteinuria. Various workers have proposed the detection of gross haematuria as an indirect screening technique for urinary schistosomiasis (Mott *et al* 1985a; Rustasitara *et al* 1984) with the aim of providing a simple, quick and relatively cheap diagnosis method (Sarda *et al* 1986).

2.2.1.2.1 CHEMICAL URINALYSIS STRIPS

In the 1970s and 1980s the simple and rapid indirect diagnosis of urinary schistosomiasis using chemical urinalysis strips for proteinuria and haematuria was recommended for large scale use in morbidity control programmes (Briggs 1971; Wilkins *et al* 1979; Pugh *et al* 1980; Taylor 1982; Savioli & Mott 1989). The strips would measure the degree of haematuria and proteinuria semi-quantitatively (Stephenson *et al* 1984) and were proposed as an alternative to the parasitological methods which were more time consuming and required expensive equipment and trained personnel (Murare *et al* 1987). Researchers in Egypt found that the reagent strips had the added advantage of being more sensitive than urine sedimentation and as sensitive as filtration (El-Sayed *et al* 1995). Studies conducted in the Gambia (Wilkins *et al* 1979), northern Nigeria (Pugh *et al* 1980), Sudan (Feldmeier *et al* 1982), Zimbabwe (Taylor 1982; Murare & Taylor 1987), Ghana (Mott *et al* 1983), Kenya (Stephenson *et al* 1984), and South Africa (Cooppan *et al* 1987) showed that the presence and concentrations of urinary haematuria and proteinuria were positively correlated with the presence and intensity of *S. haematobium* infection in children's urine specimens.

2.2.1.2.1.1 Factors affecting sensitivity and specificity readings of haematuria and proteinuria parameters of chemical urinalysis strips

2.2.1.2.1.1.1 Cut-off values, single or combined parameters

Chemical reagent strips have been recommended as screens for proteinuria and haematuria, combined proteinuria and haematuria or a combination of proteinuria, haematuria and leucocyturia. Taylor (1982) demonstrated that by using a 1+ proteinuria reading (30mg/100ml) as a diagnostic level for *S. haematobium*, a reasonably high specificity with only 5% false positives was obtained. Proteinuria has been found to be more common than haematuria in persons without *S. haematobium* eggs in the urine (Mott *et al* 1983).

A combination of at least a trace of haematuria and 30mg/100ml or more of protein has been shown to be specific for the detection of individuals with high egg counts (Briggs 1971; Wilkins *et al* 1979; Mott & Cline 1980). Wilkins *et al* (1979) showed that subjects diagnosed positive with 30mg/100ml protein and a trace of haematuria were equivalent to subjects with 200 eggs/10ml. Pugh *et al* (1980) found that use of the combined criteria was superior to any individual level of haematuria or proteinuria where sensitivity and specificity were achieved at low and high levels of haematuria and proteinuria respectively. However, the combined criterion demonstrated a specificity comparable to the higher levels of proteinuria and haematuria for the detection of intense infection without much loss of sensitivity (Pugh *et al* 1980; Mott *et al* 1983). Mott *et al* (1985) warn that the addition of the proteinuria reading should be carefully evaluated as it did not greatly improve specificity and sensitivity of the screening in children in the Gambia and Zambia. Wilkins *et al* (1979) demonstrated that the combined criteria would have been similar to treating those with an egg count of 100 ova/10ml or more. However, more recent research has shown that schistosomiasis proteinuria originates post-renally and is not a sign of impaired renal function. Therefore its use for screening would not lead to a direct form of morbidity control (Gryseels 1989). In 1985 WHO set a cut-off count of >50 eggs/10ml of urine as the threshold for risk of *S. haematobium*-induced morbidity (Lwambo *et al* 1997). Therefore, the chemical reagent strips may be used for the identification of high risk *S. haematobium* morbidity individuals particularly in the less developed countries where it may replace microscopy (Pugh *et al* 1980, Taylor 1982).

Strips have a high specificity of 95% or better emphasising the superiority of this technique over the filtration of a single 10ml urine sample in light *S. haematobium* infections (Feldmeier 1982; Mott *et al* 1985b). Sarda *et al* 1985a demonstrated that the strips have a high sensitivity of 94.4% and specificity of 96% in areas with low prevalence and intensity rates. This may have resulted from the high haematuria frequencies that were obtained in the study. However, more recently, studies in Nigeria (Mafe 1997) demonstrated a low sensitivity of the strips in areas of low intensity rates of disease.

Haematuria alone has been shown to be more specific than proteinuria alone (Feldmeier *et al* 1982; Stephenson *et al* 1984; Mott *et al* 1985a; Cooppan *et al* 1987). A survey conducted by PATH revealed that a cut-off positivity level of 10 to 15 ery/μL (i.e. "trace") would be appropriate for a positive result (Kristensen 1994). Stephenson (1984) conducted a study on Kenyan school children and obtained high sensitivity of 88% and specificity of 97% values using "trace" as a cut-off positivity level. Strong correlations between filtration and urinalysis strip testing occurred at the 2+ limit in Ethiopia (Jemaneh *et al* 1994) whereas it occurred at the 1+ limit in Zambia (Siziya *et al* 1993). Lengler *et al* (1993) compared sensitivity and specificity at the 1+ and 2+

cut-off positivity levels on Tanzanian school children. Sensitivity was greater at the 1+ positivity level, whereas specificity was higher at the 2+ positivity level. The 2+ positivity level was useful for the measurement of the community prevalence rate. A similar trend was obtained in a more recent study conducted on Pemba Island (Lwambo *et al* 1997) where chemotherapy was conducted throughout the intervention programme. For the 1+ cut-off positivity limit the following values were obtained: sensitivity 90%, specificity 51.3%, positive predictive value 44.2%, negative predictive value 98.5% and efficiency 64.5%. In comparison, values obtained at the 2+ positivity limit included: sensitivity 68%-85%, specificity 81.7%, negative predictive value 90.8%, efficiency 80.9% and positive predictive value 62.9%.

Feldmeier *et al* (1982) found a significant correlation between haematuria, leucocyturia and the intensity of infection as measured by egg excretion in urine. The correlation was strongest when all three parameters were combined. However, the frequency of false negative results was high.

2.2.1.2.1.1.2 Age of the study group

In two separate studies conducted in Ghana (Mott *et al* 1983) and Kenya (Stephenson *et al* 1984), haematuria was correlated with increasing *S. haematobium* egg counts in the 5 to 14 year age group. This is the age group of peak egg excretion. In Ghana, the 1+ haematuria positivity limit sensitivity of 98% was higher for children aged 5 to 14 yr than for children aged >15 yr which was 87%. The 1+ proteinuria positivity limit sensitivity of 92% was higher for children aged 5 to 14 yr than for children aged >15 yr which was 69%. This highlights the opinion that reagent strips may not be useful for screening adults who are over the age of peak egg excretion.

However, Mott *et al* (1985a) found the combination of 2+ to 5+ proteinuria positivity levels and 1+ to 4+ haematuria positivity levels identified most infected adults (93%) and was highly specific (83%) in Zambia. In a study conducted on Pemba Island, Lwambo *et al* (1997) obtained a high sensitivity for the identification of both adults and children with heavy infections at the 1+ micro-haematuria positivity limit.

2.2.1.2.1.1.3 Sample collection and standardisation of examination procedures

Samples should be collected from subjects around mid-day (Onori 1962) as egg output is at its maximum at this time (Bradley 1965). Lengler *et al* (1991b) showed in addition that circadian variation of haematuria and proteinuria had an influence on the diagnostic performance of

urinalysis strips. Intensity of infection has been shown to be highest after mid-day (Bradley 1965; Weber 1967) and the greatest concentrations of eggs and haematuria are evident in the last fraction of micturition stream (Weber 1967; Patwari & Aneja 1988).

Sarda *et al* (1986) demonstrated that the sensitivity of a technique can be improved by carrying out urine collection at mid-day and collecting terminal urine. Studies on Pemba Island revealed that day-to-day blood excretion in subjects with *S. haematobium* infection is more stable than that of egg excretion (Savioli *et al* 1990).

2.2.1.2.1.1.4 Factors affecting the efficiency of urinalysis strips

Several factors can alter the efficiency of urinalysis strips and result in an increased number of false positives. Firstly, the presence of ascorbic acid (Mott *et al* 1985a; Brigden *et al* 1991) and hypochlorite (J. Jenvey pers. comm., Benmore Diagnostics) in the urine; secondly, pathological proteinuria and haematuria and thirdly, menstruation (Stephenson *et al* 1984; Cooppan *et al* 1987) all result in an increased number of false positives. Pathological proteinuria can be caused by increased plasma protein concentration, increased glomerular permeability, defective tubular absorption and abnormal secretion from the urinary tract (Cooppan *et al* 1987). Pathological haematuria can be caused by sickle cell disease (Sarda *et al* 1986), though Savioli & Mott (1989) later showed it not to have an influence.

2.2.1.2.1.1.5 Variation in endemicity

One of the major factors affecting the relationship between the diagnostic potential of haematuria and proteinuria are the one hand and the relationship between proteinuria/haematuria and intensity of infection on the other was shown to be the community-specific nature of morbidity due to *S. haematobium* (Tanner *et al* 1983; Murare & Taylor 1987). Two inter-country comparative studies showed that the same strip reading (haematuria and proteinuria cut-off values 0, 1+, 2+, 3+) could be associated with very different mean egg intensities in different settings (Tanner *et al* 1983; Mott *et al* 1985a). Cooppan *et al* (1987) assessed the sensitivity and specificity of urinalysis strips in the screening of children for *S. haematobium* infection in various geographical areas of South Africa and showed that the sensitivity and specificity of the strips varied according to the endemicity of the areas concerned.

Originally the use of urinalysis strips was proposed for areas where transmission and prevalence were high and consequently where large numbers of people had haematuria and proteinuria. Studies conducted on Pemba Island, however, showed the strips to also have a high sensitivity and specificity where transmission is low (Savioli & Mott 1989; Savioli *et al* 1989; Savioli *et al*

1990). Appendix 2.1 highlights the sensitivity and specificity of chemical urinalysis strips in detecting *S. haematobium* infection in areas of varying prevalence rates.

2.2.1.2.1.1.6 User-friendliness of reagent strips

Haematuria was shown to be more sensitive than proteinuria in the diagnosis of *S. haematobium* infection (Stephenson *et al* 1984; Cooppan *et al* 1987). This was attributed to the high sensitivity of the strip to minute amounts of blood, and the difficulty in discriminating the reactivity of the protein portion. One problem, however, was that workers required extensive training to make proper readings (Mott *et al* 1985a).

2.2.1.2.1.1.7 Expiry dates of reagent strips

Savioli *et al* (1993) reported a considerable loss of sensitivity in one-year-expired haematuria test strips.

2.2.1.2.1.1.8 Gold standard

Both the filtration and sedimentation techniques have been used as the reference technique in comparative methodological studies (Lengler 1993; Jemaneh *et al* 1994; Mafe 1997) and are referred to as a *gold standard.* A single urine filtration is used as a *gold standard* against which to evaluate sensitivity and specificity of other diagnostic techniques. However, several studies have revealed that a single filtration is not sensitive enough for this purpose. A study conducted in Zimbabwe (Taylor *et al* 1990) showed that a single urine filtration was not sensitive enough to evaluate the sensitivity and specificity of the urinalysis strip and was probably not adequate for detecting light infections. Studies in Ghana (Mott *et al* 1985a) indicated that 30% of *S. haematobium* infections with 2 eggs/5ml (highly endemic area) urine would go undetected by the examination of only a single urine specimen. The filtration of only 10ml urine underestimates true prevalence, so the true sensitivity of the method is lower than what is reported (Stephenson *et al* 1984).

2.2.1.2.1.2 Value of chemical urinalysis strips for control programme purposes

Wilkins *et al* (1979) suggested that urinalysis strip parameters may have value as indicators for chemotherapy due to the relationship of proteinuria and haematuria levels to egg counts. Since then, chemical urinalysis stick detection of haematuria infections (Mott 1985) has been recommended for large scale use in morbidity control programmes (Wilkins *et al* 1979; Savioli &

Mott 1989; Lengler 1991a) to rapidly identify persons with at least 50 *S. haematobium* eggs/10ml urine (Mott *et al* 1983). Sensitivity has been shown to increase with increased intensity so that strips could be useful in areas of high prevalence and high intensity of *S. haematobium* infection (Sarda *et al* 1986). Savioli and Mott (1989) showed that sensitivity increased from 90% to 98% among those who had egg counts of greater than 50 ova/10ml urine. Due to the high sensitivity of the strips in high intensity and high prevalence areas, Stephenson (1984) recommended that where financially feasible, all positive cases should be treated.

The useful role that chemical urinalysis strips can play in a schistosomiasis control programme has been acknowledged. However, the conditions and sequence for their optimal use within a programme vary. Strips are recommended as a sole screening technique in morbidity control programmes (Savioli *et al* 1989; Taylor *et al* 1990). However, Lwambo *et al* (1997) suggested that indirect questionnaires or urine colour scales would be an appropriate method for preliminary screening of communities to identify those at high risk of morbidity. This should be followed by using chemical strips at a 1+ positivity limit to target intervention at the level of the individual. Stephenson (1984) recommended strips as an initial screening device in previously untreated populations of school age children in *S. haematobium* endemic areas. She recommended that prior to the strips being used for control project purposes in a new area, the strip results should be compared with microscopy on a sample from the community to ensure that conditions other than *S. haematobium* infection are not causing a high haematuria and proteinuria proportion of false positives. Taylor *et al* (1990) highlighted the variation of sensitivity and specificity at different intervals of the control programme. This led them to advise that control programmes should be evaluated at several intervals. Based on research conducted in Zambia, Briggs *et al* (1971) recommended that chemical strips be used for routine surveillance in underdeveloped countries.

Strips can also play a role in the assessment of the impact of control efforts on morbidity in *S. haematobium* endemic areas (WHO 1985a). Regarding the use of strips to screen previously infected children six months after treatment, Stephenson *et al* (1984) found lower sensitivities, specificities and positive predictive values. However, the amount of *S. haematobium* infection which was undetected remained the same, highlighting the importance of intensity and prevalence.

2.2.1.2.1.3 Advantages of strips

The chemical urinalysis strip method is simple, rapid and removes the need for expensive equipment and skilled personnel (Savioli & Mott 1989). Firstly, it allows for savings in terms of man-hours and cost. More children can be screened by the chemical strip method than by

microscopy in a given time. It took less than one month to screen and treat 26 000 children on Pemba Island whereas it would have taken six months to survey the same number using filters and microscopy (Savioli & Mott 1989). Secondly, moderate to heavily infected people, i.e. those who are largely responsible for transmission, can easily be detected and treated.

2.2.1.2.2 Urine colour scales

Given the correlation between intensity of *S. haematobium* infection and levels of haematuria present in urine, Rutasitara *et al* (1984) measured the frequency and levels of visible haematuria in relation to the presence and intensity of egg output in urines of infected children living in a known endemic area. Variation occurred in the colour of haematuria from an infected individual over time. There was also variation in the intensity of egg output within the same shade of haematuria of the same or different individuals. There was however much overlap in egg output between the different shades. There was also a significant increase in the number of urine samples with high egg output as the colour of urine deepened to frank red. Colour scales used by Rutasitara *et al* (1984) were clear yellow, amber, brown and frank red. It was concluded that visible haematuria was highly sensitive but only moderately specific as an index of infection intensity.

In contrast to this finding, Murare &Taylor (1987) concluded from a Zimbabwean study, that visual observation of blood was insensitive (19%) but highly specific (100%). More recently, Lwambo *et al* (1997) compared four indirect screening methods for the detection of *S. haematobium* on Pemba Island and found visual haematuria to be highly specific (88.3%), efficient (80.3%), with a negative predictive value of 84.9% whilst having moderate sensitivity (59.9%) and positive predictive values (66.9%).

Studies conducted in Zambia showed that blood occurred in the urine of 100% of children with more than 64 eggs/10ml urine (Mott 1985a). Murare & Taylor (1987) found 0.67% of children passing more than 64eggs/10ml urine were also passing visible blood. Sarda *et al* (1986) showed that higher egg counts were obtained in cloudy brown and red urine with cloudy brown and bloody red urines constituting gross haematuria. Categories used by Sarda *et al* (1986) and Mott *et al* (1985a) were clear, cloudy yellow, cloudy brown, bloody red. Sarda *et al* (1986) concluded that the detection rate of positive samples using colour analysis increases with the intensity of infection. Thus, a high sensitivity could be recorded in areas with high prevalence and intensity rates.

Visible blood is useful as an indicator of the status of *S. haematobium* infection in a community. However Murare & Taylor (1987) found that visible blood only occurs at a relatively low frequency and is highly susceptible to treatment, and they therefore suggested that it may not be sensitive enough a measure for planning control operations. Given the results obtained on Pemba Island, Lwambo *et al* (1997) concluded that visual haematuria would be suitable for preliminary screenings. However, due to its low sensitivity, it would not be useful for identifying individuals for selective population chemotherapy.

2.2.2 QUALITATIVE DIAGNOSTIC TECHNIQUE

2.2.2.1 Questionnaire method

Schistosomiasis transmission is focal and thus tends to be concentrated in particular areas. Neighbouring areas may have very different rates of infection. In most countries in Africa, little is known in detail about the status and epidemiology of schistosomiasis infection over much of their endemic areas (Lengler *et al* 1991a,b). This lack of knowledge can be problematic for the planning and implementation of control programmes especially where resources are limited. Extensive epidemiological surveys using quantitative tests may be used to identify high prevalence communities but this would be expensive and time-consuming. A need arose therefore for a rapid method for identifying communities with high prevalences of urinary schistosomiasis infection (Chitsulo *et al* 1995). In addition to financial constraints was an increased awareness that the perceptions of health problems by the beneficiaries was another important element in the success or failure of Primary Health Care strategy for disease control and health improvement (Lengler 1992).

Studies on the community-based diagnosis of urinary schistosomiasis in Tanzania (Lengler 1991a,b) have demonstrated that simple, self-administered questionnaires could be distributed in a cost-effective manner through an existing administrative system and that their diagnostic performance for the identification of high risk communities was very good. These studies were based on an "indirect" interview approach because the researchers were not personally involved in the interviewing. This represented an alternative and simplified methodology for health interviews by eliminating the need for face-to-face encounters between the investigator and the respondent.

The strengths and limitations of this approach are discussed by Lengler *et al* (1992). It is a convenient low cost method of identifying schools and communities with high levels of

schistosomiasis-related morbidity. It involves sending questionnaires to primary schools through normal administrative channels in which children are asked about the symptoms and diseases they have suffered in the recent past. Schistosomiasis is a chronic disease and one symptom of it is the appearance of blood in the urine. This symptom is easily recognised and remembered by children. The method involves active collaboration between education and health departments using an approach which was initially developed in Tanzania by Swiss researchers (Lengler *et al* 1991a,b). The method is a first step in a control programme and is designed to pick out communities in need of intervention and not individuals who need treatment. The actual carrying out of control measures will have to be made after taking into consideration the local situation and resources available (Chitsulo *et al* 1995). The method involves several steps: (i) determine which area is to be surveyed, (ii) prepare and adapt the questionnaire to the local situation, (iii) organisation, (iv) implementation and (v) results (Chitsulo *et al* 1995). Its feasibility and cost-effectiveness was assessed in seven African countries: Cameroon, Ethiopia, Malawi, Zaire, Zambia and Zimbabwe. The Red Urine Study Group (undated) compiled a report summarising the diagnostic accuracy of the indirect questionnaires a means of identifying communities (not individuals) with a high risk of urinary schistosomiasis. It also reports on the costs of using the technique and provides a detailed account of the organisational and administrative experiences of distributing and collecting the questionnaires in the seven participating countries, including the degree of collaboration between the different government departments. The Schistosomiasis Manual (1995) compiled by Chitsulo *et al* is intended to give practical information on the use of the method.

2.2.2.1.1 Advantages of the indirect questionnaire

The "indirect questionnaire" approach is an extremely accurate way of identify low risk schools which allows control to be concentrated initially on schools and community with the highest levels of morbidity. It is much less costly than other ways of mapping high risk communities and offers great hope to countries which have not yet identified the communities in which the disease is a high priority. It allows an assessment of the health priorities perceived by the community and which are reported by key informants, i.e. teachers. It allows policy makers to assess the priority that should be given to schistosomiasis control in relation to other health problems in the community (Red Urine Study Group, undated).

2.2.2.1.2 Limitations of the indirect questionnaire

The indirect questionnaire works best where there is a dense network of schools and an infrastructure that can be used for the distribution and collection of the questionnaires. In areas of poor infrastructure therefore, the method may not perform as well. The results obtained may not be typical of the whole community. The method does not identify which children are infected, it merely identifies areas of high prevalence and intensity. Further diagnostic techniques need to be utilised for the identification of individuals who are infected. True prevalence is underestimated as it relies on the respondents' ability to recall the presence of haematuria. In some countries boys and girls may perceive the disease differently or give different answers to questions about it (Chitsulo *et al* 1995).

2.3 SUMMARY

The key criterion for the setting up of a schistosomiasis control programme is the ability to determine who is infected and who is not. Presently, quantitative diagnostic techniques play a central role in urinary schistosomiasis diagnosis. This is due to the usefulness of egg output data provided by the diagnostic methods. With the current overall aim of a control programme being to achieve a reduction of morbidity caused by the infection using chemotherapy through the Primary Health Care System, the development of certain techniques have been promoted. These techniques need to be cost-effective, time-saving and require minimal skilled manpower. Thus the emphasis from the more traditional sedimentation technique has shifted to the filtration technique which remains as the reference technique in comparative diagnostic studies. Because the majority of urinary schistosomiasis-endemic countries are economically poor, several semi-quantitative techniques were introduced, i.e. urine colour scales and chemical reagent strips. The latter have shown to be highly sensitive whilst the former are highly specific. The indirect questionnaire technique which is a qualitative technique has also been shown to be highly specific. The more specific methods are useful for detecting high prevalence areas whilst the more sensitive methods are useful for assessments on an individual level. For a given area both the qualitative and quantitative methods are influenced by prevalence, intensity of infection, human error and quality of available epidemiological data. Thus no single method can be recommended for all studies. Each situation needs to be assessed with regards to finance, staff availability, prevalence and intensity of infection and aim of the programme. A sequence of methods may be required to obtain the relevant information.

CHAPTER 3.

ASSESSMENT OF FIVE TECHNIQUES FOR *SCHISTOSOMA HAEMATOBIUM* DETECTION WITHIN PRIMARY HEALTH CARE

3.1 INTRODUCTION

The main objective of schistosomiasis control is to achieve a direct reduction of morbidity due to infection using chemotherapy through Primary Health Care (PHC) (Savioli & Mott 1989). In order to effectively manage schistosomiasis within a PHC programme, the development of simple, rapid, sensitive, specific and quantitative field detection technique is vitally important for early and easy control (Hoffman *et al* 1979). For the past 20 years, the World Health Organisation has recommended the use of quantitative diagnostic techniques for both epidemiological studies and for the control of schistosomiasis (Savioli *et al* 1990). The quantitative data, i.e. prevalences and intensities, derived from these techniques provides the guidelines for the initial control strategies to be undertaken and are critical for proper evaluation and surveillance (WHO 1983a). Prevalence is the most commonly used community infection index for planning schistosomiasis control (Lengeler 1993). It describes the proportion of the population that is infected at a given time (Dixon 1986). The intensity of infection describes the parasitic worm burden carried by infected individuals and is measured indirectly by counting egg output/10ml urine sample (Rohde 1989). Currently, the quantitative techniques that are available include both direct, e.g. sedimentation, filtration, miracidial hatching, and indirect techniques, e.g. chemical urinalysis strips and urine colour analysis. One important question regarding the different techniques is their comparability in terms of prevalence data. Comparability becomes an important issue when health planners want to use existing data or researchers want to compare different endemic settings (Lengeler 1993).

For many years, counting eggs in urine specimens was the only specific, quantitative diagnostic tool for schistosomiasis diagnosis (Hoffman *et al* 1979). Egg counts can be made using the filtration (Nytrel and Nucleopore filters) and sedimentation techniques and are used to determine the intensity of infection. Intensity of infection has been classified into light and heavy categories of infection where light infections comprise 1-49 eggs/10ml of urine and heavy infections will

comprise 50+ (WHO 1983a). These methods have been widely accepted as the only ones with diagnostic accuracy and are used as the "gold standard" in comparative methodological studies. The definitive diagnosis of the disease is still based on the detection of eggs in a 10ml sample of urine (Sarda *et al* 1985b). Due to the day-to-day variation in egg output of infected subjects (Wilkins & Scott 1978, Savioli *et al* 1990, Gryseels 1996, Lwambo *et al* 1997) two 10ml urine samples should be taken on consecutive days as opposed to a single 10ml urine sample (Savioli *et al* 1990). The main problems incurred with the filtration method include clogging of filters in areas of high intensity (Peters *et al* 1976, Klumpp & Webbe 1983) and the production of false positives due to the adherence of eggs onto the filter itself (Mshinda *et al* 1989). The washing and re-use of filter membranes as a cost-saving measure is a controversial issue (Braun-Munzinger 1986; Klumpp & Southgate 1986; Mott 1988).

The main advantage of microscopy is that it detects infection, irrespective of intensity level (Pugh *et al* 1980) whereas the main disadvantage with methods that involve microscopy (i.e. filtration and sedimentation) is that they are labour-intensive, time consuming and require skilled technicians. They may therefore be better suited to laboratory conditions and may only be good for small sample sizes (Braun-Munzinger & Rohde 1986). They may not be useful for large scale control programmes.

The simple, rapid but indirect diagnosis of *S. haematobium* using chemical urinalysis strips for proteinuria and haematuria was recommended for large scale use in morbidity control programmes (Wilkins *et al* 1979; Mott *et al* 1985b; Savioli & Mott 1989; Lengeler *et al* 1991b). These strips were proposed as an alternative to the more costly and time consuming parasitological methods. Chemical urinalysis strips have been shown to be both sensitive and specific. However, the sensitivity and specificity vary according to the endemicity of the area concerned (Tanner *et al* 1983; Mott *et al* 1985a; Cooppan *et al* 1987; Murare *et al* 1987) whereby the sensitivity is affected by intensity in infection of an individual or community (Mott *et al* 1983; Taylor *et al* 1990; Lengeler *et al* 1993).

There are only a few common causes of haematuria other than schistosomiasis in school-age children, which probably accounts for the high specificity of chemical urinalysis strips (Cooppan *et al* 1987). In comparison, pathological proteinuria can result from several causes thereby reducing the sensitivity and specificity of the proteinuria parameter for schistosomiasis diagnosis. The combined criteria of at least a trace of haematuria and 30mg/100ml or more of protein has been shown to be specific for the detection of individuals with high egg counts (Briggs 1971; Wilkins *et al* 1979; Mott & Cline 1980; Mott *et al* 1985b). Mott *et al* (1985a) warned that these combined criteria may only be useful when screening adults and would not be as effective for

children. Cooppan *et al* (1987) concluded from their study conducted in South Africa that strips would be useful in detecting moderate to severe intensities of infection (>200 ova/10ml). Studies on Pemba Island, Tanzania, obtained high sensitivity and specificity values for samples with 50eggs/10ml (Mott *et al* 1989). However, they also demonstrated the usefulness of strips in areas of low transmission. There are several brands of chemical urinalysis strips on the market and Lengeler *et al* (1993) showed variation in performance between two of them.

The use of urine colour scales has been proposed as an indirect method for the detection of areas of high prevalence (Rutasitara *et al* 1984, Mott 1985a, Sarda *et al* 1986). The method is highly specific (Murare & Taylor 1987; Lwambo *et al* 1997). The use of indirect questionnaires as advocated by Lengler *et al* (1991a) is another highly specific, low cost method and can be valuable in identifying communities with high levels of *S. haematobium*-related morbidity.

Sensitivity, specificity and predictive value are criteria used to assess the diagnostic performance and appropriateness of a technique. These criteria are used to assess the accuracy of a new method by comparing the values obtained for a particular group of subjects against the results obtained for the same group of subjects using a method that is already known to be accurate, i.e. a gold standard. An ideal schistosomiasis test would have a sensitivity (ability of the test to correctly identify all schistosomiasis-positive people) of 100% and at the same time have a specificity (ability of a test to correctly identify all schistosomiasis-negative people) of 100% as well. However, in the field this 'ideal' is not attainable because natural and sampling variation results in an overlap between the observed healthy and diseased people. As the sensitivity of the test increases, the number of schistosomiasis-infected people who are missed by being incorrectly classified as test-negative (false negatives) will decrease. Similarly, as the specificity of a test increases, the number of healthy people who are incorrectly classified as schistosomiasis-infected (false positives) will decrease. The sensitivity of a test may be influenced by variables such as age, sex and other medication the subjects may be taking. Both sensitivity and specificity can be altered by modifying the criteria for the cut-off reading of the test. The cut-off point of a test should give an indication of morbidity and/or mortality. The levels of sensitivity and specificity that are considered acceptable depend on the purpose of the test, and involve weighing the consequences of leaving cases undetected (false negatives) against erroneously classifying healthy persons as diseased (false positives). The number of false positives and negatives that are acceptable would be based on the prevalence of the disease, severity of the disease, advantages and probability of early treatment and the cost of the test. Schistosomiasis is not a life-threatening disease, therefore a few false negative cases, especially light ones, would not create a life-threatening situation. With improved chemotherapy, side-effects have been reduced so that treatment of false positives would not lead to health problems.

However, chemotherapy is one of the major expenses in any schistosomiasis control programme and a high number of false positives will increase costs and is therefore undesirable.

The predictive value of a positive test is defined as the proportion of people with a positive test who actually have the disease while the predictive value of a negative test is the proportion of people with a negative test who actually do not have the disease (Salum *et al* 1996). The predictive value of a test gives an indication of the workload, estimation of the reliability and cost-effectiveness (number false positives and negatives) of a procedure; it provides information on how accurately the test will predict the presence or absence of disease. The predictive value is influenced by the prevalence of the condition in the population. When the prevalence is low the positive predictive value of a test will be low whilst the negative predictive value will be high. Even with a highly sensitive and specific test, if the prevalence of disease is low, the predictive value of a positive test will also be low.

Due to financial and staff constraints and variability in diagnostic potential of schistosomiasis screening techniques, no one method can be recommended for all purposes. Several researchers have recommended certain techniques or combinations of techniques depending on the aim and phase of the particular programme. Tests can be combined in parallel or in series. Parallel testing results in the highest sensitivity but the lowest specificity, whereas serial testing results in the lowest sensitivity but highest specificity (Galen & Gambino 1975). Serial testing has been conducted on Pemba Island (Savioli *et al* 1989b; Lwambo *et al* 1997).

KwaZulu-Natal, South Africa, is in the first phase of a Provincial Helminth Control Programme of which urinary schistosomiasis is a major component. One of the issues that needs to addressed is which diagnostic techniques should be used in the programme. This study was initiated to assess the diagnostic performance of five techniques available in South Africa and determine the best available method to perform the task in this country.

The study contained several aims:

1. to determine prevalence and intensity of *S. haematobium* infection at Mpolweni, Empangeni and Verulam;
2. to compare the prevalence rates as measured by five quantitative, semi-quantitative and qualitative techniques (sedimentation, filtration, urine colour analysis, chemical urinalysis strips and an indirect questionnaire) against each other at Mpolweni, Empangeni and Verulam;
3. to compare the proportion of positive specimens detected by three brands of chemical urinalysis strips at their various cut-off values against filtration - the gold standard;

4. to compare the sensitivity, specificity, predictive values and efficiency of four diagnostic techniques as measured against filtration - the gold standard;
5. to relate the quantity of eggs measured by filtration to the cut-off values as measured by three brands of chemical urinalysis strips at Mpolweni, Empangeni and Verulam;
6. to propose a surveillance strategy suitable for the South African situation.

3.2 MATERIALS AND METHODS

Urine samples were collected from three different areas of unknown prevalence namely Mpolweni Mission (29° 25' S, 30° 29' E, altitude 620m), Empangeni (29° 25' S, 30° 55' E, altitude 156m) and Verulam (29° 38' S, 31° 1 'E, altitude 340m).

The Mpolweni Mission samples were collected randomly from children aged between 6 and 12 years at three schools on 15 March 1996. The total population of children in all the schools was 988, comprising 480 males and 508 females. A total of 322 urine samples was collected with 161 from males and 161 from females. The school teachers and the PHC nurses assisted with the collection. A questionnaire was handed out to all the schools and collected 10 days later.

The Empangeni samples were collected randomly from children aged between 9 and 14 years from six schools on 1 November 1995. The total population of children in all the schools was 947, comprising 508 females and 439 males. A total of 196 urine samples was collected and included 78 males and 117 females. The school teachers and medical staff from Ngwelezana Hospital assisted with the collection. A questionnaire was handed out to all the schools and collected 10 days later.

The Verulam samples were collected randomly from children aged between 6 and 13 years from two schools on 22 June 1996. The total population in all the schools was 308, comprising 184 males and 124 females. A total of 211 urine samples was collected from 111 males and 100 females. The school teachers and members of the Verulam Environmental Health Department assisted with the collection of the urine samples. A questionnaire was handed out to all the schools and collected 10 days later.

In all cases urine samples were collected in 250ml bottles between 11h00 and 14h00. After collection, samples were taken to the laboratory where they were tested using four quantitative and 1 semi-quantitative methods of analysis. These were urine colour scales, chemical

strips, filtration and sedimentation. Each 250ml sample was shaken and three 10ml aliquots were set aside for sedimentation (2) and filtration (1).

3.2.1 Filtration

Filtration of a single 10ml aliquot was conducted on fresh urine samples. This technique was the 'gold standard'. Nucleopore® filters (13mm diameter, 8 μm pore size) were used. Egg counts were recorded as number of eggs/10ml urine samples. Both viable and non-viable eggs were counted (Figures 3.1, 3.2). New filter membranes were used for each urine aliquot. At the end of the study, all the used filter membranes were washed using a technique recommended by Mshinda *et al* (1989) and examined for residual eggs.

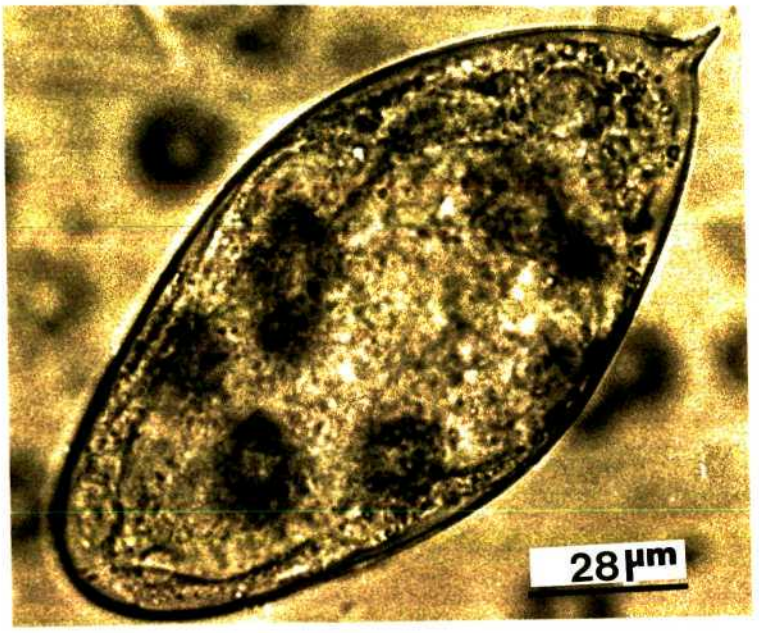


Figure 3.1: A viable *S. haematobium* egg on a Nucleopore® filter membrane.

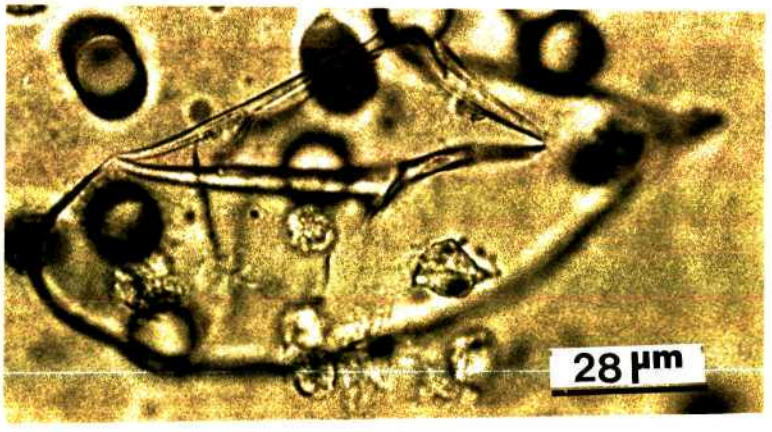


Figure 3.2: A non-viable *S. haematobium* egg on a Nucleopore® filter membrane.

3.2.2 Sedimentation

Two 10ml aliquots from each original sample was analysed microscopically. Samples were preserved with the addition of a few drops of a solution of 10% formalin and 1% merthiolate. Egg counts were recorded as the number of eggs/10ml urine sample.

3.2.3 Chemical urinalysis strips

Chemical strips used included; Lenstrip-5® (Benmore Diagnostics), Ecur-4® (Boehringer Mannheim), Labstix® and Multistix 9® (Ames, Bayer Diagnostics). The strips were dipped into the urine samples and any colour changes on the haematuria and proteinuria parameters were recorded following the manufacturers' instructions. The Ecur-4®and Lenstrip-5® haematuria parameters were recorded as: negative, ca. 5-10 ery/μL, ca. 50 ery/μL, ca. 250 ery/μL and coded as 0, A, B, C respectively. The Labstix® and Multistix 9® haematuria parameter were recorded as: negative, ca. 10 ery/μL, ca. 25 ery/μL, ca. 80 ery/μL, ca. 200 ery/μl and coded as 0, A, B, C, D respectively. The Ecur 4® and Lenstrip-5® proteinuria parameters were recorded as: negative, 30 mg/dl, 100 mg/dl, 500 mg/dl and coded as 0, A, B, C respectively. The Labstix® and Multistix 9® proteinuria parameter were recorded as: negative, 10 mg/dl, 30 mg/dl, 100 mg/dl, 300 mg/dl, 2000 mg/dl and coded as 0, A, B, C, D, E respectively. All samples were analysed within three hours of collection.

3.2.4 Urine colour scales

Four urine colour scales were used namely clear, cloudy yellow, cloudy brown and red. These colour scales were based on those used by Sarda *et al* (1986) and Mott *et al* (1985a) and are depicted in figure 3.3. Colour analysis was conducted by the same person on each occasion.

3.2.5 Questionnaire

An indirect health questionnaire written in Zulu was administered by the teachers. Two questions were directed specifically at schistosomiasis, whilst the rest were general health questions. Do you have blood in your urine? was question 1. Do you have bilharzia? was question 2.

Figure 3.3: Urine colour scales that were used. From left to right - clear (yellow), cloudy yellow, clear (brown), cloudy brown and red.

3.2.6 Ethical considerations

The aim of the study was explained to the teachers. Following the investigation at each study area, infected children were treated by PHC nurses.

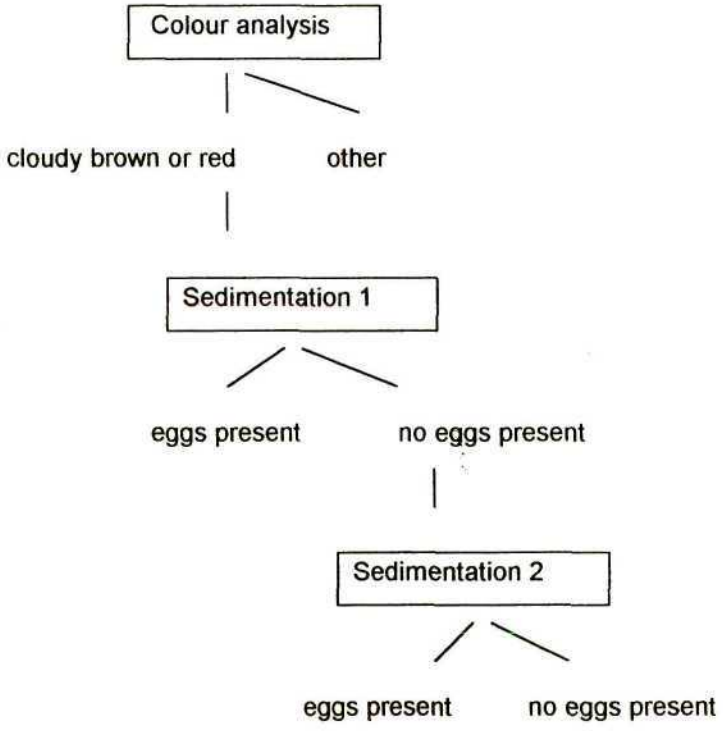
3.2.7 Multiple testing

Sensitivity, specificity, positive and negative predictive values and efficiency were calculated for multiple schistosomiasis diagnostic techniques according to a series of five sets of algorithms. Each set addressed the requirements of different operational constraints, e.g. available finances,

staff and the aim of the study. A single 10ml urine aliquot filtration was used as the gold standard.

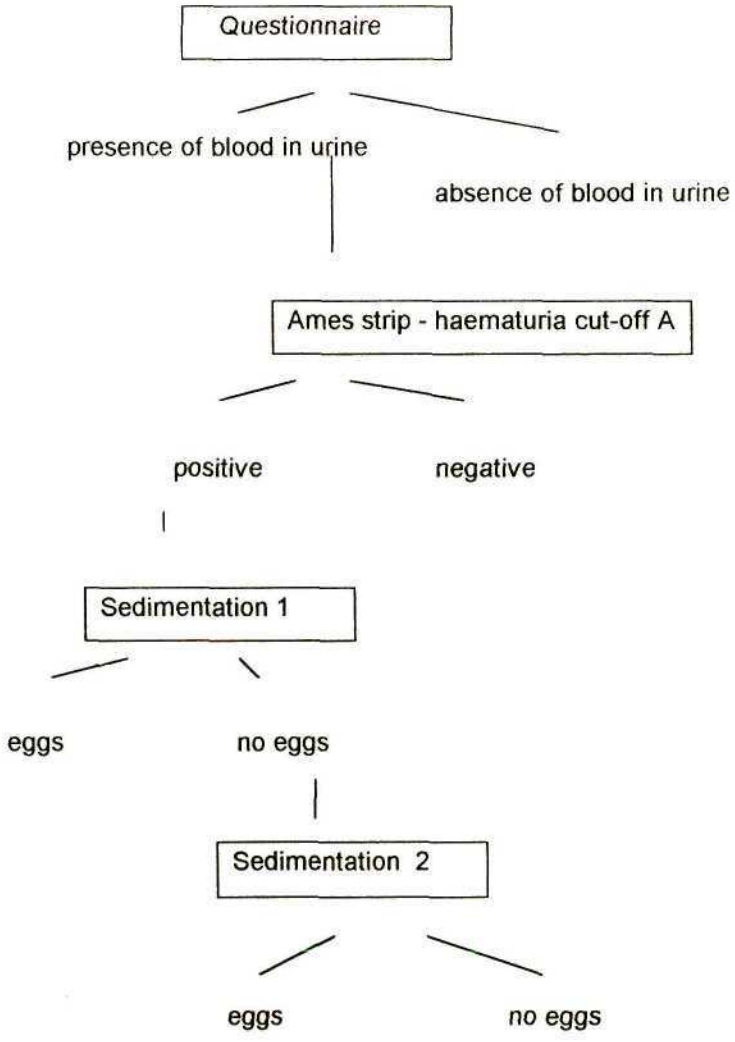
3.2.7.1 Algorithm 1

This set utilises a test sequence of urine colour analysis, sedimentation 1 and sedimentation 2. This set of tests should be used to survey large geographical areas so as to initially identify high prevalence areas and then identify high intensity individuals for treatment.



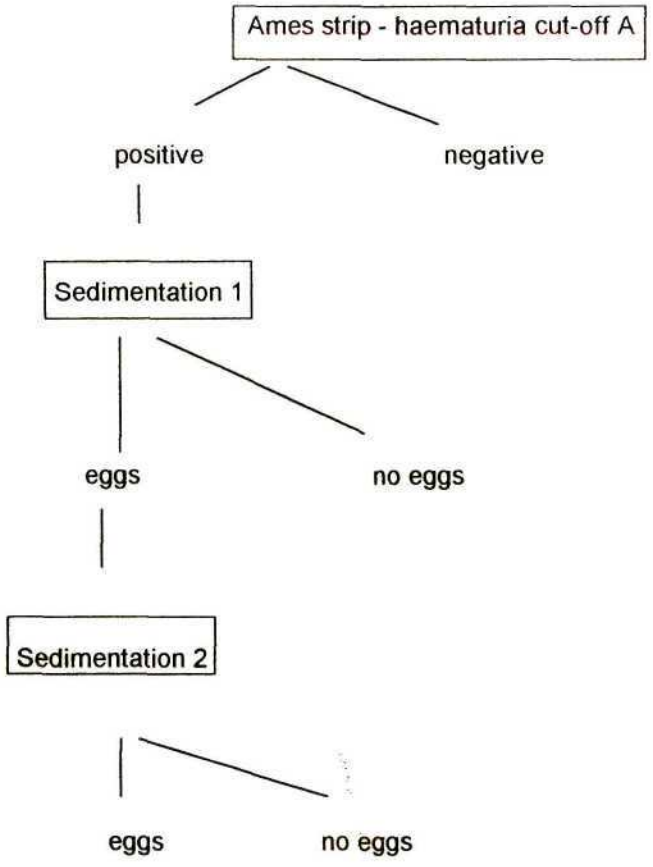
3.2.7.2 Algorithm 2

This set utilises the sequence of indirect questionnaire, chemical urinalysis strips with a haematuria cut-off value of ca. 10ery/μL, microscopy 1 and microscopy 2. These tests should be used to survey large geographical areas so as to initially identify high prevalence areas and then identify high intensity individuals for treatment. This set of tests needs to be conducted in areas where no previous schistosomiasis intervention has occurred.



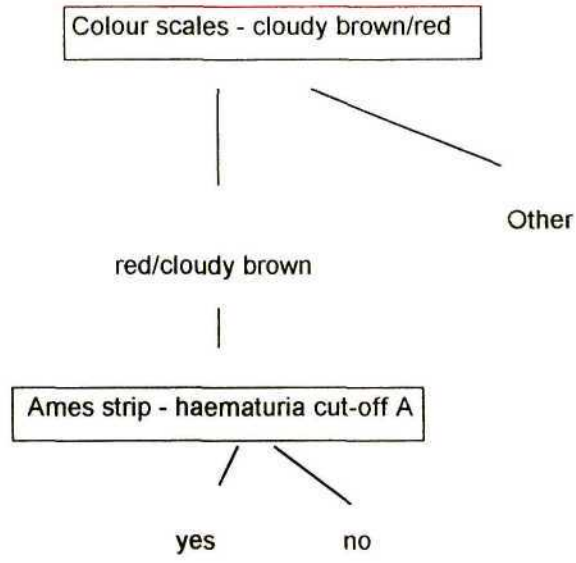
3.2.7.3 Algorithm 3

This set utilises a sequence of chemical urinalysis strips with a haematuria cut-off value of ca. 10ery/μL, microscopy 1 and microscopy 2. This set of tests should be used to survey large or small geographical areas with the aim of obtaining prevalence, intensity and micro-haematuria base-line data for schistosomiasis control.



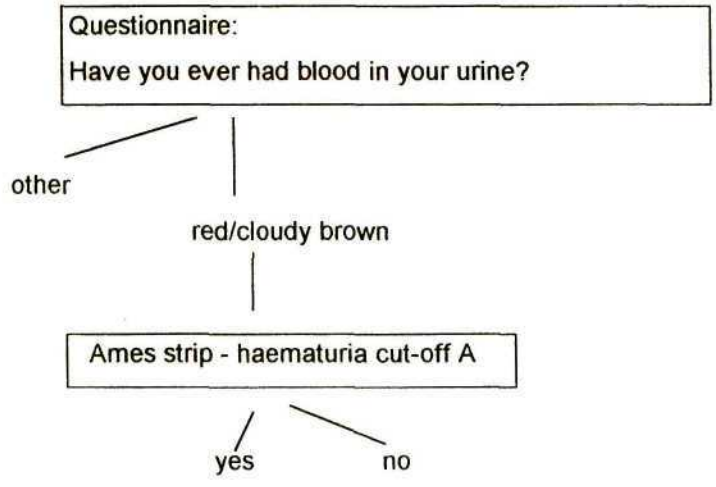
3.2.7.4 Algorithm 4

This set utilises the sequence of urine colour analysis followed by chemical urinalysis strips with a haematuria cut-off value of ca. 10ery/μL. This set of tests should be used to survey large geographical areas so as to initially identify high prevalence areas and then identify high intensity individuals for treatment. This sequence of tests is used if finance and staff are inadequate. This sequence has been used on Pemba Island and is documented by Savioli *et al* (1989b).



3.2.7.5 Algorithm 5

This set utilises a sequence of the indirect questionnaire and chemical urinalysis strips with a haematuria cut-off value of ca. 10ery/μL. This sequence of tests should be used initially to eliminate any areas of low prevalence and then identify infected individuals and treat them. The main use of the sequence would be for chemotherapy purposes in large areas of high prevalence. A sub-sample of the population needs to be taken first using filtration technique. The method is recommended if finances and staff are inadequate. Sarda *et al* (1985) and Lwambo *et al* (1997) suggested this strategy.



3.2.8 Calculations

Data analysis was done using Microsoft Office - Excel, EPI-INFO version 6 and StatGraphics softwares. 2x2 contingency tables and formulae (Table 3.1) outlined by Galen and Gambino (1975) were used to calculate sensitivity, specificity, positive predictive value, negative predictive value and efficiency. The association between the prevalence values of the different techniques at the three study sites was calculated using the X^2 test. McNemar X^2 paired tests of association were used to calculate the proportion of positive samples diagnosed by a technique and measured against the gold standard (Kirkwood 1988). Box and Whisker plots were used to demonstrate the relationship between the number of eggs obtained from a single urine filtration and the cut-off values of chemical urinalysis strips. A single filtration was used as the gold standard. Prevalences calculated for each area were based on gold standard figures. The geometric mean egg count (based on $\log_{10}$ (x+1) transformation to allow for zero counts) calculated for the filtration and sedimentation examinations.

Table 3.1: Gold standard values versus diagnostic test values.

		'Gold standard' reference	
		+	-
Test	+	a	b
result	-	c	d

True positives = a
False positives = b
False negatives = c
True negatives = d
Sensitivity = a / a + c
Specificity = d / b + d
Positive predictive value = a / a + b
Negative predictive value = d / c + d
Efficiency = a + d / total number of samples

3.3 RESULTS

3.3.1 Prevalence and intensity of infection

The prevalence rate measured by five techniques (sedimentation, filtration, chemical urinalysis strips (Lenstrip-5®, Ecur-4®, Ames multistix-9®), urine colour scales and the indirect

questionnaire) at each of the study sites varied significantly (X^2, $p<0.000001$ at all three sites). A summary of prevalence rates using all techniques from Mpolweni, Empangeni and Verulam are presented in Figure 3.4 and Appendix 3.1.

The prevalences of infection at Mpolweni, Empangeni and Verulam were 44.1%, 30.3% and 72.0% respectively when the 'gold standard' technique (filtration) was used. In comparison, the prevalences at Mpolweni, Empangeni and Verulam were 19.9%, 47.2% and 46.9% when the sedimentation technique was used as the gold standard (Appendix 3.1). The geometric means for Mpolweni, Empangeni and Verulam were 44.8 eggs/10ml, 23.6 eggs/10ml and 67.1 eggs/10ml respectively when using the filtration technique.

The micro-haematuria and proteinuria prevalence rates for the three different chemical urinalysis strips varied at each cut-off value. The three brands of urinalysis strips did not differ significantly in their detection of micro-haematuria at the 10erythrocyte/μl cut-off value at Empangeni and Verulam. However, at Mpolweni a significant difference between the Ames multistix-9® and Ecur-4® strip occurred (McNemar X^2, $p<0.005$).

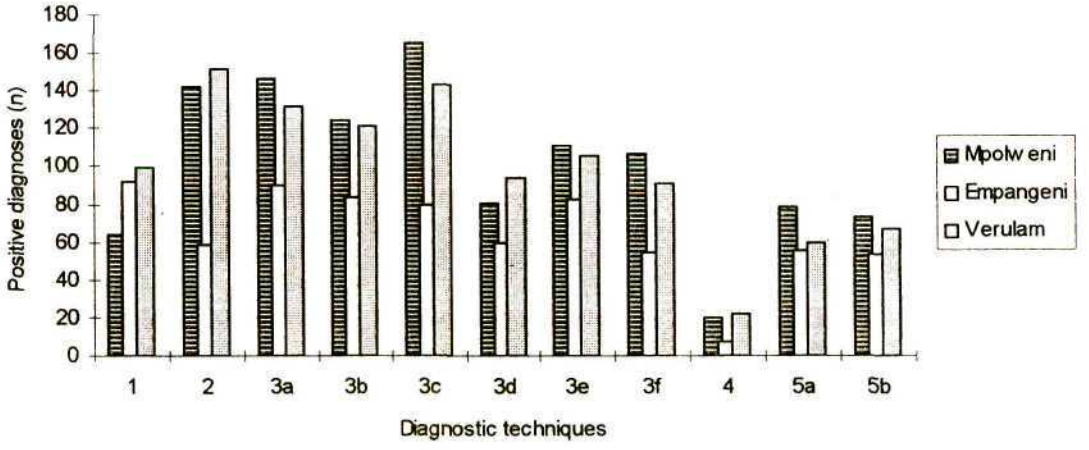


Figure 3.4: Summary of prevalence results given by the qualitative and quantitative *Schistosoma haematobium* diagnostic techniques used at Mpolweni Mission, Empangeni and Verulam. 1=sedimentation; 2=filtration; 3a, b, c= Lenstrip-5®, Ecur-4®, Ames® respectively at haematuria 10ery/μl cut-off; 3d, e, f = Lenstrip-5®, Ecur-4®, Ames® respectively at proteinuria 30mg/dl cut-off ; 4 = colour red; 5a, b =questionnaire with questions - Do you have blood in your urine and do you have bilharzia?, respectively.

3.3.2 COMPARATIVE DATA FOR THE GOLD STANDARD (FILTRATION) VS THE OTHER DIAGNOSTIC TECHNIQUES

The measure of association of the ability of each of the techniques to detect positive samples was measured against the gold standard using McNemar's paired X^2 test. The diagnostic techniques and their cut-off values that did not differ significantly from the 'gold standard' are tabulated in Table 3.2. The 10ery/μl cut-off value for the haematuria parameter for the three brands of strips was the only one that did not differ to the 'gold standard' at the three sites. The Ecur-4® strip was the only strip that did not differ significantly at all three sites for the proteinuria parameter at a cut-off value of 30mg/dl. Both the indirect questionnaire and urine colour analysis differed significantly at Verulam but not at Mpolweni or Empangeni.

Table 3.2: Comparative data highlighting the diagnostic techniques with their cut-off values and parameters for Mpolweni Mission, Empangeni and Verulam that did not differ significantly in their ability to detect positive samples when measured against filtration (McNemar X^2 , $p<0.005$).

	Mpolweni Mission	Empangeni	Verulam
Lenstrip-5®			
Haematuria	10 ery/μl and 50 ery/μl	10 ery/μl, 50 ery/μl, 250 ery/μl	10 ery/μl
Proteinuria		30mg/dl, 100mg/dl	
Ecur-4®			
Haematuria	10 ery/μl and 50 ery/μl	10 ery/μl, 50 ery/μl, 250 ery/μl	10 ery/μl
Proteinuria	30mg/dl	30mg/dl	30mg/dl
Ames®			
Haematuria	10 ery/μl	10 ery/μl, 25 ery/μl, 80 ery/μl,	10 ery/μl
Proteinuria		200 ery/μl	
	30mg/dl	30mg/dl	10mg/dl
Questionnaire	Questions 1 & 2	Questions 1 & 2	none
Colour	Colour 2 (cloudy yellow)	Colour 3 (cloudy brown)	none

3.3.3 SENSITIVITY, SPECIFICITY, PREDICTIVE VALUES (POSITIVE AND NEGATIVE) AND EFFICIENCY

The performances of the four *S. haematobium* diagnostic techniques were measured against the gold standard (filtration). Details of their diagnostic performance values are given in appendices 3.2a,b,c, 3.3a,b,c, 3.4 and 3.5. The term "diagnostic performance" has been developed to represent the combined terms of sensitivity, specificity, positive and negative predictive and efficiency values of a particular technique.

3.3.3.1 Sedimentation

The diagnostic performance of the sedimentation technique varied between study sites (Figure 3.5). The greatest variation occurred between sensitivity, specificity and the positive predictive values. In comparison, little variation occurred between efficiency and the negative predictive values. Sensitivity ranged from 41.5% to 96.6%, specificity from 46.4% to 97.2%, positive predictive value from 41.5% to 98.1%, negative predictive value from 60.5% to 67.8% and efficiency from 68.2% to 81.0%.

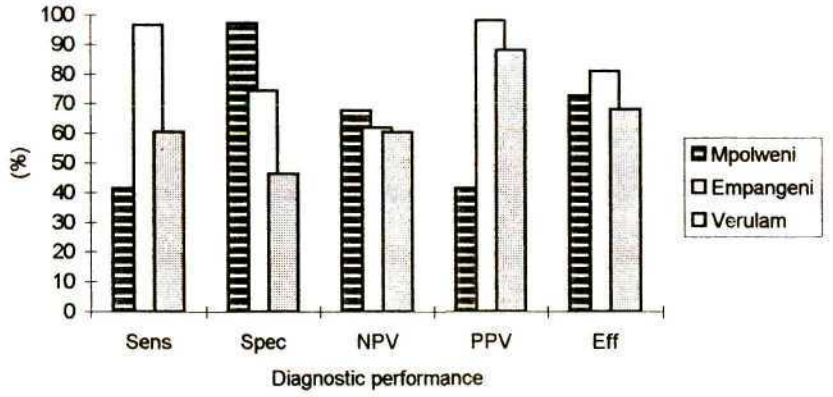


Figure 3.5: Diagnostic performance values of duplicate sedimentations taken from single samples at Mpolweni, Empangeni and Verulam. Sens = sensitivity (%), spec = specificity (%), NPV = negative predictive value (%), PPV = positive predictive value (%) and Eff = efficiency (%).

3.3.3.2 Chemical Urinalysis strips

3.3.3.2.1 Haematuria

Variation in sensitivity, specificity, positive and negative predictive values and efficiency occurred amongst the three strips and at the different haematuria cut-off levels at all three test localities (Figures 3.6, 3.7 and 3.8).

3.3.3.2.1.1 Mpolweni Mission (Figure 3.6)

The diagnostic performance ranges for all three brands of strips, inclusive of all the cut-off values, was from 52.8% to 80.3% for sensitivity, from 71.7% to 97.8% for specificity, from 72.4% to 82.2% for negative predictive value and from 69.1% to 94.9% for positive predictive value. The sensitivity, negative predictive and efficiency values were highest at the 10 ery/μL cut-off point. At this cut-off point the greatest diagnostic variation between the three strips occurred between specificity and positive predictive values. The Ames Labstix® had the highest sensitivity of the three brands of strips at the 10 ery/μL cut-off point (80.3%). Overall, greatest efficiency occurred with the Ecur-4® strip at the 10 ery/μL cut-off point (82.9%).

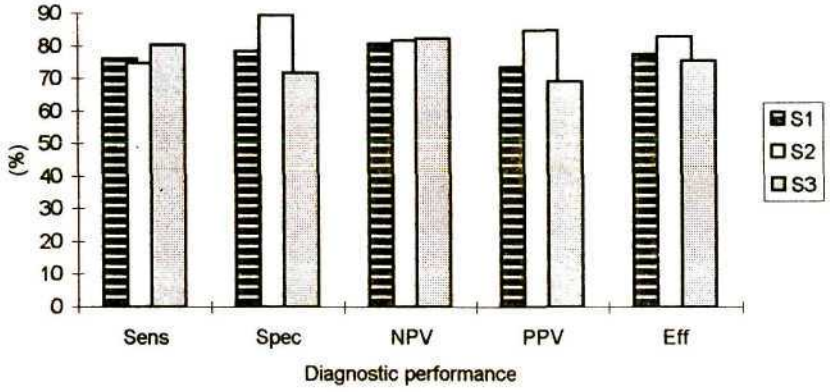


Figure 3.6: Comparative diagnostic performance data for three brands of chemical urinalysis strips at the haematuria 10 ery/μL cut-off value at Mpolweni. Sens = sensitivity (%), spec = specificity (%), NPV = negative predictive value (%), PPV = Positive predictive value (%) and eff = efficiency (%). S1 = Lenstrip-5®, S2 = Ecur-4®, S3 = Ames Multistix-9® and Labstix®.

3.3.3.2.1.2 Empangeni (Figure 3.7)

The diagnostic performance ranges for all three brands of strips, inclusive of all the cut-off values, was 50.8% to 93.2% for sensitivity, 73.5% to 90.4% for specificity, 80.9% to 96.4% for

the negative predictive value and 60.0% to 69.8% for the positive predictive value. The sensitivity, negative predictive and efficiency values were highest at the 10 ery/μL cut-off point. At this cut-off point the diagnostic performance of the three strips did not vary greatly. Ecur-4® had the greatest sensitivity of the three brands of strips at the 10 ery/μL cut-off point (93.2%). Overall, greatest efficiency occurred with the Ecur-4® strip at the 10 ery/μL cut-off point (82.9%).

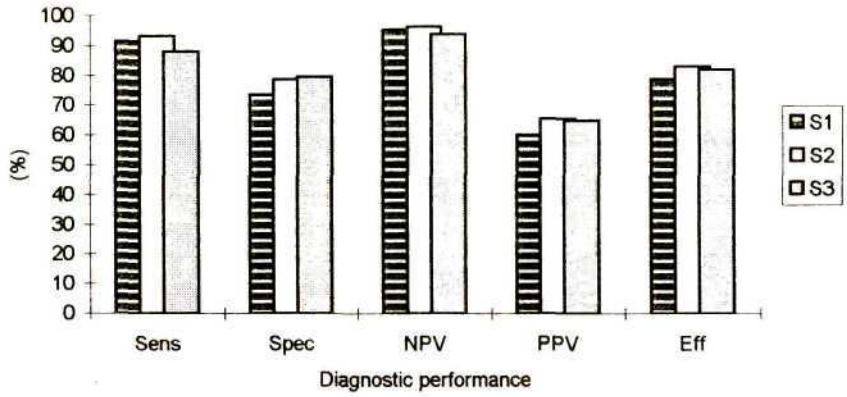


Figure 3.7: Comparative diagnostic performance data for three brands of chemical urinalysis strips at haematuria the 10 ery/μL cut-off value at Empangeni. Sens = sensitivity (%), spec = specificity (%), NPV = negative predictive value (%), PPV = Positive predictive value (%) and eff = efficiency (%). S1 = Lenstrip-5®, S2 = Ecur-4®, S3 = Ames Multistix-9® and Labstix®.

3.3.3.2.1.3 Verulam (Figure 3.8)

The diagnostic performance ranges for all three brands of strips, inclusive of all the cut-off values, was 57.9% to 82.9% for sensitivity, 71.2% to 96.6% for specificity, 47.1% to 61.8% for the negative predictive value and 88.1% to 97.8% for the positive predictive value. The sensitivity, negative predictive and efficiency values were highest at the 10 ery/μL cut-off point. At this cut-off point the area of greatest diagnostic variation between the three strips occurred within specificity. Of the three strips, Labstix® had the highest sensitivity at the 10 ery/μL cut-off point (82.9%). Overall, greatest efficiency occurred with the Lenstrip-5®strip at the 10 ery/μL cut-off point (80.1%).

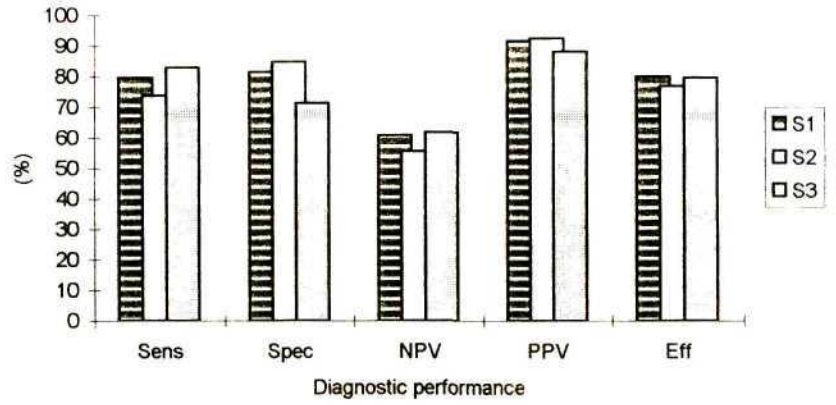


Figure 3.8: Comparative diagnostic performance data for three brands of chemical urinalysis strips at haematuria 10 ery/μL cut-off value at Verulam. Sens = sensitivity (%), spec = specificity (%), NPV = negative predictive value (%), PPV = Positive predictive value (%) and eff = efficiency (%). S1 = Lenstrip-5®, S2 = Ecur-4®, S3 = Ames Multistix-9® and Labstix®.

3.3.3.2.2 Proteinuria

Variation in sensitivity, specificity, positive and negative predictive values and efficiency occurred amongst the three strips tested and at the different proteinuria cut-off levels at all three test localities (Figures 3.9, 3.10 and 3.11). Sensitivity for all three chemical strips was greatest at cut-off point of 30 mg/dl.

3.3.3.2.2.1 Mpolweni (Figure 3.9)

The diagnostic performance ranges for the three strip brands, inclusive of all the cut-off values, was 3.5% to 92.9% for sensitivity, 41.7% to 100.0% for specificity, 56.8% to 88.2% for the negative predictive value and 3.5% to 100.0% for the positive predictive value. Sensitivity, negative predictive value and efficiency were greatest at a cut-off point of 30 mg/dl. Of the three strips, Ecur-4® had the greatest sensitivity (61.9%) and efficiency (79.2%) at cut-off point 30 mg/dl.

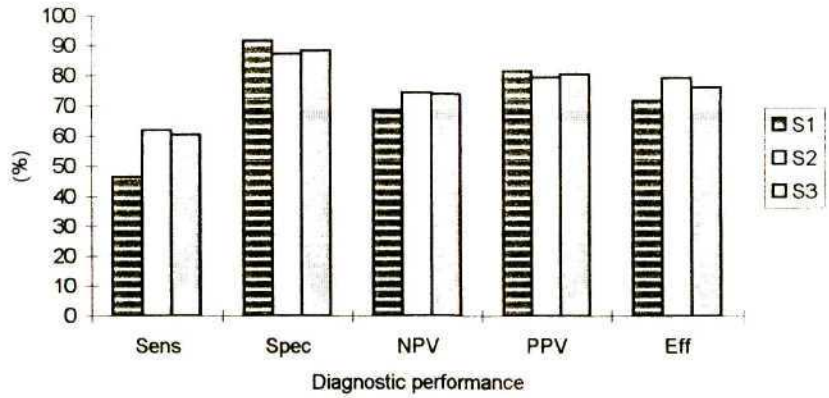


Figure 3.9: Comparative diagnostic performance data for three brands of chemical urinalysis strips at proteinuria 30 mg/dl cut-off value at Mpolweni. Sens = sensitivity (%), spec = specificity (%), NPV = negative predictive value (%), PPV = positive predictive value (%) and eff = efficiency (%). S1 = Lenstrip-5®, S2 = Ecur-4®, S3 = Ames Multistix-9® and Labstix®.

3.3.3.2.2.2 Empangeni (Figure 3.10)

The diagnostic performance ranges for the three strip brands, inclusive of all the cut-off values, was 0.0% to 89.8% for sensitivity, 50.7% to 99.3% for specificity, 69.6% to 92.0 for the negative predictive value and 0.0% to 57.1% for the positive predictive value. Sensitivity, negative predictive value and efficiency were highest at a cut-off point of 30 mg/dl. Of the three strips, Ecur-4® had the greatest sensitivity at cut-off point 30 mg/dl (72.99%) whilst overall best efficiency occurred with the Labstix® strip (57.4%).

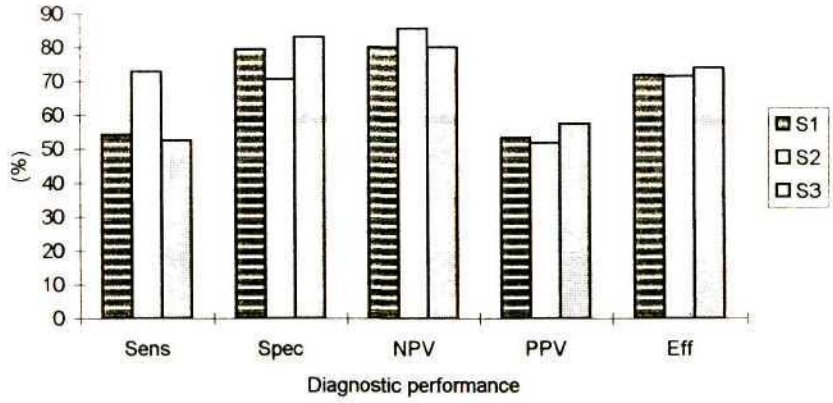


Figure 3.10: Comparative diagnostic performance data for three brands of chemical urinalysis strips at proteinuria 30 mg/dl cut-off value at Empangeni. Sens = sensitivity (%), spec = specificity (%), NPV = negative predictive value (%), PPV = positive predictive value (%) and eff = efficiency (%). S1 = Lenstrip-5®, S2 = Ecur-4®, S3 = Ames Multistix-9® and Labstix®.

3.3.3.2.2.3 Verulam (Figure 3.11)

The diagnostic performance ranges for the three strip brands, inclusive of all the cut-off values, was 3.3% to 75.0% for sensitivity, 70.6% to 100.0% for specificity, 28.6% to 85.7% for the negative predictive value and 50.0% to 100.0% for the positive predictive value. Of the three strips, Ecur-4® had the highest sensitivity (72.9%) and efficiency (70.6%) at a cut-off point of 30 mg/dl.

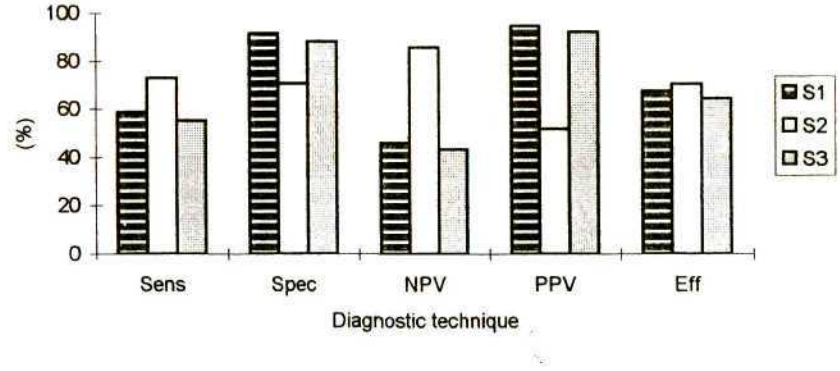


Figure 3.11: Comparative diagnostic performance data for three brands of chemical urinalysis strips at proteinuria 30 mg/dl cut-off value at Verulam. Sens = sensitivity (%), spec = specificity (%), NPV = negative predictive value (%), PPV = Positive predictive value (%) and eff = efficiency (%). S1 = Lenstrip-5®, S2 = Ecur-4®, S3 = Ames Multistix-9® and Labstix®.

3.3.3.3 Urine Colour Scales (Figure 3.12)

Sensitivity of the colours red, cloudy brown and cloudy yellow ranged from 5.1% - 83.3%. Sensitivity was highest at Mpolweni for the colour scale - cloudy brown (83%). Specificity was high at all three sites for the colour red (99.4%, 97.1%, 98.3%). Positive predictive values ranged from 42.3% to 98.3% whilst negative predictive values ranged from 30.7% to 93.3%. Overall best efficiency occurred within the colour category cloudy yellow at Mpolweni (75.7%).

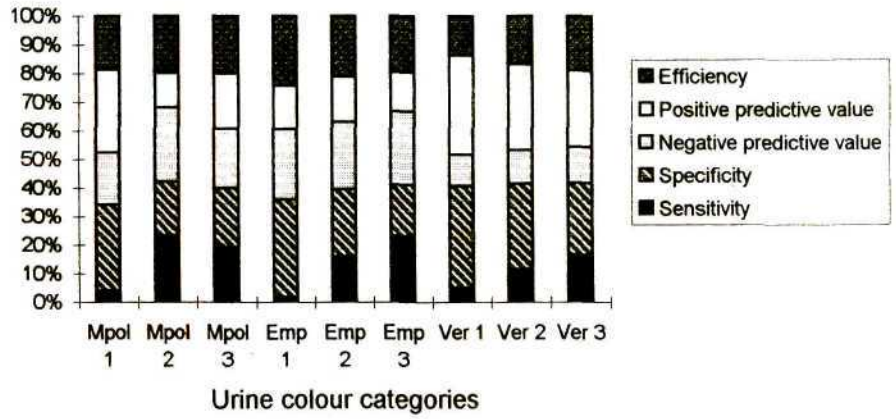


Figure 3.12: Diagnostic performance of urine colour scales at Mpolweni, Empangeni and Verulam. 1 = red, 2 = cloudy brown and 3 = cloudy yellow.

3.3.3.4 Indirect Questionnaire (Figure 3.13)

Sensitivity for both schistosomiasis questions was low and ranged from 46.7% to 62.7%. Specificity was higher and ranged from 80.4%-93.2%. Verulam had a very low negative predictive value (38.7%), i.e. high number of false positives but a high positive predictive value (95%). Question 2 had highest efficiency at Empangeni (80.4%).

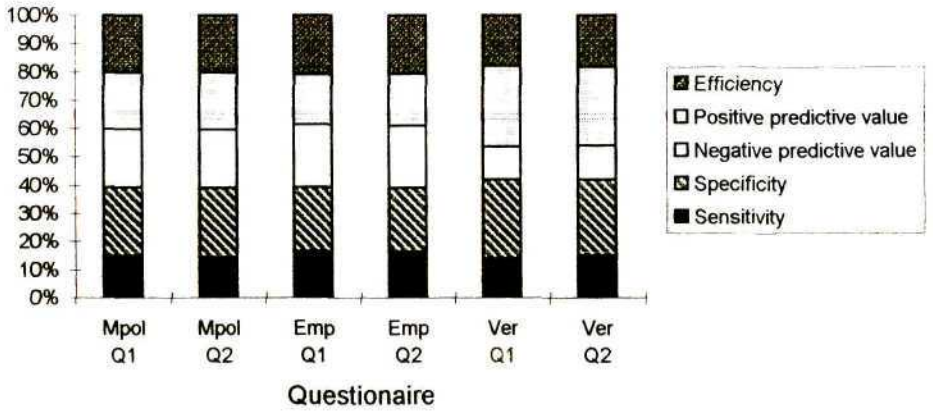


Figure 3.12: Diagnostic performance of questions (1) and (2) at Mpolweni, Empangeni and Verulam where (1) represents the question - Do you have blood in your urine?, and (2) - Do you have bilharzia?

3.3.3.5 Haematuria diagnostic performance ranges

Haematuria "diagnostic performance ranges" were developed for each of the techniques. These ranges included the combined "diagnostic performance" values for three areas of varying prevalence and intensity rates of disease. The "diagnostic ranges" indicate the upper and lower "diagnostic performance" values that a particular technique achieved in areas of prevalence rates between 30% to 72% and intensity rates between 24eggs/10ml to 67eggs/10ml.

The "diagnostic performance ranges" varied for each technique and for the various cut-off values (Table 3.3). The "range length", i.e. upper and lower limit varied for each technique. Sedimentation and the colour cloudy brown had broad sensitivity range lengths. Ames strips at a 10ery/μl cut-off value for the haematuria parameter had the narrowest sensitivity range. The positive predictive value (PPV) ranges for all three strips was broad at a 10ery/μl cut-off value, thereby indicating a potential large number of false positive values. However, the PPV range for all three strips narrowed at the next cut-off value, i.e. 25ery/μl and 50ery/μl, indicating a fewer number of false positive values.

Table 3.3: Diagnostic performance ranges including sensitivity, specificity, positive predictive value and efficiency. The ranges include results from all three study sites.

Diagnostic techniques	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Efficiency (%)
Sedimentation	42 - 97	46 - 97	42 - 98	68 - 81
Lenstrip-5®				
10 ery/µl	76 - 92	73 - 81	60 - 92	77 - 80
50 ery/µl	69 - 76	86 - 92	70 - 94	76 - 83
Ecur-4®				
10 ery/µl	74 - 93	79 - 89	66 - 93	77 - 83
50 ery/µl	69 - 83	84 - 93	69 - 96	76 - 84
Ames Labstix® & Multistix-9®				
10 ery/µl	80 - 88	71 - 79	65 - 88	76 - 82
25 ery/µl	59 - 69	86 - 96	68 - 95	75 - 80
Colour red	5 - 14	98 - 99	43 - 96	37 - 69
Colour cloudy brown	38 - 83	67 - 98	42 - 98	55 - 72
Question 1	47 - 63	80 - 93	65 - 95	60 - 79
Question 2	49 - 63	83 - 89	67 - 93	61 - 80

"Diagnostic performance ranges" were established using combined values from the three strip brands at each of the study sites, i.e. Mpolweni, Empangeni and Verulam, to determine if varying prevalence and intensity rates influenced them (Table 3.4). Filtration was the 'gold standard' used at Mpolweni, Empangeni and Verulam. As a comparison at Empangeni, sedimentation was used as the 'gold standard' due to the poor performance of the filtration results at this site (Appendix 3.6). The sensitivity diagnostic performance ranges were similar at the three sites whilst the positive predictive value (PPV) ranges varied considerably. Thus highlighting the influence of changes in prevalence and intensity rates on the PPV and not on sensitivity values.

Table 3.4: Diagnostic performance ranges for three combined chemical urinalysis strip brands at a cut-off value of 10ery/μl at three sites of varying prevalence of disease, i.e. Mpolweni, Empangeni and Verulam. Filtration was the 'gold standard' for Mpolweni, Empangeni and Verulam. As a comparison, sedimentation was the 'gold standard' for Empangeni.

10ery/μl	Mpolweni Filtration	Empangeni Microscopy	Empangeni Filtration	Verulam Filtration
Sensitivity (%)	75-80	75-79	88-93	74-83
Specificity (%)	72-89	84-89	74-79	71-85
Positive predictive value (%)	69-85	81-87	60-66	88-93
Efficiency (%)	76-83	82-85	79-83	77-80

3.3.4 COMPARSION OF THREE BRANDS OF CHEMICAL URINALYSIS STRIPS

3.3.4.1 Ability to detect haematuria

The proportion of specimens found positive, i.e. containing at least micro-haematuria, between the three methods were compared for each of the three study sites. None of the strips were significantly better at detecting micro-haematuria at either Empangeni and Verulam. However, at Mpolweni the Ames strip was significantly better at detecting the presence of micro-haematuria than Ecur-4 (McNemar X^2 , $p<0.005$).

3.3.4.2 Relationship of cut-off values to number of eggs/10ml detected

A correlation between the detection of the number of eggs/10ml urine sample by filtration and the haematuria parameter of strips was demonstrated at Mpolweni Mission, Empangeni and Verulam (Appendices 3.7a,b,c). Overlap between the two measurements occurred in all three strips. Egg detection ranges for each brand of strip and their cut-off values are given in Tables 3.5, 3.6.

Table 3.5: Comparative data for three chemical urinalysis strip brands and their cut-off values with the corresponding egg range as detected by filtration (combined Mpolweni Mission, Empangeni and Verulam data). The data was obtained from Box and Whisker plots given in appendices 3.7a,b,c.

Strip brand and parameter	Corresponding egg output ranges (no. eggs)
Lenstrip-5®	
10 ery/µl	0 - 1680
50 ery/µl	0 - 900
250 ery/µl	20 - 5000
Ecur-4®	
10 ery/µl	0 - 330
50 ery/µl	0 - 275
250 ery/µl	22 - 5000
Ames multistix-9®, Labstix®	
10 ery/µl	0 - 450
25 ery/µl	0 - 450
80 ery/µl	0 - 200
200 ery/µl	50 - 5000

Table 3.6: Comparative geometric mean egg data at the various cut-off values for the haematuria parameter for three brands of chemical urinalysis strips at three study sites of varying prevalence and intensity rates of disease.

	Mpolweni	Empangeni	Verulam
Lenstrip-5®			
10 ery/µl	14.7	5.7	25.5
50 ery/µl	16.5	1.4	18.9
250 ery/µl	157.1	50.3	192.9
Ecur-4®			
10 ery/µl	8.9	5.5	1.59
50 ery/µl	21.7	13.6	24.2
250 ery/µl	165.6	47.3	227.8

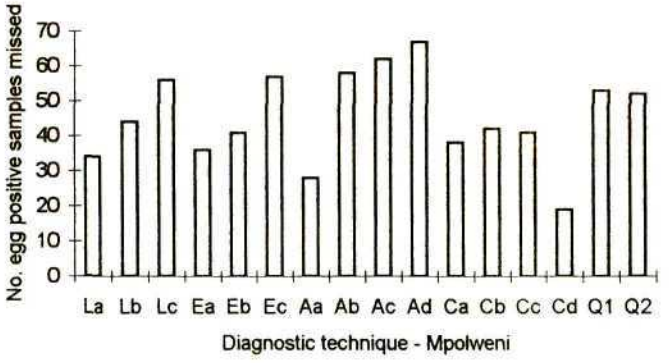
Table 3.6: continued

Ames Labstix® or Multistix-9®			
10 ery/µl	13.7	10.8	13.9
25 ery/µl	35.1	26.3	63.1
80 ery/µl	11.1	14.3	13.2
200 ery/µl	212.4	61.1	204.8

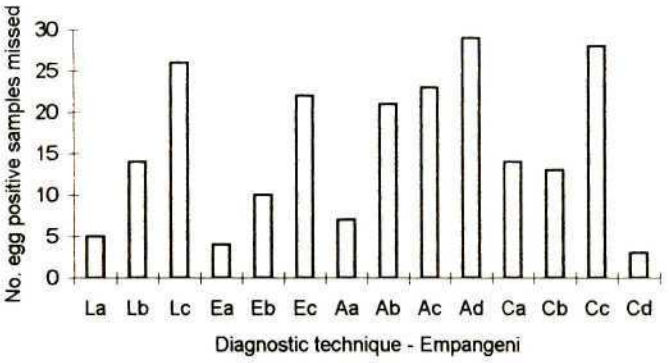
3.3.5 Relationship between samples diagnosed positive by the chemical urinalysis strips, urine colour scales and indirect questionnaire and the gold standard (filtration).

The gold standard, i.e. filtration, uses the presence/absence of eggs in a urine sample to diagnose the person as diseased or not, whereas the indirect methods use the presence or absence of haematuria. When the indirect methods' ability to diagnose diseased persons was compared to the gold standard, none of the former methods had the same detection rate. Many samples containing eggs were mis-diagnosed by the indirect techniques. The number of samples missed varied between techniques and their cut-off values (Figures 3.13A, 3.13B and 3.13C).

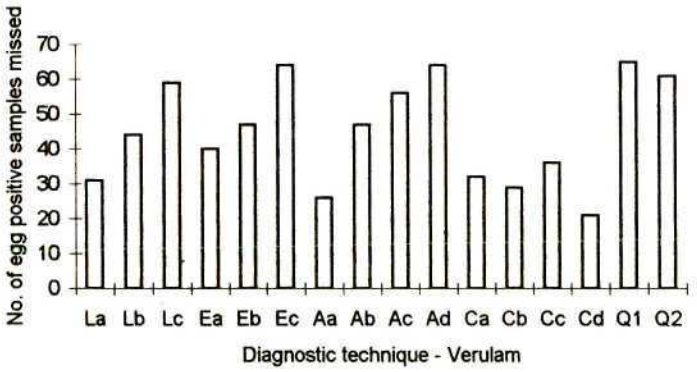
A



B



C



Figures 3.11 A, B, C: Comparative data of the number of egg positive samples missed at Mpolweni (3.11A), Empangeni (3.11B) and Verulam (3.11C) for three chemical urinalysis strips measured at various haematuria cut-off values, urine colour analysis measured at three cut-off values and an indirect questionnaire using two different questions. All the techniques were measured against the filtration technique. La, Lb, Lc = Lenstrip-5 - 10 ery/μL, 50 ery/μL, 250 ery/μL respectively; Ea, Eb, Ec = Ecur-4 - 10 ery/μL, 50 ery/μL, 250 ery/μL respectively; Aa, Ab, Ac = Ames - 10 ery/μL, 25 ery/μL, 80 ery/μL 200 ery/μL respectively; Ca, Cb, Cc, Cd = urine colours clear, cloudy yellow, cloudy brown, red respectively; Q1, Q2 = questionnaire where (1) represents, Do you have blood in your urine?, and (2) - Do you have bilharzia?

3.3.6 Algorithms

The diagnostic performance of the five tested algorithms varied at Mpolweni, Empangeni and Verulam.

Algorithm 4 (urine colour analysis, chemical urinalysis strips) had the highest sensitivity whilst Algorithm 2 (questionnaire, chemical urinalysis strips, sedimentation 1 & 2) had the highest specificity and positive predictive value at Mpolweni (Table 3.7).

Table 3.7: Diagnostic performance of algorithms 1 to 5 for Mpolweni.

Mpolweni	Sensitivity	Specificity	PPV	NPV	Efficiency
Algorithm 1	24.6	99.4	97.2	62.6	66.5
Algorithm 2	21.1	100	100	61.6	65.2
Algorithm 3	38.7	98.3	94.8	67.0	72.0
Algorithm 4	42.2	95	86.9	67.6	71.7
Algorithm 5	34.5	96.1	87.5	65.0	68.9

Algorithm 3 (chemical reagent strips, sedimentation 1 & 2) had the greatest sensitivity and efficiency whilst algorithm 2 (questionnaire, chemical urinalysis strips, microscopy 1& 2) had the greatest specificity and positive predictive value at Empangeni (Table 3.9).

Table 3.8: Diagnostic performance of algorithms 1 to 5 for Empangeni.

Empangeni	Sensitivity	Specificity	PPV	NPV	Efficiency
Algorithm 1	54.2	88.9	68.1	81.8	78.5
Algorithm 2	59.3	91.2	74.5	83.8	81.5
Algorithm 3	88.1	87.5	75.4	94.4	87.7
Algorithm 4	52.5	90.4	70.5	81.5	78.9
Algorithm 5	59.3	91.2	74.5	83.7	81.5

Algorithm 3 (chemical haematuria strips, microscopy 1 & 2) had the greatest sensitivity and efficiency for Verulam (Table 3.10). Algorithms 1 (urine colour analysis, sedimentation 1 & 2) 2 (questionnaire, chemical urinalysis strips, sedimentation 1 & 2) and 4 (urine colour analysis, chemical urinalysis strips) had high specificity and positive predictive values.

Table 3.9: Diagnostic performance of algorithms 1 to 5 for Verulam.

Verulam	Sensitivity	Specificity	PPV	NPV	Efficiency
Algorithm 1	29.6	98.3	97.8	35.2	48.8
Algorithm 2	26.9	98.3	97.6	34.3	46.9
Algorithm 3	56.6	93.2	95.6	45.6	66.8
Algorithm 4	37.5	98.3	98.2	37.9	54.5
Algorithm 5	33.6	96.6	96.2	36.1	51.2

3.3.7 Diagnostic techniques cost analysis

The costs of all equipment and consumables required for individual techniques were tabulated in Table 3.10. Capital equipment required to set up a laboratory was priced as well as the disposable equipment required to conduct a particular test on a patient. Costs were accurate on February 1998.

Table 3.10: Cost and equipment analysis five schistosomiasis diagnostic techniques. Start-up costs and cost per patient are included.

Schistosomiasis Diagnostic Technique	Quantity	Amount	Start up price	Cost per person
MICROSCOPY				
microscope	1	R6670.00		
slides	50	R9.50		R0.19
coverslips	100	R14.00		R0.14
centrifuge				
centrifuge tubes				
sample bottles 40ml	500	R230.00		R0.46
Honey jar sample bottles 250ml	280	R274.40		R0.98
formalin	2.5	R25.00		R0.01
gloves	100	R33.50		R0.34
Pasteur pipettes 150mm	250	R20.35		R0.8
Merthiolate	1Kg	R2062.00		R0.2
Total			**R6852.00**	**R3.21**

Table 3.10: Continued.

Schistosomiasis Diagnostic Technique	Quantity	Amount	Start up price	Cost per person
FILTRATION				
microscope		R6670.00		
Swinnex filter holders (13mm)	10	R250.00		R25.00
(25mm)	12	R479.00		R40.00
filter membrane (13mm 8.0μm pore)	100	R255.00		R2.55
(25mm 8.0μm pore)	100	R294.00		R2.94
filter membrane (13mm 12.0μm pore)	100	R408.00		R4.08
(25mm 12.0μm pore)	100	R469.00		R4.69
Glass slides (26mm x 76mm)	50	R9.50		R0.19
cover slips	100	R14.00		R0.14
flat tweezers	1	R92.00		R92.00
sample bottles 40ml	500	R230.00		R0.46
Honey jar sample bottles 250ml	280	R274.00		R0.98
syringe - 20ml (12)		R182.00		R15.00
Millipore Schistosomiasis kit -		R3406.00		
Swinnex 13mm filter holders (4)				
Syringe 20ml (2)				
Flat tweezers (1)				
Millipore filters 13mm 12.0μm pore size (500)				
Total			**R7194.00**	**R4.32**
CHEMICAL URINALYSIS STRIPS				
Honey jar sample bottles 250ml	280	R274.40		R0.98
Ecur -4® strip (Boehringer Mannheim)	50	R53.75		R1.10
Labstix® strip (Ames Bayer)	100	R130.20		R1.30
Urichek 5N® (Promex Diagnostics)*	100	R25.00		R0.25
Total				**R1.23**

Table 3.10: Continued.

Schistosomiasis Diagnostic Technique	Quantity	Amount	Start up price	Cost per person
URINE COLOUR ANALYSIS				
Honey jar sample bottles 250ml	280	R274.40		R0.98
Total				**R0.98**
INDIRECT QUESTIONNAIRE				
Questionnaire copies		R0.20		R0.20
Total				**R0.20**

Note*: Urichek 5N® (Promex Diagnostics) has replaced Lenstrip-5 ® (Benmore Diagnostics). It is currently the strip used by the Department of Health.

3.4 DISCUSSION

The comparability of community prevalence rates measured by different diagnostic techniques is important and has implications for schistosomiasis control. This study demonstrated significant differences in the techniques' determination of prevalence rates at each of the study sites. This finding complicates comparisons of prevalence rates over time where the methods used may change. It also complicates comparison of community prevalence rates measured at varying geographical locations where several diagnostic techniques have been used. A good association between the three chemical urinalysis strips at certain cut-off values and the gold standard was obtained for all three study sites. This finding is in agreement with studies in Zimbabwe (Taylor *et al* 1990), Ethiopia (Jemaneh *et al* 1994), Zambia (Siziya *et al* 1993) and Tanzania (Lengeler *et al* 1993). On average, the three chemical urinalysis strips obtained higher prevalence rates than filtration. This may have resulted from the fact that only a single urine filtration was conducted. Previous studies have shown that a single filtration is not very sensitive and probably not adequate for the detection of light infections (Taylor *et al* 1990).

The two methods recognised as 'gold standards' in comparative diagnostic studies, i.e. filtration and sedimentation, differed significantly in their ability to determine prevalence and intensity rates. It has been demonstrated that infection data based on the examination of single urine samples using the sedimentation technique underestimates prevalence rates (Anonymous 1987, Webbe & El Hak 1990). It is estimated that urine sedimentation is about 20% less sensitive than

urine filtration and in areas of low prevalence, urine sedimentation may be 35% less sensitive (Webbe & El Hak 1990; N'Goran *et al* 1997). Prevalence values were consistently lower for Mpolweni and Verulam when sedimentation was used. However, the reverse was recorded at Empangeni. This was a result of error in the filtration technique which resulted in the loss of 16% (32/196) of sample results. Thus, in the case of Empangeni, sedimentation may provide a more accurate reflection of the prevalence rate in the area than filtration.

The inability of the two 'gold standard' methods to determine comparative prevalence and intensity rates may result from the fact that egg counts were used. This use of egg counts has limitations. Gryseels (1996) highlighted the problems encountered when using egg counts. These included day-to-day fluctuations in egg output on an individual level, unavoidable inaccuracies with common egg counting techniques, time of collection and concentration of urine samples; errors in microscopy and recording. Also, the distribution of *S. haematobium* eggs in urine samples is not homogenous even if thoroughly mixed so that the use of egg counts as a measure of worm burden remains questionable. These fluctuations in egg output complicate the collection of data for control purposes as it is often not financially feasible or there is insufficient time to collect more than single urine sample from each study subject.

WHO (1983b) set threshold prevalence values for estimating risk of infection in children aged 7-14yrs. Prevalences of > 50% in children were considered likely to indicate high risk of schistosomiasis, prevalences of 25-50% indicated moderate risk and prevalences of <25% were at low risk. Prevalence levels obtained using the 'gold standard' indicated that the children at Verulam were at high risk of schistosomiasis whilst those at Mpolweni and Empangeni were at low to moderate risk. When comparing intensity values where a count of >50 eggs/10ml of urine is taken as the threshold for risk of *S. haematobium* morbidity (WHO 1985b), both Verulam and Mpolweni are areas that need to be targeted for chemotherapy.

The diagnostic performance values, i.e. sensitivity, specificity, positive predictive and efficiency, calculated for the four techniques varied amongst themselves and between sampling sites. This led to the development of diagnostic performance ranges for each of the techniques incorporating the wide prevalence range. These ranges were affected by the prevalence and intensity of infection and the type of technique and cut-off value that was used. Other factors that may influence the diagnostic potential of a technique have been elaborated upon in Chapter 2. The sensitivity of the combined brands of urinalysis strips for each of the three sites did not vary greatly. Thus, highlighting the fact that prevalence does not affect the sensitivity range of a technique. However, in comparison, the positive predictive values of the combined strips at each of the three sites varied greatly. Verulam which has the highest prevalence and intensity

rates also had the highest positive predictive value. Both the sensitivity range and the positive predictive values were high thus indicating a low number of false positive values and a more cost effective method.

The haematuria parameter of the chemical urinalysis strips at 10ery/μl cut-off value were highly sensitive. The sedimentation technique was moderately sensitive whilst the indirect questionnaire and urine colour analysis was highly specific. WHO (1983a) set a guideline haematuria parameter value of 80% sensitivity and 85% specificity for chemical urinalysis strips in children 14 years or younger who have > 50 eggs/10ml urine. The diagnostic performances ranges for all three brands of strips and sedimentation fell within the 80% to 85% range. As there was no significant difference between the three brands of strips in their detection of the proportion of positives, the individual strip brand diagnostic ranges were combined. The sensitivity range for the chemical urinalysis strip haematuria parameter at a 10ery/μl cut-off value were comparable to those obtained in Nigeria (Mafe 1997) and Pemba Island, Tanzania (Lwambo *et al* 1997). The specificity range was comparable to those obtained in Pemba (Lwambo *et al* 1997) and Zambia (Mott *et al* 1985b).

The specificity diagnostic ranges for urine colour analysis for the colour red were comparable to those of other studies (Mott *et al* 1985b; Sarda *et al* 1985; Lwambo *et al* 1997). However, in comparison the sensitivity range was lower and not comparable to other studies. A large number of urine samples contained eggs but did not have visible haematuria. This indicates minimal pathology of the urinary tract and bladder. The indirect questionnaire specificity diagnostic range was high and comparable to Sarda *et al* (1985). In contrast the sensitivity range was low and not comparable to other studies (Mott *et al* 1985b; Sarda *et al* 1985; Lwambo *et al* 1997). This could be a result of firstly, the subjects' inability to accurately recall the presence of haematuria in their urine, secondly, the manner in which the questionnaires were administered may have resulted in subjects lying in order to prevent embarrassment and thirdly, the low community prevalence and intensity rates that were recorded.

Certain cut-off values of techniques may be better indicators of morbidity than others and would therefore be useful for control programmes. In order to obtain the optimum cut-off value of a technique e.g. chemical urinalysis strips it is important to relate the haematuria parameter cut-off value with egg output figures and morbidity. For this study the egg output values were tabulated for each of the haematuria parameter cut-off values. However, the relationship between morbidity and egg output was not established. Previous studies in Egypt (Abdel-Wahab *et al* 1992) and Sudan (Feldmeier *et al* 1982) indicated that dysuria, haematuria, renal, urinary bladder and liver lesions all occurred in children with light infections (1-10 eggs/10ml) and

increased in heavy infections (>100eggs/10ml). In contrast, Cooppan *et al* (1986) conducted a study in South Africa and found that these symptoms occurred in children with moderate (201-1200eggs/10ml) and heavy infections (>1200eggs/10ml). It has been postulated that the degree of pathology encountered in this country is different to those of other endemic countries. This is an area at which future research needs to be targeted. If Cooppan *et al's* (1986) egg numbers are used, all strips should then be read at a 10ery/μl value.

The intensity of infection, as demonstrated by geometric mean egg value, correlated positively with the cut-off values of the haematuria parameters of the chemical urinalysis strips. In areas of overall lower intensity rates, the same cut-off value of the haematuria parameter corresponded with less eggs than in areas of higher intensity rates. These findings correspond with those of Sarda *et al* (1985), Mott *et al* (1985b) and Murare & Taylor (1987).

None of the cut-off values for the haematuria and proteinuria parameters of the chemical urinalysis strips, the urine colour analysis or questionnaire ensured that all positive samples were identified when compared to the total number of positive samples diagnosed by filtration. However, the number of false negatives and the total number of missed positive samples were lower for the haematuria parameter at the 10ery/μl cut-off value. The cloudy brown urine samples frequently contained eggs and should be recorded as a positive as is the colour red.

The sensitivity range for the proteinuria parameter at 30mg/dl cut-off was large (47% - 93%) and less consistent than for haematuria which is recognised as the better diagnostic criterion (Murare & Taylor 1987; Lengeler *et al* 1991a; Lengeler *et al* 1993). Mott *et al* (1985a) commented on the difficulty of reading the colour change of the protein parameter on some strips. This problem was also experienced during this study and it may have led to the reduced sensitivity. Due to the poor consistency of the results, proteinuria would not be a recommended screening criterion for schistosomiasis control. The use of proteinuria is no longer recommended as its presence is of post-renal origin and therefore not a sign of any impaired renal function which could be due to schistosomiasis (Gryseels 1989).

Nucleopore filters (13mm diameter and pore size of 8μm) are reputed to be prone to clogging but this was not experienced here, perhaps due to the small number of high intensity infections found. Whilst conducting this study, the filters were not washed and re-used, however they were washed at a later stage following the method suggested by Mshinda *et al* (1989). The washing technique was successful with 99% (475/476) of the filters being egg-free. However, this procedure was time consuming and would be impractical for large control programmes where staff and equipment were limited.

Due to the great variability in the diagnostic performances of various techniques a schistosomiasis control programme may often utilise several methods over a period of time. Some of these may be highly sensitive whilst others may be highly specific. Several different tests administered in series have been recommended for different prevalence conditions (Cooppan *et al* 1987; Savioli *et al* 1989; Lwambo *et al* 1997). The questionnaire method followed by urine colour analysis are highly specific and may be used as initial tests to isolate high prevalence areas. Later, the chemical urinalysis strips or filtration may be used to identify infected individuals and provide intensity data.

Diagnostic techniques administered in series have a low sensitivity value. The five algorithms that were tested mostly showed low sensitivity values that ranged from 21.1% to 59.3%. Specificity ranged from 87.5% to 100%, positive predictive values from 68.1% to 100% and efficiency from 46.9% to 87.7%. The following algorithms had high specificity values at all three sampling sites: algorithm 1, i.e. urine colour analysis, sedimentation 1 & 2; algorithm 2, i.e. indirect questionnaire, chemical urinalysis strips, sedimentation 1 & 2. At Verulam algorithm 4, i.e. urine colour analysis, chemical urinalysis strips had a high specificity value. This finding correlates with those suggestions of Lwambo *et al* (1997) and results of Savioli *et al* (1989b). At Verulam and Empangeni algorithm 3, i.e. chemical reagent strips followed by sedimentation 1 & 2 had the highest sensitivity and efficiency values. At Mpolweni, algorithm 4, i.e. urine colour scales followed by chemical urinalysis strips had the highest sensitivity value.

Better sensitivity values would have been obtained if tests had been run in parallel as opposed to in series. Financial and staff constraints limit the use of parallel testing. However in order to measure the impact of programmes, prevalence and intensity of infection rates are used as indicators of change and should be monitored (Korte & Mott 1989). Thus, parallel testing is used for the collection of base-line data and the assessment of current programmes. Chemical urinalysis strips are used for the assessment of prevalence rates using micro-haematuria data whilst sedimentation or filtration are used for the collection of intensity data.

Lack of finances tends to be a limiting factor in schistosomiasis control. Good financial planning is required prior to the establishment of a programme to ensure adequate funding for its full duration. Schistosomiasis diagnostic techniques have been assessed with regards to sensitivity, specificity, positive predictive value, negative predictive value and efficiency. However, at the end of the day, the technique most likely to be adopted will be the cheaper one. Ideally, a balance between cost and diagnostic performance should be aimed for. Excluding capital costs, i.e. microscopes and centrifuges, the cost per/sample for the sedimentation technique is R3.21, filtration technique R4.32, chemical urinalysis strips vary from R1.23 to R2.28, urine colour

analysis 98c and the indirect questionnaire 20c. The cost of techniques used in series depends on the techniques used. For the algorithm of urine colour analysis, sedimentation 1 & 2 the cost is R7.38; indirect questionnaire, chemical urinalysis strips, sedimentation 1 & 2 the cost is R7.83; urine colour analysis, chemical urinalysis strips the cost is R2.21 and chemical urinalysis strips followed by sedimentation 1 & 2 the cost is R7.63. If filtration replaced sedimentation, the costs would increase.

3.5 Recommendations and implications

The variability in results obtained from the five different diagnostic techniques has implications for the planning and assessment of control programmes and for comparative studies. Due to this variability in the techniques results the researcher must carefully assess what data needs to be collected and what will be done with the data, prior to the initiation of any control programme. No single technique can be recommended for all situations. However, certain techniques are better suited to situations of analysis than others. Some techniques are highly specific, e.g. urine colour analysis whilst others are highly sensitive, e.g. filtration. Sensitive techniques are better suited for making positive diagnoses at an individual level and obtaining intensity data whilst specific tests are used to eliminate large areas of low prevalence, thereby identifying areas of high prevalence. Assumptions cannot be made regarding the diagnostic performance of techniques in areas of varying schistosomiasis prevalence and geographic location. However, the indirect diagnostic techniques' performance does increase as prevalence increases.

When using a diagnostic test, the operator needs to be aware that each test has its own diagnostic potential range. Differing brands of diagnostic techniques have variations in performance. There are several factors that affect the choice of a diagnostic technique which need to be taken note of prior to choosing one. These include the location, scale and aim of the programme, available finances, prevalence of the disease, skills and quantity of staff available to analyse the samples, type of population and whether any prior interventions have occurred. Factors affecting the diagnostic performance of a technique include age and sex ratios of the sampled population, prevalence and intensity of the disease, number of urine samples that are taken from each individual, time of day that the samples were taken, amount of bladder content that is sampled and whether or not individuals have received prior treatment.

The choice of a particular diagnostic technique is a difficult one. Mott (1987) outlines a few criteria that affect the choice. These include the scale of the programme, available finances, location of diagnosis, i.e. laboratory or field, the questions that a particular technique is expected to answer and finally the aims of programme. Braun-Munzinger (1986) added several others to the list: viz. reproducibility, acceptability both to populations studied and to technicians, the cost

of equipment and disposable materials, the amount of skill and time required per test from the field worker, and the amenability of the test to quality control. The selection of any technique in a large-scale control programme is based on a number of choices. The diagnostic technique must maximise efficiency at low cost. The cost of schistosomiasis control projects is important because the endemic countries generally contain a large infected population but the countries are poor (Hoffman et al 1979). Where resources are limited, they should be concentrated in areas where infection is highest. Therefore, quick ways are needed for identifying communities which should be given priority when interventions are planned. Mott (1987) highlights the ways in which this can be achieved: firstly, a large number of persons may be examined each day to reduce logistical problems; secondly, persons being examined should spend a minimum amount of time obtaining the specimen container, providing the specimen, receiving the result of the examination and being treated afterwards; thirdly, all equipment should be available and easily replaced if required; fourthly, the technique must be sufficiently sensitive and reproducible to detect all heavily infected persons and a high proportion of those who are lightly infected.

When deciding on a diagnostic technique the researcher needs to consider the comparative diagnostic performance of the various techniques. However, the ultimate choice will probably be dictated by available funding.

CHAPTER 4.

URINARY SCHISTOSOMIASIS PILOT CONTROL PROGRAMME AT MPOLWENI MISSION

- A CASE-STUDY

4.1 INTRODUCTION

4.1.1 MOTIVATION FOR THE STUDY

In 1995 the teachers of Mpolweni Mission in the KwaZulu-Natal Midlands recognised a urinary schistosomiasis problem amongst the community's school children. A total of 125 children were tested by the school health team nurses. All were diagnosed positive. These results prompted the nurses to request the assistance of the Environmental Health Officers (EHOs) of the Provincial Health Department, Pietermaritzburg. At the time, the EHOs and I were conducting a joint freshwater snail survey for the schistosomiasis intermediate hosts, *Bulinus africanus* and *Biomphalaria pfeifferi* in the area. Because of my involvement with schistosomiasis, I was approached to assist the EHOs with the Mpolweni Mission urinary schistosomiasis problem. A meeting was held on 5 March 1996 at the Provincial Health Department in Pietermartizburg to establish a plan of action. All people who could be of assistance were invited. These included Chief Mgadi, school teachers, the school nurse team and mobile unit team, EHOs and Umgeni Water representatives. Attendance at the meeting was good. I believe this was due to the community representatives recognising the problem and being happy to co-operate with others to search for a solution. Everybody at the meeting recognised that a joint effort was required to resolve the schistosomiasis problem. At the meeting it was decided that a holistic pilot control programme based on the World Health Organisation Guidelines (WHO 1985b) would be initiated. The programme was to have three phases: 1) assessment and planning; 2) attack; and 3) monitoring. It would be based within the schools as that was where the problem was recognised and co-operation and infrastructure would be good.

4.1.2 AIMS OF THE STUDY

The four aims of the study were:

1. The maintenance and analysis of the cost effectiveness and efficiency of a holistic schistosomiasis control programme at Mpolweni Mission;
2. Utilisation of existing resources in the community to address the schistosomiasis problem in both the long and short terms;
3. Empowerment of the community with skills and knowledge via a health education programme;
4. Development of a working schistosomiasis control model based on the proposed National Health Plan (Ntsaluba 1995) for future reference by various organisations involved in control programmes.

4.1.3 COMMUNITY STRUCTURE

Mpolweni Mission (29° 25' S, 30° 29' E, altitude 620m) is situated along the banks of the Mpolweni River, 30km north-west of Pietermaritzburg on the Greytown road. It comprises approximately 950 households and has an estimated population of 10 000. The community is characterised by poor infrastructure and low income. Part of the community has electricity and pit-latrines of varying quality; very few have telephones whilst nobody has access to piped water. Everyone relies on the Mpolweni River for drinking, washing and recreational activities, e.g. fishing and swimming. Cattle roam the area and also utilise the river for drinking. This perennial river has a varying width of 3-10m and two bridges and a weir which alter the flow of the river. During the study, the flow rate at the weir fluctuated from 0.08m^3/sec (October 1995) to 9.56m^3/sec (Feb 1996). There are three schools namely; Kanyisani lower primary (grade 1 - std 2), Bathengi higher primary (std 3 - std 5) and High school (std 6 - std 10) with an overall attendance of 1200. A Primary Health Care Mobile Unit visits the area from Pietermaritzburg once a month and a school health team visits the schools about once a year. All other medical treatment is obtained from Wartburg or Pietermaritzburg, 22km and 30km away respectively.

The community leaders incorporate both an "traditional" and a "new" committee titled the Reconstruction and Development Forum. The "traditional" committee comprises Chief Mgadi and his induna's whilst the "new" committee comprises the chairperson Mr M. Mkhize, secretary Mr R. Hadebe and treasurer Mr A Mkhize. The Forum is divided into several sub-committees, each dealing with different issues. The channels of authority are very strict with final decisions being made by and documents signed by the secretary, chairperson and treasurer. New

proposals need to be presented to the whole Forum and if accepted, subsequent dealings are conducted with the relevant sub-committee. Forum meetings are held once a month.

4.2 METHODOLOGY

The pilot control programme was divided into several intervention steps. These various steps were based on the WHO (1985b) guidelines and comprised:

Step 1. Assessment and Planning Phase

Base-line data were collected enabling an assessment of the situation and the formulation of plans for intervention. This step was conducted over a short period of time, i.e. a few months, and included:

- the collection of urine samples to obtain infection prevalence and intensity data for the school children;
- a snail survey to locate the presence of the freshwater intermediate hosts of urinary schistosomiasis (*Bulinus africanus*) and screen them for infection;
- a water contact study to ascertain the community's water-related activities and the location of contact sites. Together with snail distribution data, this will serve to establish the location of transmission sites.

Step 2. Attack Phase

Various strategies for the reduction of the prevalence and intensity of the disease were initiated. This step was conducted over a short period of time, i.e. a few months, and included:

- targeted or blanket chemotherapy;
- the establishment of education programmes;
- molluscicide the contact sites along the river with Bayluscide®;
- the building and installation of structures to help the community avoid direct contact with the water, e.g. bridges, swimming pools and washing blocks.

Step 3. Maintenance Phase

Follow-up programmes were initiated with the aim of maintaining the reduced prevalence and intensity levels of schistosomiasis. This step was to be conducted over a longer period of time, i.e. a few years, and included:

- education programmes;
- snail surveys and screening of snails;
- urine collection and analysis;
- targeted chemotherapy using Praziquantel (Biltricide®).

4.2.1 STEP ONE - Assessment and planning phase

The collection of base-line data comprised three main parts, namely; 1) urine collection; 2) snail surveys; and 3) water contact studies.

Urine samples were collected and analysed using several techniques to obtain prevalence and intensity data. These techniques included an indirect questionnaire, filtration, urine colour scales, chemical reagent strips and sedimentation. More detailed methodology of the various techniques has been given in Chapter 3. The presence of *Schistosoma haematobium* eggs was determined by quantitative urinary egg counts by means of the filtration technique. Urinary micro-haematuria was determined using Lenstrip-5® (Benmore Diagnostics) for the initial survey. It was recorded as ca. 10 (erythrocytes/μL), ca. 50 (erythrocytes/μL) and ca. 250 (erythrocytes/μL) following the manufacturers instructions.

At the initial meeting of 5 March 1996, dates were set for urine collections, chemotherapy and the beginning of an education programme. It was decided that a meeting should be held with the teachers to discuss the urine collection strategy, explain the schistosomiasis life-cycle and offer them the opportunity to ask any questions they may have. For the duration of the whole programme it was very important to keep people notified, provide channels of communication, answer questions and ask the people involved what their opinions were. If the programme was to succeed, the community needed to be involved at all times.

The meeting was well supported by the teachers. The need for community interaction was emphasised and the teachers' role throughout the programme was explained. They were told they would be updated with the results and future interventions. Their advice regarding the situation was requested and they were told their advice would always be welcomed. The teachers themselves had concerns regarding the programme. They were anxious to know what would be done in the long-term as they were afraid of being used as "guinea pigs". In the past researchers and "do-gooders" had come to the community, collected their data, presented solutions to problems they recognised and left. The teachers were afraid this would happen again. They struggled to understand the schistosomiasis life-cycle and did not seem to identify with the miracidial and cercarial stages. This highlighted two problems namely the lack of adequate educational material and the possible lack of understanding we may encounter amongst the community and the Mpolweni school pupils. On the whole they welcomed the programme and offered their support.

4.2.1.1 URINE COLLECTION

The aim of the urine collection process was to measure the proportion of the population aged between 6yrs and 20yrs that was infected. Due to time and staff constraints, a representative sample of 322 children, 161 males and 161 females, was chosen for diagnosis prior to the collection day. They were chosen randomly from class lists obtained earlier.

A team of nurses went out to the schools on the 15 March 1996. Questionnaires were handed to the teachers on the same day (Appendix 4.8). The nurses labelled bottles whilst the teachers gathered the selected children. The nurses briefed the children as to why they had been chosen and what they were expected to do with the urine samples. They highlighted the importance of the study and urged the children not to exchange urine samples. Each designated child was handed a bottle and total bladder contents were collected between 11am and 2pm. Samples were collected and the names of the targeted children were ticked off on the lists as the bottles were returned. Bottles were taken to the University of Natal, Pietermaritzburg (Department of Zoology and Entomology) for analysis.

There was resistance amongst the older children (15yrs to 20yrs) to co-operate as they were embarrassed to be seen carrying urine samples especially those that were a red colour. This lack of co-operation is contrary to Pugh's (1980) experience where subjects with intense infections were more willing to come forward for analysis and subsequent treatment. Perhaps to alleviate the "embarrassment factor", non-transparent or coloured bottles should be used for older children. It may even be better to standardise the bottles used for all ages of children so as not to draw attention to the different bottles.

During an assessment meeting following the urine collection day, the nurses highlighted their dissatisfaction with the labelling of bottles on the day. They suggested that bottles should be prior-coded to ensure conformity of coding and a hastier pace on the collection day. One problem with prior-labelled bottles is poor school attendance. Several children chosen for screening purposes were not at school on collection day and others had to be selected. However, an advantage to prior-labelled bottles would be that all labels would be legible.

4.2.1.1.1 RESULTS

The overall prevalence of urinary schistosomiasis amongst the school children at Mpolweni Mission schools was 45.7% (Table 4.1). The geometric mean was 48.2 eggs/10ml thereby classifying the infections as light (1-200 ova/10ml)(Cooppan et al 1987). Urinary blood was present in all urinary schistosomiasis positive children (Table 4.1) but a greater number had severe haematuria (ca. 250 ery/μL n=93) than ca. 5-10 ery/μL(n=35). Only 14% of the surveyed children answered "yes" to the question, "Do you have blood in your urine?"

Table 4.1: Summary of qualitative and quantitative base-line data on urinary schistosomiasis using different methods.

Prevalence (Filtration)	45.7% (147/322)
Intensity (Geometric mean - filtration)	44.8 eggs/10ml
Micro-haematuria (Lenstrip-5®) ca. 5-10 ery/μL ca. 50 ery/μL ca. 250 ery/μL	 45.7% (n=147/322) 34.8% (n=112/322) 28.9% (n=93/322)
Questionnaire "Do you have blood in your urine?"	14% answered "yes" (252/1756)

4.2.1.2 SNAIL SURVEY

A freshwater snail survey for the schistosomiasis intermediate hosts was conducted in the Mpolweni area jointly with the Umgeni Water Pollution Prevention Unit on 16 January 1996. Only the west bank of the Mpolweni River was surveyed as this is the side the community inhabits and uses. Collection points included those that were accessible via bridges, roads or areas not too densely vegetated or steeply banked. Visible snails were collected using forceps whilst a metal scoop net (3 mm mesh size) was used to collect snails from vegetation along the bank at points that were less accessible. The snails were taken to the University laboratory where they were screened for patent schistosome infections.

4.2.1.2.1 RESULTS

Snails were collected from nine points along the river (Figure 4.1). In total only a small number of *Bulinus africanus* was collected at a few points along the river. Conditions along the river were not conducive to snail habitats with the river banks being steep and densely vegetated with sedges. Accessibility was limited in several areas so that snails may have been missed. Both *B. africanus* (55) and *Lymnaea columella* (25) were collected. Nine *B. africanus* (16.4%) harboured infections from three trematode families namely Schistosomatidae (22%), Strigeidae (11%) and Echinostomatidae (66.6%). Snails harbouring patent Schistosomatidae infections were found at collection points 1, 5, 6 and 7 (Figure 4.1). Snails tended to aggregate in pools created by structures such as the weir and the two bridges. This is important for control purposes and needs to be considered when structures are in the planning phase. Careful design could reduce the number and extent of suitable habitats created.

4.2.1.3 WATER CONTACT STUDY

Water contact studies are useful for determining the human activities that involve a high risk of exposure to schistosomiasis in areas where it is endemic. They also serve as a means of assessing various alternatives to direct water contact, e.g. installation of piped water, which may reduce human exposure to cercariae (Dalton & Pole 1978). There were several objectives to the present water contact study. The first was to provide preliminary information regarding the human activities that were responsible for placing people in contact with schistosome-infested water. The second was to establish the precise locations where these activities occurred. The final objective was to correlate the location of these activities with those where snails with patent infections had been collected. This would allow transmission sites along the river to be located so that appropriate control strategies could be implemented.

4.2.1.3.1 EXPERIMENTAL DESIGN

4.2.1.3.1.1 OBSERVATION POINTS

The west bank of the Mpolweni River was surveyed for signs of water contact, e.g. clearing and flattening of vegetation, presence of mud steps, bridges and foot paths. A total of 26 water contact points was observed, of which 15 were used for the water contact study. The 15 points

(marked A-O in Figure 4.1) covered the whole stretch of the river running parallel to the main axis of the community. It was the maximum number of points that the available number of observers could cope with during the observation period.

Eight observers (two per point) were placed at four of the 15 points. These four points were termed "home-bases". The observers could see several other points from their home-bases. They were requested to stay at the home-base but to also monitor the other points from a distance. Home-base 1 included observation points A, B and C; 2 included D and E; 3 included F and 4 included G, H, I, J, K, L, M, N and O (Figure 4.1). Home-base 3 was situated at the weir which was known to be a heavily utilised position on the river. Home-base 4 included many observation points which were not all visible from one point and required the observers to walk several kilometres. These contact points were far from the community and it was thought they may not be heavily utilised. Observers answered any questions asked by anyone enquiring.

4.2.1.3.1.2 STUDY PERIOD

There is no standardisation of data regarding the duration, season or days and frequency of water contact study periods (Table 4.2). However, most studies were conducted over periods enabling them to maximise seasonal differences in water contact patterns. Due to time, staff and financial constraints, the present study was conducted in summer over a period of 2 days - one weekday (26 September 1996) and one weekend (28 September 1996). These were chosen to maximise the differences between working day and weekend water contact patterns (J.D. Kvalsvig pers. comm). Due to the short duration of the study and the fact that it was conducted in one season only, the interpretation of the data obtained is limited.

Day 1 (26 September 1996) was a cloudy, cold day with an air temperature at 12:00 of 17°C whilst day 2 (28 September 1996) was a hot day with temperature at 12:00 of 28°C. Observations began at 6:30am and ended at 5:30pm.

Figure 4.1: Water contact study observation points A-O and freshwater snail collection points 1-9 along the Mpolweni River.

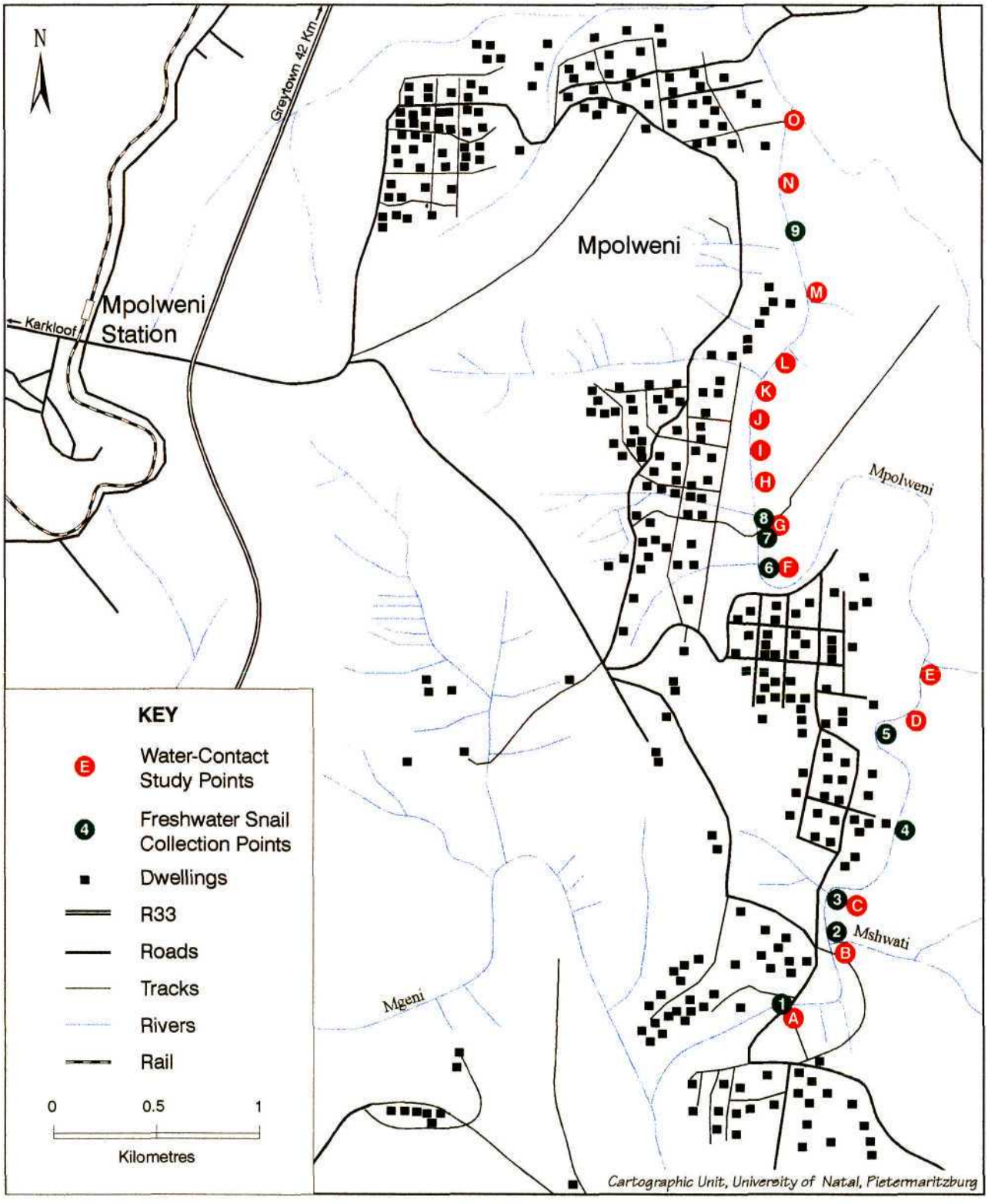


Table 4.2: Observation periods used in the design of five published water contact studies.

Observation period	Frequency	Time of year	Reference
7 days	2x	Winter, summer	Kvalsvig & Schutte (1986)
7 days Sunday - Saturday	12x	Every month from Aug 1991- July 1992	Akogun & Akogun (1996)
4 days	3x	Every season	Dalton & Pole (1978)
14 days	7x	July, October 1978 March, July, October 1979 March, July 1980	Kloos *et al* (1990)
7 days	2x	Dry season, rainy season	Kloos & Lemma (1980)

4.2.1.3.1.3 DATA COLLECTION

Data collected included the time of day each contact occurred, number of persons present at particular times, sex, length of stay and percentage body wetted. Each observer had a stopwatch and length of stay was recorded in minutes. A scale for percentage of body wetted was compiled by dividing the human body into various proportions (Table 4.3). Activities were classified and numbered into 10 categories (Table 4.4).

Table 4.3: Scale for % body wetted used during the water contact study conducted in the Mpolweni River.

% body wetted	body part
5	hands and/or feet
25	knees
50	waist
75	chest
80	shoulders
100	total immersion

Table 4.4: Categories of water contact activities used during the water contact study conducted in the Mpolweni River.

Activity	Activity number
Fetching water	1
Child playing	2
Drinking	3
Fishing	4
Washing of clothes	5
Washing of body	6
Crossing river	7
Washing extremities	8
Swimming	9
Other	10

4.2.1.3.1.4 EXPOSURE INDEX

Several exposure indices have been developed using various combinations of frequency, duration and intensity of immersion. Frequency is the total number of activities occurring in each category, duration is the mean time in minutes spent at each activity and intensity is the mean body percentage wetted in each activity.

The various indices include:

exposure index A	= frequency x duration x intensity	(Kloos & Lemma 1980; Kvalsvig & Schutte 1986)
exposure index B	= frequency x duration	(Dalton 1976; Dalton & Pole 1978; Tayo *et al* 1980)
exposure index C	= total body minutes (TBM) of contact with water, i.e. total duration of contact x % body surface exposed	(Kloos *et al* 1990).

All three indices were calculated in the present study and comparisons made between them.

4.2.1.3.2 RESULTS

Total activity counts recorded at each of the observation points (A-O) were tabulated (Tables 4.5 & 4.6). A total of 307 and 436 water contacts were made on days 1 and 2 respectively. Eighty seven males and 203 females were recorded at the river on day 1 whilst 118 males and 315 females were recorded on day 2. The greater number of females can be attributed to the frequency of clothes washing. Both swimming and collection of water increased on day 2. Swimming occurred more frequently at point F, the weir, which also had the greatest activity count of all surveyed points for both days (87 & 103 respectively).

Table 4.5: Total water activity counts recorded from points A-O on day 1 (26 September 1996) during the water contact study at Mpolweni Mission.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Tot
Tot	1	29	35	46	34	87	9	3	10	11	13	5	2	6	1	307
M	1	9	6	11	7	38	3	1	7	3	-	1	2	2	-	87
F	1	22	27	35	28	49	6	2	3	9	13	4	-	4	1	203
Act1	1	25	27	46	34	68	7	3	8	8	13	3	2	5	-	250
2	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2
3	-	4	1	-	-	2	-	-	-	-	-	-	-	-	-	7
4	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	5
5	-	-	7	1	2	9	2	-	-	3	-	2	-	1	1	28
6	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
7	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
8	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	2
9	-	-	-	-	-	2	-	-	1	-	-	-	-	-	-	3
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0

Table 4.6: Total water activity counts recorded from points A-O day 2 (28 September 1996) during the water contact study at Mpolweni Mission.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Tot
Tot	62	2	25	77	40	103	16	8	2	17	42	35	4	3	-	436
F	46	2	23	64	29	74	7	6	2	6	28	21	4	3	-	315
M	16	-	2	13	11	29	8	2	-	10	13	14	-	-	-	118
Act1	50	2	71	37	47	8	6	2	8	22	21	4	1	-	-	302
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
3	-	-	-	-	-	3	-	-	-	-	-	1	-	-	-	4
4	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	3
5	8	-	2	3	3	22	6	2	-	4	11	3	-	-	-	64
6	-	-	-	-	-	2	-	-	-	-	2	3	-	-	-	7
7	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
8	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
9	4	-	-	3	-	27	1	-	-	5	5	6	-	2	-	58
10	-	-	-	-	-	-	1	-	-	-	2	1	-	-	-	4

Activities were recorded during hourly intervals throughout the day (Tables 4.7 & 4.8). The collection of water and washing of clothes occurred throughout both days whereas on day 1, water collection peaked between 7:30am and 9:00am and then later, between 3:00pm and 6:00pm. On day 2 water collection continued intensively for a longer period in the morning and peaked again in the late afternoon. Swimming occurred throughout most of day 2.

Table 4.7: Frequency of activities 1-10 recorded during the observation period on Day 1 (26 September 1996).

Time	Act. 1	2	3	4	5	6	7	8	9	10
7:30-8:00	17	-	-	-	-	-	-	1	-	-
8:00-9:00	29	-	-	-	2	-	1	-	-	-
9:00-10:00	8	-	-	1	2	-	-	-	-	-
10:00-11:00	11	-	1	-	6	-	-	-	1	-
11:00-12:00	6	-	2	-	-	-	-	-	-	-
12:00-13:00	7	-	-	-	5	1	-	-	-	-
13:00-14:00	1	-	-	2	-	-	-	1	-	-
14:00-15:00	8	1	1	-	-	-	-	-	-	-
15:00-16:00	34	-	-	2	5	-	-	-	2	-
16:00-17:00	31	1	2	-	4	-	-	-	-	-
17:00-17:30	20	1	1	-	2	-	-	-	-	-

Table 4.8: Frequency of activities 1-10 recorded during the observation period on Day 2 (28 September 1996).

Time	1	2	3	4	5	6	7	8	9	10
6:30-7:00	11	-	-	-	-	-	-	-	-	-
7:00-8:00	84	-	-	-	4	-	-	-	-	-
8:00-9:00	62	-	-	-	11	-	-	-	-	-
9:00-10:00	28	-	-	-	12	-	-	-	2	-
10:00-11:00	17	-	-	-	10	-	-	1	11	-
11:00-12:00	5	-	-	-	6	-	-	-	11	2
12:00-13:00	11	-	2	-	5	2	-	-	7	1
13:00-14:00	4	-	-	-	2	2	-	-	1	-
14:00-15:00	9	-	-	1	5	1	-	-	2	1
15:00-16:00	5	-	-	-	3	-	-	-	2	-
16:00-17:00	32	1	-	2	3	1	1	-	2	-
17:00-18:00	36	-	-	-	3	1	-	-	-	-

Activities ranked in order of significance for day 1 using index A were:
washing of clothes > collecting water > fishing > swimming > washing extremities > washing body > drinking water > playing > crossing river (Table 4.9). Only 9 activities were recorded. There were no "other" activities.

Activities ranked in order of significance for day 1 using index B were:
collection water > washing clothes > fishing > washing extremities > drinking > swimming > playing > crossing river > washing body (Table 4.9). Only 9 activities were recorded. There were no "other" activities.

Activities ranked in order of significance for day 1 using index C were:
fishing> washing clothes> swimming> washing extremities> washing body> playing> crossing river> drinking water> collecting water (Table 4.9). Only 9 activities were recorded. There were no "other" activities.

Table 4.9: Exposure indices A, B, C calculated for activities 1-10 on day 1 of the Mpolweni Mission water contact study.

Activity	Index A	Index B	Index C
1	12400	1240	50
2	522	12	270
3	558	56	80
4	8723	249	1750
5	22775	1139	820
6	627	6	600
7	221	7	210
8	1550	62	775
9	2538	25	800
10	0	0	0

Activities ranked in order of significance for day 2 using index A were:
swimming > washing of clothes > collection water > washing body > fishing > other > washing extremities > crossing river > drinking (Table 4.10).

Activities ranked in order of significance for day 2 using index B were:
washing of clothes > collection of water > swimming > other > washing of body > fishing > washing extremities > drinking > crossing river (Table 4.10).

Activities ranked in order of significance for day 2 using index C were:
fishing> swimming> washing body> washing clothes> other> washing extremities> crossing river> fetching water> drinking water> children playing (Table 4.10).

Table 4.10: Exposure indices A, B, C calculated for activities 1-10 on day 2 of the Mpolweni Mission water contact study.

Activity	Index A	Index B	Index C
1	25536	1702	86
2	0	0	0
3	38	7.6	10
4	12672	132	4268
5	114660	4095	1764
6	12968	137	1900
7	130	2	130
8	150	30	150
9	132696	1368	3360
10	1560	156	380

4.2.1.3.3 DISCUSSION

The water contact study revealed that the Mpolweni river is heavily utilised by the community for a range of activities, several of which had a social and recreational importance. Since there are

no recreational facilities at Mpolweni Mission, the children swim and fish in the river a great deal. Fishing is a very important activity in the community and is conducted using nets which require the fishermen to become fully immersed in the water. Fish are often herded into corners, trapped and then caught. Many of the older children force the younger ones to fish.

Swimming is an activity which places the community at a high risk of contracting urinary schistosomiasis. Washing of clothes is a social time for the women which provides them with an opportunity to socialise whilst washing and waiting for the clothes to dry. Washing of clothes occurred along most of the riverbank but especially where granitic outcrops occurred which were used as a hard surface for scrubbing and drying clothes. This often involved half-body immersion as the women stand in the water to scrub clothes on the rocks. It is a long process and women were observed to be in one position washing all day long. It is another activity which places the community at risk of contracting urinary schistosomiasis.

The collection of water is the most frequent activity, however it only lasts a short time and very little of the body is exposed to the water. It is thus one activity which would not place the community at much of a risk of contracting schistosomiasis.

The three exposure indices all ranked the activities in different orders of importance. Indices A and B values were skewed by the high-frequency activities, e.g. collection of water, and did not accurately reflect those which have a greater intensity and duration, e.g. fishing. Exposure index C reflected most accurately those activities which would be rated as high risk activities, e.g. washing clothes, swimming and fishing.

Several water contact points (A, D, F) coincided with snail collection points where schistosome infected *Bulinus africanus* were found (1, 5, 6). These points are clearly sites of active urinary schistosomiasis transmission and should be targeted for control purposes. It is important to note that only a small proportion of water contact sites (4/15) were found to harbour schistosomiasis infected host snails.

4.2.2 STEP TWO - ATTACK PHASE

The primary objective of the use of chemotherapy in schistosomiasis control programmes is the immediate reduction of human morbidity to levels at which it is no longer of public health importance (WHO 1983b). There are added advantages to the use of Praziquantel. Treatment with Praziquantel has resulted in an increase of growth in Kenyan children (Stephenson *et al*

1989) and reductions in the thickening of the bladder wall and vesical polyps (Doehring *et al* 1985b).

The effects of the drug are highlighted by (WHO 1983b) as:

1. elimination and cure of the infection is obtained in a high proportion of the infected population;
2. the intensity of infection is reduced in those persons who remain infected;
3. after elimination of the infection or reduction of its intensity, the level of contamination by those remaining infected is dramatically reduced;
4. after this "chemotherapeutic shock" the risk of snail infection and transmission of schistosomiasis is lower; and
5. the risk of development of severe disease, associated with heavy infections, is lower.

Several delivery systems for anti-schistosomal chemotherapy are recognised : mass treatment, selective population chemotherapy, selected group treatment, targeted chemotherapy and phased treatment. **Mass treatment** refers to treatment of entire populations without prior individual diagnosis (WHO 1983b). It has been considered a good option where "safe" anti-schistosomal drugs are available and removes of the need to screen individuals for infection (Chandiwana & Taylor 1990). The decision to employ mass treatment must be based on adequate epidemiological data indicating that a very high proportion of the population is infected (WHO 1983b). The main advantage is that case detection costs are minimal and restricted to preliminary sampling to establish the existence of transmission (Pugh *et al* 1980). Despite case detection costs being low, treatment costs are high (Ndamba *et al* 1990). Several disadvantages to this strategy have been documented. Logistical problems in drug administration may prevent everyone in the community from being treated thereby reducing the effectiveness of a single treatment and preventing the elimination of disease. Unless there are resources for repeated mass treatments and coverage is good, re-infection will take place and within a few years the average intensity of infection will have returned to its pre-control level. There are also problems with infected immigrants coming from adjacent endemic areas and who will introduce new infections to the controlled areas (Chandiwana & Taylor 1990).

In light of these disadvantages some researchers advocate that treatment should be targeted at the most heavily infected individuals or age group in a population to eradicate symptoms of disease which are positively correlated with high worm burdens and which in turn are related to egg output. However, the main problem with this **selective chemotherapy** is the cost of identifying the heavily infected individuals.

There is also interest in treatment strategies which target specific age groups or individuals predisposed to heavy infections, without the need to identify individual infection status before each round of treatment. This is **targeted** or **selected mass treatment** and it is facilitated by the uneven age-specific distribution of infection, with peak intensities in teenagers and young adults (Chandiwana & Taylor 1990). The major drawback of this strategy is that persons from other age groups may be able to maintain transmission. Age group targeting has shown to work in Zimbabwe (Chandiwana & Taylor 1990). The rationale for treating the age group with high intensities of infection (5 to 15yrs) is to reduce the high incidence of disease symptoms which are usually associated with this group (Butterworth & Hagan 1987).

The chemotherapy programme at Mpolweni Mission could have been either school or community based. The advantages of a school based programme include: the ability to target the age group that harbours the highest intensities of infection, fewer numbers to treat and therefore reduced expenditure, better infrastructure and greater co-operation from non-health Department personnel. The main disadvantage of a school based programme is that people who do not attend school and are infected will not be treated and could maintain transmission.

4.2.2.1 THE SCHOOL-BASED CHEMOTHERAPY PROGRAMME

The chemotherapy strategy adopted at Mpolweni Mission was selected group treatment. All children between the ages of six and 20 years of age were treated. There were several reasons for this strategy being adopted. Firstly, the programme was school-based and thus it incorporated the age groups at greatest risk of infection as well as those which are responsible for a high proportion of environmental contamination (Butterworth & Hagan 1987; Chandiwana & Taylor 1990; WHO 1983b; Ahamed *et al* 1996; Pugh *et al* 1980). Secondly, prior to treatment, the infection status of every school child could not be established due to financial, staff and time constraints. Thus, to overcome this problem, all children had to be treated in order to avoid missing any infected ones. Financially, selected group treatment has advantages because case detection costs are limited to the survey defining the epidemiological status of the area and drug delivery costs are kept at a minimum compared with mass chemotherapy or even selective population chemotherapy. Selected group treatment has been successful in Zimbabwe (Chandiwana & Taylor 1990).

Biltricide® (600mg Praziquantel) was the drug used. It is given as single dose (40mg/kg body mass) so that administration is easy. It is the only anti-schistosomicidal drug available in South Africa and is in use by PHC services. Metrifonate® would have been cheaper but has not been

registered for use in this country (A. C. Evans pers. comm.). Metrifonate® should be the drug of choice for *S. haematobium* but the fact that it is not effective against *S. mansoni* makes it of limited use in areas where both parasites occur.

Treatment with Biltricide® took place on the 17 and 18 May 1996. All school children present on the days of treatment were treated. A team comprising four nurse aides, one registered nurse and a driver from the Provincial Health Department, Pietermaritzburg, administered the medication. Several children were not present on the days of treatment despite the fact that they had been informed of our arrival. This was problematic as missed infections could maintain transmission. Due to time and staff constraints, nurses could not return repeatedly to ensure that everyone was treated. Absentees need to be taken into account (Pugh 1980).

Because it is very important to get as much co-operation from the community on the treatment day as possible, the schools were consulted prior to our arrival about the arrangements. It is important to update the teachers and consult them regarding arrangements and results. Contact with the community and programme drivers had to be maintained at all times to ensure co-operation, trust and the continuation of the programme. Treatment should take place soon after diagnosis. This is important for two reasons: (i) because of the mobility of the population - the later treatment is left, the harder it will be to trace individuals, and (ii), the community must not feel it has been forgotten. Many rural communities have been used for research purposes in the past and promises of help made but not kept.

Treatment at each school took 3½hrs. Class lists were compiled prior to the visit. This facilitated a smooth treatment process on the day. All equipment needed had to be taken to the schools. This included water, cups, refuse bags, scales, calculators, knives, boards/plates to work on, marker pens and clipboards. The nurses explained to the children what they were being given and why. This re-enforced their knowledge of schistosomiasis, enabled them to ask questions and ensured that they were kept informed at all times as to what was being done. To facilitate the speedy administration of medication, dosage versus body weight tables should be prepared. Tablets should be broken into quarters (150mg each) for easier consumption by the children. Following the administration of medication, each child's mouth had to be checked to ensure they had swallowed their tablets.

The strategy outlined above was ran successfully in both primary schools but problems were encountered in the high school. Time constraints prevented this school from being treated on the scheduled days and they had to be treated by the nurses at a later stage. The nurses ran

short of Biltricide® resulting in several students not getting treatment. More tablets could not be purchased due to financial constraints on the part of the Health Department.

4.2.2.2 HEALTH EDUCATION PROGRAMME

Schistosomiasis is a disease caused largely by human behaviour. As Patwari (1988) stated, "Ignorance about the disease seems to be a very important factor in the transmission of the disease." Thus the aim of a health education programme is to empower a community with the knowledge and understanding that their own behaviour is a key factor in the transmission of the disease. This will enable them to make behavioural decisions which would improve their own health. **Participation from the whole community is an important factor which will ultimately determine the success of such programmes.**

As WHO (1990) points out, not only is participation important but "health education involves people in all phases of solving their own problems: in finding out about the problems and in planning, implementing and evaluating programmes to solve them".

The education programme at Mpolweni was school-based, initiated and conducted by myself, Umgeni Water's External Education Services and the Provincial Health Department's Environmental Education Unit. The educational media used included videos, discussions, worksheets and posters. The videos were produced specially for Umgeni Water and contained material on general health, river conservation and pollution. The discussions were conducted by Ms Gumede (Umgeni Water), Mr Ndlovu (Health Department) and myself. These discussions covered a range of topics from general health, water conservation, river pollution and more specifically, schistosomiasis. The children were asked questions allowing the educator to assess their base-line knowledge. The educator then provided additional information following which the children were able to ask them questions in return.

The aims of the programme were as follows:

1. inform the children about schistosomiasis;
2. re-enforce any schistosomiasis knowledge they may already have;
3. identify any misconceptions they may have and disclaim them;
4. ascertain their perceptions of the disease and its control;
5. test their knowledge about schistosomiasis directly following the programme;
6. test their knowledge about schistosomiasis several months after the programme.

The schools were notified of the education programme and they were asked to put forward any suggestions they may have regarding its structure and information content. They requested that general health care and river conservation be included in the programme. Due to a lack of educational material on schistosomiasis, all material used had to be produced. Posters, worksheets and education sheets were drafted (Appendices 4.1a,b,c). The children were informed about schistosomiasis using these newly compiled worksheets and posters.

The worksheet had two components, a question section and an informative diagram. The diagram design was based on the WHO (1990) poster but was altered so to depict a South African situations. All answers to the questions were provided via talks, videos or were included in the diagram section of the worksheet. This informative diagram included the distribution of urinary schistosomiasis in South Africa, its life-cycle, diagnosis and prevention. The worksheet was designed for use in the classroom where teachers could use it as a teaching aid for both primary and high school children.

The poster was designed to be both visually appealing to the local population and informative. The nurse featured as the key person in the poster because the majority of community members respect nurses. Basic life-cycle information was provided by means of diagrams with short sentences and by providing answers to commonly asked questions. Advice and suggestions were provided for communities to consider. The poster was designed for use in clinics, schools and churches. It was intended to create an awareness amongst community members so that they might start asking questions themselves and try to find solutions to problems regarding urinary schistosomiasis.

Designing the poster was not an easy task because it targeted a group which was different culturally and had a different educational level from myself. The design had to appeal to its target group, i.e. rural school children, and convey the required information in an easily understandable way. Biological concepts such as the parasite's life-cycle were difficult to describe and illustrate. Compounding the problem was the target group's lack of knowledge of biological concepts. This resulted in many of the school children and teachers not being able to grasp the concept of a life-cycle, let alone its various components. The cercariae posed the greatest problem.

Laver (1977) highlights some important criteria that a poster should fulfil in order to be successful. Firstly, it must increase awareness of the problem; secondly, it must increase people's knowledge about the problem; thirdly, it needs to reach people who are not reached via other methods, i.e. radio, formal education and television; fourthly, it needs to bring about

changes in attitude which are in line with the objectives of the programme and fifthly, the extent to which the method contributes to or obstructs good public relations is important as well. In addition to this schistosomiasis poster, Umgeni Water's general health and river conservation posters and videos were used. All equipment needed had to be taken to the schools. This included a generator, television set, educational material and drawing material.

The education programme was conducted over three days with the educators moving from class to class. The children were asked questions regarding the various issues in order to assess their baseline knowledge and to which the educators added and disclaimed any misconceptions the children had. The children were shown videos and asked to complete the worksheets.

Children in the lower primary school were asked to draw picture posters depicting their own understanding of schistosomiasis and its control. They were given this task for several reasons:

1. enable us to gain an understanding of what the children perceive as important,
2. to allow us to estimate their general understanding of the life cycle and control of schistosomiasis,
3. to allow us to use their drawings for the production of educational material because these contained ideas/information they could obviously relate to,
4. to give us an idea of the age at which perceptions of the disease and strategies for its control change,
5. to provide the children with the opportunity to review bilharzia with their teachers and peers,
6. to add the element of "fun" to the education process,
7. to ensure that the education process was an interactive one, involving both educators and pupils.

The primary schools co-operated well with the programme and displayed their posters in their classrooms. Most of these included scenes depicting situations of disease transmission and prevention (Figure 4.2). Activities that promote good health were depicted e.g. placement of JIK in water to purify it. Activities that lead to the spread of communicable diseases, especially schistosomiasis, were depicted, e.g. defecation and urination near waterways. Recreational activities e.g. fishing and swimming were highlighted in most posters. Three posters depicted the parasites' life-cycle (Figure 4.3). On all three occasions the life-cycle was not complete. The freshwater snails and cercaria were left out. The fact that the parasite's life-cycle was not frequently used highlights the children's lack of understanding of it and/or the lack of importance they place on the cycle. Several posters (Figure 4.4) were designed using a "correct" and

"incorrect" situation diagram. Often the diagrams showed a random pattern of "correct" and "incorrect" situations. However, on occasions the "incorrect" situation was flanked by the "correct" situation. This is important as it shows that primary school children are able to relate to "correct/incorrect" situation diagrams. This type of poster design is often not used for educational purposes as people tend to focus on the "incorrect" situation.

The high school did not co-operate with the poster programme. From standard 7 upwards, interest in the programme was poor. It is not "cool" for adolescent pupils to get involved in discussion groups, fill in worksheets or listen to talks. One possible way of alleviating this problem is to train the standard 10 pupils and get them to teach the standard 9s who in turn teach the standard 8s. This may work because it gives responsibility to the older group by getting them to use their knowledge to teach the younger children. This forces them to become involved in the programme since they will not want to look inadequate in front of the younger children whom they have to teach.

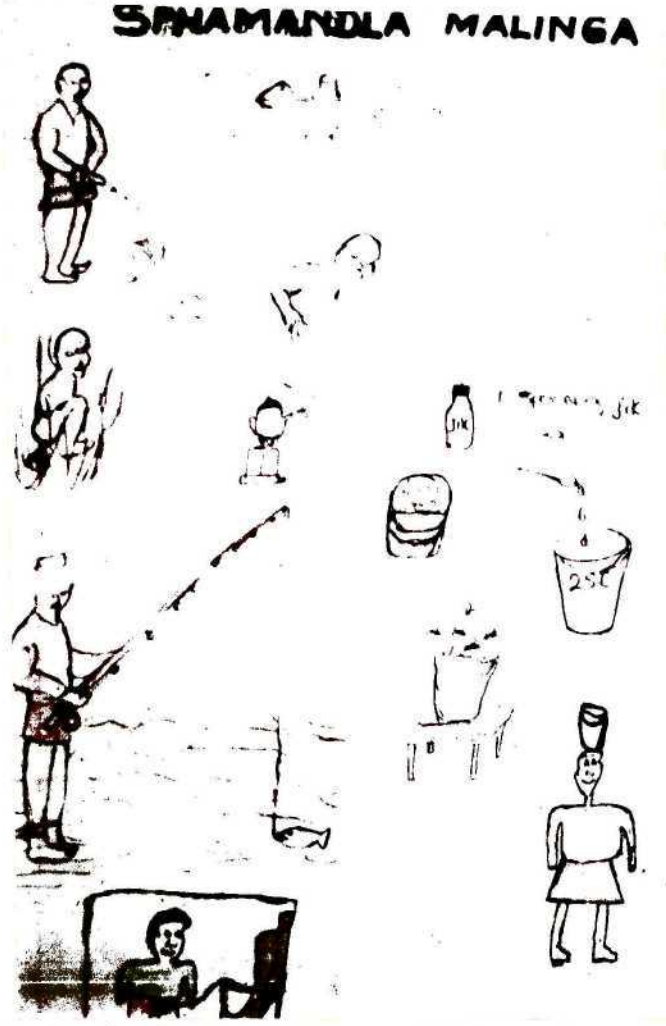


Figure 4.2: Health education poster depicting both good and poor health practices. It was produced by a standard 2 pupil at Khanyisani Primary School at Mpolweni Mission.

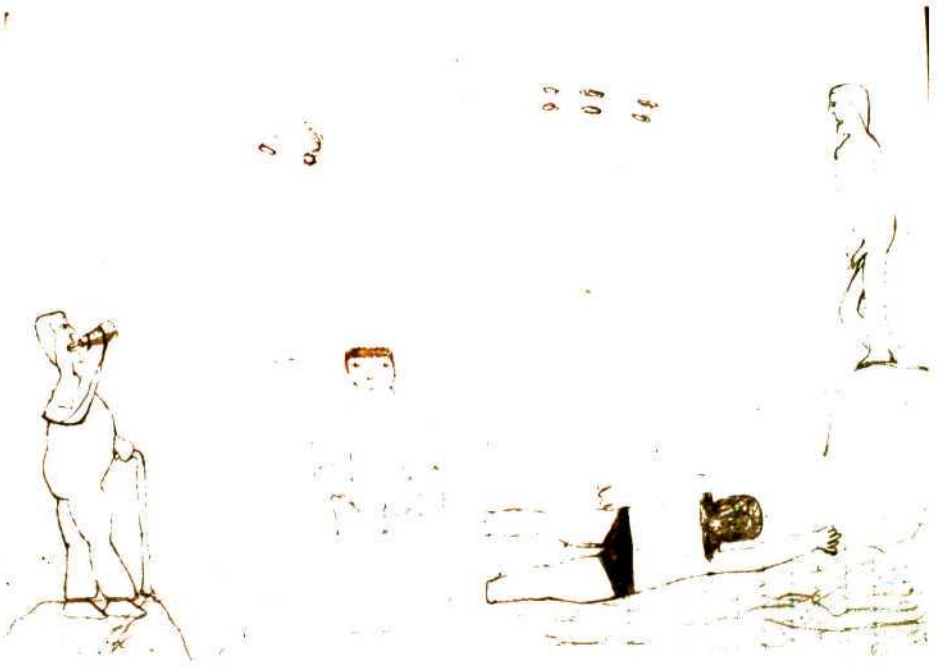


Figure 4.3: Health education poster depicting schistosomiasis life-cycle. It was produced by a standard 4 pupil at Khanyisani Primary School at Mpolweni Mission.

Figure 4.4: Health education posters depicting both good and poor health practices. They were produced by a standard 2 pupils at Khanyisani Primary School at Mpolweni Mission.

The younger group may listen as they respect their peers. Another suggestion is to get the children to paint the classroom walls depicting various health issues. This will brighten up their educational environment and force their interaction with the education process.

One important lesson learnt from the school programme was that teachers need to be closely involved in the programme. Most of the contact during the planning stage had been with the headmasters but they were not the ones doing the educating. Teachers need to be present in the classroom during the programme so they know what material was covered and to ensure their involvement and interest in the programme. It is very important to put the information one wants to convey into a context which the children can understand and give it relevance.

On the whole, the education programme proceeded well but the assessment of its success was difficult. Education programmes aim in the short term to provide scholars with information enabling them to make decisions regarding their behaviour which in the long term will lead to changes in behavioural patterns that would promote good health. In order to asses the children's short term knowledge retention, they were given tests to do. The tests were in Zulu for both primary schools (Appendix 4.2) but due to the teachers' insistence the high school's (Appendix 4.3) tests were in English. One hundred and seventy-one tests were completed by the high school pupils. The results of the test were not good. There was a 65% (111/171) failure rate (Table 4.11). One hundred and sixty-two tests were completed by the primary school pupils. In comparison, there was a 88% (144/163) pass rate (Table 4.11).

Table 4.11: A mark break-down of results from the Mpolweni Health Education test 1 administered to the primary and high school pupils.

Mark break-down (%)	Primary School (n)	High School (n)
<20	2	0
20	3	32
30	5	40
40	4	39
50	13	35
60	29	20
70	27	5
80	66	0
90	10	0
100	4	0
Total	163	171

The reasons for the high school pupils poor performance in the test was difficult to determine. Firstly, the pupils may not have understood the test due to them having a poor command of the english language. Their english writting and reading skills were very poor. It seemed that the pupils did not understand the questions being asked nor what answers were required from them. When asked to list three symptoms of bilharzia they would list methods for the prevention of

spreading the disease. When asked to tick correct statements, many left that question out. Secondly, the pupils may not have had any interest or will to co-operate with the programme. Both these reasons have implications for future education programmes conducted in high schools. Despite the teachers insistence that the tests should be in english, they should rather be in the community's language. The manner in which the education programme was conducted should be altered. High school pupils are resistant to co-operate with such programmes. New avenues that captivate the interest of the older pupils need to be established.

One problem regarding the school programme was that it became evident as time went by that it no matter how much knowledge the children had, the parents influenced the children's health practices in the home environment. It was not enough to educate only the children. The parents needed to be targeted as well if any long term behaviour changes were to occur.

All educators involved in the school programme got together for a brainstorming session on how best to relay the required knowledge to the community. It was decided that any community programme would have to be more than just an information carrier, it would have to demonstrate the need for changes in the community's behaviour and the programme would have to interact with the community. The biggest question facing the educators was - how one gets the community to attend an education programme and ultimately to participate in one. It was decided that the best channel to relay the required information would be by means of a play. The main problem here would be financial. The only alternative was to conduct a series of talks which could be given on days of monthly gatherings, e.g. pensioners pay-day, mother and child clinic day and church services. This method lacked interactive potential and despite having an audience, attendees might not listen because their gatherings had other purposes. The educators decided that before any kind of community education programme could be conducted, a meeting with community members would have to take place. The aim of this meeting would be to ascertain their understanding of the problem, their level of commitment to the programme and their current knowledge of the work conducted by the educators at the schools.

The overall response to this meeting was poor and it was attended mostly by women. However, the feedback obtained was encouraging and useful. All parties involved in the Mpolweni programme were introduced to the community. They were brought up to date with the happenings of the programme and briefed regarding future plans. These plans included a molluscicide programme, the provision of piped water and swimming facilities. Participants were told that no future interventions would occur without their consent and co-operation and their approval for future work was requested. This they happily gave. They were asked if they understood the future plans, if they saw a need for them and if they understood the importance

of the project. They answered yes to all these questions. Three very important issues were also discussed, namely the time frame, communication and the materialisation of the plans. The community was advised that all these plans would take time and would probably only happen in stages. They were urged to communicate with their community leaders regarding problems or suggestions they may have. In return, Mr Simon Mashigo (Umgeni Water representative) and I promised to keep them updated as much as possible. The community was warned that the provision of these facilities depended on the availability of funding and if this could not be raised then the projects would not happen. When the women were asked if they were aware that school-based education programmes had been conducted, they said that their children had told them. This was encouraging as it meant they knew we had already been active within the programme.

The community had four questions to ask namely:

1. could we provide water tanks for them till piped water was available?
2. were all these facilities just false promises?
3. once the money had been obtained for the facilities, would we just give it to them and abandon them?
4. how many swimming pools would we build and where would they be placed?

Following the meeting, it was decided a health education play would be the best avenue to convey the relevant information. The educators made enquiries regarding potential drama groups and costs. A list of quotes is attached (Appendix 4.4). Most of the quotes would put the cost of the whole programme into the thousands of rands and if sponsorship was not obtained it would have to be cancelled. In the meantime, DramAidE/Go Grow (Appendix 4.5) was contacted and plans for the play commenced. After several meetings they agreed to conduct a community interactive play. The play's format was drawn up by DramAidE/Go Grow and the content was based around themes the educators had provided. Information regarding the structure and content of the plays is included in Appendix 4.6. DramAidE/Go Grow and the committee forum met and their permission for the programme had to be obtained. At first the forum did not agree with the play idea, did not understand it and thought it a waste of money. Following several more meetings they agreed to the idea and it was decided that the whole event would be a community social day. Money obtained from sponsors would be used to buy food which the community would cook. There would be "free-stage time" for the community to sing, dance or act out scenes of their choice. The idea behind the "free-stage time" was to get the community involved in activities of their choice and also to provide a show that the rest of the community would want to attend. Sponsorship was obtained from Suncrush Ltd and Development Facilitation (inland region). Further plans for the programme continued.

The biggest problem facing the success of the community education day was to adequately inform the community of the event and persuade them to attend the day's festivities. Local newspapers and radio stations were notified of the event and they were asked to advertise it a week in advance and to report on it. A request was made to the radio stations for air coverage on the day. We also requested a "questions and answer" health interview on the radio conducted by Mr Mashigo and the DJ on at the time, to try and create greater health awareness amongst the local population. Initially it was hoped that the community members would spread the message by word of mouth but community communication was not as good as at first thought and messages did not go beyond a certain point, often due to internal politics and conflicts. It was therefore decided that a series of informal meetings and mini-plays would have to be conducted at various places in the community over a period of time. The community was notified of these mini-plays a day beforehand via a loudspeaker. DramAidE/Go Grow acted out one community-relevant health scene and then stimulated conversation around this scene. The community's response to these mini-plays was good. The community members had various ideas and attitudes regarding schistosomiasis. Some felt that soap acted as a barrier to infection whilst others believed the Lord would protect them. The majority knew that schistosomiasis infection could be cured by going to a doctor but there were still some who consulted traditional healers. The fact that infection recurred following treatment was a problem. Fast flowing water was considered "safe" water whilst slow moving water was "unsafe". The general feeling was that children were the ones at risk because they swam whilst the older people do not swim and are therefore less likely to get infected. It was pointed out by other community members that despite not swimming, older people do get infected from other water contact activities and a suggestion was made that when washing clothes they should wear boots and gloves. One common problem was that children don't tell their parents that they are infected and thus treatment is delayed. The issue of witchcraft was discussed where several community members felt that witches could contaminate the rivers with schistosomiasis. The disease is thought to cause insanity and it is also considered a form of punishment. The example given by the community was that an alcoholic got schistosomiasis as a form of punishment. Following the discussion the community members were told of the larger play and their attendance was requested.

After six months of preparation, meetings and planning, the main play day was scheduled for 23 November 1996. Suncrush Ltd sponsored a CocaCola promotion van, cokes and a DJ for the day's festivities. The van came complete with a sound system and fold-out stage. Without this sponsorship the day could not have been held due to the costs of hiring such equipment. Umbrellas were hired and a cameraman was employed to video the events. Invitations were sent out to guests selected by the community, Umgeni Water, University of Natal and the

Department of Health. Dr Zweli Mkize (minister of health KwaZulu-Natal) was approached, and was asked to address the community. Representatives from Umgeni Water, Mpolweni Youth League, Mpolweni Health Chairperson, Provincial Health Department - Environment Division and the Chief from Mpolweni were all asked to briefly address the community regarding several health issues. A week before the scheduled date, the forum committee leader contacted me and told me that it had to be postponed. There had been a spate of recent deaths in the community and they could not give their consent to the festivities. The organisers realised that they did not have any choice at all, so the event was postponed to 26 January 1997. Due to the postponement, Dr Zweli Mkize was unable to attend the event. However, Dr Baloyi (Deputy Director-General Health Care Branch) was able to join us and he addressed the community. The event went ahead successfully as planned.

4.2.2.3 THE PROVISION OF ALTERNATIVES

Urinary schistosomiasis is a disease that people both contract and pass on (WHO 1990) because of their behavioural habits and a lack of facilities that reduce water contact. People contract schistosomiasis by swimming in rivers, fishing, bathing and washing whilst they pass it on by urinating in the water or on nearby banks. Contact with infested water can be reduced by the provision of certain facilities, e.g. swimming pools, washing blocks and piped water and behaviour can be altered through the extensive use of education programmes (Pitchford & Gear undated).

A meeting was held with the Forum to discuss the construction of facilities that would reduce water contact. Umgeni Water had already committed itself to the installation of a piped water system. This was viewed by the community as the key ingredient for the reduction of schistosomiasis transmission. However, the provision of piped water alone does not guarantee a reduction in community members' river usage (Noda *et al* 1997). Factors such as the cost of the piped water, provision of complementary facilities, e.g. washing blocks and showers, distances from the home to taps and the willingness of the community to alter their behavioural patterns (Lima e Costa *et al* 1997) all play a role. A holistic approach needs to be adopted if schistosomiasis prevalence is to be reduced. Pitchford & Gear (undated) advocated the importance of the environmental management on the life cycle of the parasite. Therefore, it was decided that the provision of piped water was not sufficient and that financial support had to be found for the construction of added facilities, e.g. swimming pool and washing blocks. The forum was asked to write a letter requesting funding to be sent to several potential donors. One matter that seemed very important was that everyone involved in the programme should not just provide for the community, they had to want changes to happen and must be part of making

them happen. The piped water scheme is still under construction and additional facilities are on the drawing board for the future. Everything depends on financial assistance and community drive to make it happen.

4.2.2.4 SNAIL CONTROL USING MOLLUSCICIDES

Molluscicides have been used on their own (Barbosa & Costa 1981, Evans 1983) or in conjunction with other strategies in the control of schistosomiasis around the world (Appleton 1985b, Hesse 1993, Iarotski *et al* 1981, McCullough 1992). Several factors have led to a reduction in the use of molluscicides as the primary means of controlling schistosome transmission in endemic countries. These include the availability of cheap drugs, high cost of molluscicides and the failure of blanket mollusciciding to control schistosome transmission (Klumpp & Chu 1987). However, Klumpp & Chu (1987) warn that a balanced approach to schistosomiasis control should not be overlooked and that mollusciciding retains a useful role in control programmes. The advantages and disadvantages of mollusciciding are discussed by McCullough (1992). Probably the major question surrounding the use of niclosamide is the effect it would have on aquatic fauna besides snails, fish and tadpoles which are all susceptible to the molluscicide. Andrews *et al* (1983) reviewed several toxicity studies and concluded that the use of niclosamide at molluscicidal concentrations does not seriously affect the aquatic invertebrate fauna.

The use of molluscicides has been considered as an option at Mpolweni Mission. Consent was obtained from the community but there is resistance from Umgeni Water which is insisting on a full environmental impact assessment before they will allow a molluscicide programme to commence.

4.2.3 STEP THREE - MAINTENANCE PHASE

4.2.3.1 FOLLOW-UP CHEMOTHERAPY PROGRAMMES

WHO (1983b) warns that a single treatment with an anti-schistosomal drug should not be expected to achieve a permanent cure or to prevent re-infection. A planned assessment of the treatment programme is required after 6 months or 1 year depending on the pre-treatment prevalence and intensity levels. Transmission will continue after large-scale treatment but probably at a lower level than before for a while at least. Further treatments will be required to maintain control over morbidity. The pupils at Mpolweni Mission are awaiting a second

chemotherapy programme. The new prevalence and intensity values were established and are outlined below. However, the limiting factor is the ability to obtain Biltricide® tablets at national parasite control programme prices.

4.2.3.2 FOLLOW-UP PREVALENCE AND INTENSITY SURVEY

A follow-up prevalence and intensity study at Mpolweni had been discussed on several occasions with the nurses but they were unable to conduct any such assessment due to other commitments. They suggested that the teachers should collect the urine samples and test them using chemical strips. The teachers agreed to this and were pleased that they could be of direct assistance with the programme. The nurses explained to the teachers how to use the strips and then left them to conduct the study on their own. The teachers however, did not fully understand how to use the strips and often gave the pH value instead of the haematuria value. This was unfortunate as compliance with the follow-up study was 100% in both the primary schools. The high school did not comply with the re-assessment. For future studies it would seem that using teachers for follow-up assessments is a good idea but someone should be present on the day to supervise them and assist with any problems they may have.

The follow-up prevalence and intensity survey was delayed due to the commitments and heavy workload of the nurses who had been busy with other campaigns throughout the year. It eventually took place on the 22 October 1997, 18 months after treatment.

4.2.3.2.1 METHODOLOGY

Due to time and staff constraints it was decided that chemical strips would be used to test all children present at the schools on two selected days. Analysis of the samples took place on the day of sampling at the schools. Five people were involved in the assessment and documentation of the results whilst the teachers were instrumental in organising the collection of urine samples from the children. Plastic honey jars (250ml) were used for the collection of urine but possibly waxed paper cups would have been just as useful, cheaper and easier to dispose of after the study.

At the time of the follow-up survey, Lenstrip-5® (Benmore Diagnostics) were no longer available. The company had changed and was now referred to as Promex Diagnostics. The replacement strip was UriChek 5N®. The two strips labels and haematuria colour parameters appeared the same. The micro-haematuria parameters recordings were the same. Therefore, urinary micro-haematuria was determined using UriChek 5N® (Promex Diagnostics) and was recorded as ca.

10 ery/μL, ca. 50 ery/μL and ca. 250 ery/μL following the manufacturers instructions. This UriChek 5N® strip currently has the tender and is being used by the Health Department.

4.2.3.2.2 RESULTS

The results of the follow-up survey are given in Table 4.12. The difference in sample sizes limits the comparative interpretation of the data. However, prevalence recorded during the follow-up survey (32.8%) was lower than that of the initial survey (45.6%) as were the levels of haematuria. The number of urine samples containing haematuria value of ca. 250 ery/μL was reduced by 38% whilst ca. 50 ery/μL was reduced by 15.4%. Both ca. 10 ery/μL remained at 100%.

Table 4.12 : A comparative table highlighting the prevalence and micro-haematuria intensity data recorded at the intitial (15 April 1996) and follow-up (22 October 1997) surveys conducted at Mpolweni Mission.

	Initial Survey (15 April 1996)	Follow-up Survey (22 October 1997)
Sample size	320	1065
Prevalence	45.6% (146/320)	32.8% (349/1065)
Haematuria ca. 5-10 ery/μL (n)	100% (146/146)	100% (349/349)
ca. 50 ery/μL (n)	76.7% (112/146)	61.3% (214/349)
ca. 250 ery/μL (n)	63.6% (93/146)	26.0% (91/349)

Using the 134 pupils that participated in both surveys, Table 4.13 shows that the prevalence was reduced from 46.3% to 29.9%. The number of urine samples with haematuria ca. 250 ery/μL was reduced by 35.4% whilst ca. 50 ery/μL was reduced by 15.8%. Both ca. 5 - 10 ery/μL remained at 100%. At Mpolweni Mission the percentage of people who were test negative during the initial survey and then were test positive at the follow-up survey was 11.2%.

Table 4.13: Prevalence and micro-haematuria intensity longitudinal data comparing results from the initial survey (15 April 1996), followed by chemotherapy (17 May 1996) and the follow-up survey (22 October 1997) at Mpolweni Mission.

	Initial survey (15 April 1996)	Follow-up survey (22 October 1997)
Sample size (n)	134	134
Prevalence (%)	46.3 (62)	29.9 (40)
Incidence (%)		11.2
Haematuria ca. 5 - 10 ery/μL (n)	100% (62/62)	100% (40/40)
ca. 50 ery/μL (n)	75.8% (47/62)	60.0% (24/40)
ca. 250 ery/μL (n)	62.9% (39/62)	27.5% (11/40)

Prevalence and micro-haematuria values were determined for 466 individuals who received chemotherapy 18 months prior (Table 4.14). These individuals were not necessarily test positive following the initial survey. They were individuals that received treatment during the mass treatment programme. The prevalence was 29.4%. This value is also the re-infection value from the time of treatment. It includes both newly acquired infections and also old infections as value includes those positive individuals whose intensity was reduced but not eliminated following treatment. The haematuria ca. 5 - 10 ery/μL category contained the greatest number of positive samples (100%), followed by the ca. 50 ery/μL (59.1%) and lastly the ca. 250 ery/μL (23%).

Table 4.14: Prevalence and micro-haematuria intensity longitudinal data recorded following chemotherapy (17 May 1996) and the follow-up survey (22 October 1997) at Mpolweni Mission.

Sample size (n)	466
Prevalence/re-infection	29.4 (137)
Haematuria ca. 5 - 10 ery/μL (n)	100.0%(137/137)
ca. 50 ery/μL (n)	59.1% (81/137)
ca. 250 ery/μL (n)	23.3% (32/137)

4.2.3.2.3 DISCUSSION

The overall prevalence and intensity of urinary schistosomiasis amongst primary school children at Mpolweni Mission was reduced following chemotherapy. High intensity infections were reduced thereby highlighting one of the effects of chemotherapy. These results conform to those of King *et al* (1991) in Kenya and Savioli & Mott (1989) on Pemba Island who demonstrated a reduction in prevalence following the first chemotherapy programme.

The prevalence and intensity figures might have been lower if the follow-up survey had been conducted sooner. The recommended time interval is six months to a year depending on the

initial prevalence (WHO 1983c). The reduction in prevalence and intensity may also have been influenced by fluctuations in climate (flood), altered water contact patterns, sample size and other interventions such as the health education programme.

The re-infection rate is influenced by the extent of water contact the community has, the number of people that participated in the programme, population movement and seasonality (WHO 1983). The re-infection rate at Mpolweni could have been influenced by the level of absenteeism amongst primary school pupils at testing and chemotherapy (8.5%, 62/730). These pupils, if positive, may be able to maintain transmission in the area. The extent of water contact the community has is high due to the lack of a water supply scheme forcing the community to rely on water from the river. Seasonality may have played an influencing role as the follow-up survey was conducted 18 months following the first and it included a summer. Summer is the time when the children are highest risk of schistosome infection due to swimming. Population movement was not monitored in the community and so its effects on the prevalence levels is not known.

The incidence value at Mpolweni Mission was 11.2% This value is normally expressed as a percentage per year (Wilkins 1987a). However, at Mpolweni Mission this was possible as the follow-up took place 18 months following the initial survey. The incidence value is important as it is a measure of the effectiveness of the control programme which was aimed at reducing transmission. The significance of the value increases with each year it is measured. It would be interesting to measure the value at Mpolweni Mission for at two more years to establish if the control programme is having any impact on prevalence in the area. Incidence values are not easy to obtain. The main problem is the maintenance of a "core sample" group for consecutive years. The children have several names and often alternate the use of them depending on their age. Therefore, correlating specific children with each survey is difficult. The high level of absenteeism is a problem as children are often not present on the survey day, thereby reducing the "core sample" group.

4.2.3.3 AN ASSESSMENT OF THE SCHOOL-BASED HEALTH EDUCATION PROGRAMME

A second health test was administered to the primary school pupils 18 months following the first one. The second test was not administered to the high school pupils due to their lack of co-operation and poor performance as a result of language problems with the initial test. The aim was to assess the amount of long-term health information the children remembered following the initial intervention. The test format was the same as for the first test enabling a direct

comparison with the results of the first test. Since the first programme the educators team had not returned to the school and conducted a follow-up.

Four hundred and forty-two pupils from grade 3, std 3, std 4 and std 5 completed the test. The pass rate (over 50%) was 89% (392/440). A break-down of results are highlighted in Table 4.15.

Table 4.15: A percentage break-down of the results obtained from a health test administered to the Mpolweni Mission Primary School pupils (grade 3, std 3, std 4, std 5), 18 months following the education programme.

%	20	30	40	50	60	70	80	90	100	Total
Number of tests (n)	2	18	28	123	73	81	68	47	0	440

A comparison of marks was made from pupils that had participated in both test 1 and 2 (n=107). Test 1 results were taken from the pupils in classes grade 2 and standard 3. Test 2 results were taken from pupils in classes grade 3 and standard 3. A break-down in the marks is shown in Table 4.16. The pass rate for test 1 was 92% (98/107), whilst in test 2 was 80% (86/107). Two of the pupils results improved in test 2. However, the majority of the pupils marks decreased. Paired student-t tests were conducted on the two classes test results to assess the significance of the decrease in the test results. The standard 2 (mean 70.1%) and standard 3 (mean 68.6%) difference in results was not significant ($p>0.05$, n=52). However, the grade 2 (mean 79.9%) and grade 3 (65.3%) difference in results was significant ($p<0.05$, n=55).

Table 4.16: A comparison of primary school pupils health test results from two tests administered 18 months apart at Mpolweni Mission.

%	<20	30	40	50	60	70	80	90	100	Total
Test 1 (n)	2	3	4	7	25	15	42	7	2	107
Test 2 (n)	0	6	15	19	15	25	16	11	0	107

4.3 Difficulties encountered

A pilot control programme of this nature has not previously been carried out in South Africa and several problems were encountered during the initiation and running of this study. Many of these difficulties highlight infrastructural problems which have been experienced in the Primary School Feeding Scheme and unless addressed will hinder the efficient running of any other control programme. These include:

1. Poor health infrastructure and lack of trained staff available to assist with the programme. On several occasions I was given staff members from various departments to assist me but they were not adequately trained.

2. Schistosomiasis was rated as a low priority disease by certain nursing staff. The priority of any public health problem does not depend on the amount of suffering, loss and death as a result of the disease but rather on the feasibility of effective control (Gyrseels 1989). Effective control of schistosomiasis would require treatment as well as a reduction in water contact by the local community. Several nurses felt that following treatment, children would enter the water and re-infection would occur. Thus, they felt that the time required for urine collection and treatment was not justified and that due to the limited number of staff numbers and the demands that are placed on them, they could be spending their time on many other projects. Schistosomiasis is requires long-term commitment from all parties. The nurses just did not have the time to commit.

3. Community problems, including: poor infrastructure, bad communication, apathy in co-operation by parents and some teachers, poverty and time delays were experienced.

4. Absenteeism amongst the school children and name problem. Many children were often absent for various stages of the programme. This resulted in children not receiving medication despite possibly being infected. These children could then maintain a level of infection. Longitudinal studies were hindered by the level of absenteeism. Specific pupils could not be followed through the various stages of the programme. Pupils names often posed a problem as they would use either their english names, traditional names, only surname or only first name. This complicated following specific pupils through various stages of the programme. Pupils need to be told at the start of the programme what name to use.

5. Expense of the programme and difficulty in raising sufficient funding. Control programmes, especially 'vertical' programmes are costly and rely heavily on external funding. This programme has cost in excess of R56 000.00. The expense of the programme was met via financial donations and equipment. The major expense of programmes is the cost of the drugs and examination. However, other expenses can be reduced by integrating vertical programmes into horizontal structures i.e. district-based health care delivery services, especially for the maintenance phase of the programme (Tanner 1989b). This worked to

some extent with Mpolweni, however the various health departments and university were having to adhere to strict budgets and were not able to contribute much.

6. Lack of schistosomiasis educational material.

7. Fragmentation and overlap of services resulting in inefficiency and poor use of available skills and resources. Personnel from various departments visited the Mpolweni area, however communication was poor between the employee's and often services overlapped or were neglected.

8. Difficulty in obtaining Biltricide® at the recommended control programme price of R3.70/tablet and later R1.25/tablet. I had extreme difficulty in obtaining tablets for the follow-up programme despite having the funds to pay for them. The health departments were not able to order extra for me as I was told they were allocated a certain quota and no more. I tried ordering them directly from the provincial pharmaceutical store and was told they could not sell any to me directly as they could not accept cash from me. As a last resort I tried ordering them directly from Bayer-Miles pharmaceutical company and was told they could not sell them directly to me, I had to order via a pharmacy or doctor. Time delays, number of calls and effort that was needed to obtain the tablets, despite having the funds to pay for them was remarkable!

9. The extent of the researchers responsibility to the community. In order to conduct a community-based study, the researcher needs to get to know the community, earn the trust and respect of the community before they can conduct their research. This all takes time. Once the research has been completed, researchers often leave and very little contact with the community is maintained. I question this lack of community interaction/assistance once the data has been collected. However, a researcher is limited by time, financial and other academic commitments which dictate the duration of involvement a researcher may be able to have with a community. Surely a balance between the two needs to be achieved.

10. Lack of guidance on how to run a control programme. One big problem was how to integrate the pilot control programme into the health services. Ideally they should be integrated from the start and strengthened as need be (Korte & Mott 1989). Initially, all relevant health parties were involved in the programme but as time progressed, instead of strengthening the programme with their support they backed out of the programme due to time, staff and financial constraints. I question whether the present health structures are strong enough to support such programmes.

A National Framework for Parasite Control was developed for the **National** Department of Health in **1995** but was very broad-based and did not focus on local strategies. At the time there was no clear methodology regarding sampling, treatment, education and analysis of samples. This has since been to some extent resolved, at least for KwaZulu-Natal.

Several of these difficulties were actually targeted for improvement by the National Health Plan (1994). The ANC is committed to the promotion of health through education and prevention. The guiding principles of the Health Plan aim to ensure that upliftment of overall health will result from the improvement of education, increased level of employment and the increased provision of housing, sanitation and electricity. Community participation will be encouraged at all levels but especially at the local level. There will be an increase in the training of health workers and an improvement of the health sector planning and monitoring of health status and health services. Fragmented health services at all levels will be united to form a comprehensive and integrated National Health System whereby an intersectoral approach will be encouraged. Epidemiological units will be strengthened at provincial and national levels, through the production and deployment of qualified health personnel and the appropriate allocation of necessary resources to ensure both continued epidemiological work and surveillance.

These guiding principles which are set out by the ANC may resolve some of the difficulties encountered with this study but they do not answer the more specific questions that are raised by it. The main question arising out the study is - who will conduct the maintenance phase of the control programme at Mpolweni Mission? The maintenance phase is the crucial one for ensuring good health in an area as health problems can be detected early and treatment/intervention will be prompt. An integrated approach is essential for the implementation of the maintenance phase. However, it seems with the adoption of the PHC approach, the trained staff working in the rural areas have been overburdened with work, so that none have the time to conduct follow-up schistosomiasis surveillance work. The maintenance phase requires a co-ordinator, someone to collect and screen freshwater snails, someone to collect and analyse urine samples, a laboratory in which to conduct the analyses, educational material and funding for the whole phase. It seems there are good guiding principles in place but not much action at grass roots level.

4.4 Suggestions

Presently there are good health guidance principles in place and if they can be achieved/maintained, health for all will be accomplished. However, there are discrepancies between these health principles and what is happening at grassroots level. These discrepancies can be reduced via the implementation of a few ideas. These include:

1. Co-ordination of workshops involving all relevant parties aimed at skill building and idea sharing;
2. Training programmes for various staff members who are going to assist with the programme prior to event happening;
3. Better communication between the nurses, academics and EHOs;
4. Nurses/EHOs should be able to recognise a problem, initiate research on it and follow it through to the end;
5. People at all levels of the programme should be involved in the assessment of its various stages thereby increasing enthusiasm, skills and knowledge;
6. Portfolios need to be established at the start of the programme;
7. EHOs should play a central role in problem recognition and assessment because of their close community contact and well established working relationship;
8. Analysis of specimens should be conducted by EHOs at Health Department-based laboratories;
9. There needs to be sound financial planning for the programme to ensure its long-term maintenance viability;
10. Targeted educational material needs to be designed and/or developed;
11. Create awareness of parasitic diseases at community level to improve knowledge and prevention;
12. Based on past studies, policy developers need to consider all relevant factors that may hinder the progress of a control programme.

CONCLUDING REMARKS ON SCHISTOSOMIASIS CONTROL IN SOUTH AFRICA

These concluding remarks and suggestions regarding schistosomiasis control in South Africa are based on encountered obstacles and lessons learnt whilst conducting the various components of this present multifaceted *S. haematobium* study. The study incorporated both theoretical and applied components and highlighted several important health issues and potential problem areas which may be encountered within a Schistosomiasis Control Programme. These South African issues have also been documented with recommendations by global researchers thereby highlighting the universality of these problems.

South Africa is in a unique position regarding schistosomiasis control and Primary Health Care (PHC) with their implementation having done a full circle. In the 1940s South Africa was the world leaders in PHC (Glatthaar 1992) and in the 1970s was advocating schistosomiasis control via Rural Management in rural areas (Pitchford 1966; Pitchford 1970). However, PHC and schistosomiasis control declined in years that followed and today the country faces the task of re-initiating and re-implementing within the developing PHC system. The task of implementing the recently drafted National Framework for Parasite Control (1995) is not going to be an easy one.

Urban schistosomiasis was recorded in Pietermaritzburg. This was a first for the city and a first for South Africa. The present schistosomiasis distribution could be influenced by the rural-urban migration that is impacting upon the major metropolitan areas. Without intermediate host snail surveys and schistosomiasis prevalence surveys amongst members of the population, the real geographic distribution of the disease will not be known. Both base-line data collections and follow-up assessments are needed.

There is a need for staff training programmes and a core staff based within the PHC system that is dedicated to parasite control. Successful planning, implementation and maintenance of schistosomiasis control programmes require sufficient numbers of well trained personnel at the district, regional and provincial levels as well as motivation of the community concerned. Different target groups may be identified for training, each of which requires a different training approach (Christensen *et al* 1989).

Feasible methods and strategies need to be developed at the beginning of a programme which will remain feasible and affordable for regular health services (Gryseels 1989). This includes allocation of staff to do the work. Successful control programmes have been possible where resources have been put into strengthening the infrastructure of health services, both facilities

and personnel (Anonymous 1993). The infrastructure of health services may be strengthened via workshops, improved communication, education courses, time allocated specifically to parasite programmes, project co-ordinators and designated tasks.

A horizontal approach relying heavily on community participation through PHC is considered essential for the success of any National or Provincial Control Programme. Vertical programmes may have operational advantages but are often short-lived and rely heavily on outside budgets and expertise (Gryseels 1989). The Mpolweni Mission case study highlighted the high cost of a partial vertical programme and the fact that the maintenance of the programme relies on its adoption by the PHC system. In order to cope with limited financial resources, schistosomiasis control activities should be integrated into the health regional level of the health care delivery services (Tanner 1989). The success of parasite control programmes is going to depend on careful financial budgeting.

There is a need for the standardisation of the use of schistosomiasis diagnostic techniques as several are available in this country and their diagnostic performance varies according to the diseases intensity and prevalence in a given area. The techniques may be used in series or in parallel. However, the use of various diagnostic techniques is going to be dictated more by the availability of funding than by any operational advantages.

There is a need for studies in small communities whereby the whole community can be examined, short-term follow-up strategies initiated, guidelines for control programmes may be formulated. Pilot projects should be integrated into National Health System from the beginning and these should be strengthened accordingly (Davis 1989).

A holistic approach incorporating health education and rural management in rural areas should run concurrently with any morbidity control programme. Once a programme has been initiated the evaluation and monitoring of control activities are pre-requisites for the successful maintenance of initial reductions in transmission and/or morbidity levels (Tanner 1989). Several disease control programmes, despite starting out well, often cannot sustain themselves at the levels of control achieved during the attack phase. This is due to several reasons namely, limited attempts to integrate these disease control activities into existing health services, programmes did not include appropriate mechanisms to ensure evaluation and monitoring during the maintenance phase, applied technologies did not match the cultural and social features of the communities in which they were applied and many of the technologies developed in the laboratory had not been shown to be effective in the field (Tanner 1989).

Areas for future research include: health systems research, i.e. the successful implementation of parasite control within the South African situation, freshwater snail distribution patterns need to be updated, patterns of prevalence and intensity of disease need to be established and the improvement of cost effective and efficient field diagnostic techniques.

The challenge of implementing the National Framework for Parasite Control, of which schistosomiasis is a major component, is immense in South Africa. Lack of finances, staff shortages, and a health system which is undergoing reform are just a few of the hurdles. As in the rest of the tropics, schistosomiasis is not the most prevalent or most serious of diseases; These are Aids, TB, malaria, diarrhoea and malnutrition. The fact that it is endemic to this country and may cause disease amongst the younger population means that it deserves attention. It is one disease for which there is a cure and reducing the prevalence levels in this country is an aim worth striving for. A recognition of the parasite problem, a desire for change within the health system and recognition of the "right time" are fundamental requirements for the successful implementation of the National Framework for Parasite Control.

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Appendix 1.1: The Pietermaritzburg Informal Settlement Questionnaire.

DATE:.....

NUMBER:.....

NAME:.....

AGE:.....

SEX:.....

1. WHERE DID YOU LIVE BEFORE YOU MOVED HERE?.....
2. WHEN DID YOU MOVE?.....
3. WHY DID YOU MOVE?.....
4. DO YOU SWIM IN A NEARBY DAM OR RIVER?.....
5. IF FEMALE - HAVE YOU STARTED MENSTRUATING?.....
6. IF YES - ARE YOU MENSTRUATING TODAY?.....
7. HAVE YOU GOT BLOOD IN YOUR URINE?.....
8. HAVE YOU EVER HAD BLOOD IN YOUR URINE?.....
9. DO YOU KNOW WHAT BILHARZIA/ISICHININI IS?.....

Appendix 1.2: *Bilharzia Atlas of South Africa* (1980) distribution data of *S. haematobium, B. africanus, B. pfeifferi* in the Greater Pietermartizburg Area.

Location	S. haematobium	B. africanus	B. pfeifferi
Pietermaritzburg	1-5%	present	absent
Table Mountain	1-5%	present	present
Mpolweni	51-70%	present	present
Sweatwaters	1-5%	present	absent
Claridge	11-25%	present	absent
Hopewell	26-50%	present	absent
Taylors	1-5%	present	absent
Henley Dam	absent	present	absent
Lidgetton	absent	absent	present
Albert falls	absent	present	present
Hilton	absent	absent	present
Balgowan	absent	absent	absent
Lion's River	absent	absent	absent

Appendix 2.1: Comparative sensitivity and specificity values for chemical urinalysis strips in areas of varying prevalence rates of infection.

Study site	method	sensitivity (%)	specificity (%)	gold std	prevalence(%) intensity
Gambia*	strips	39	96	filtration	55
Wilkins 1979	Ames	12h00		trace=200	
	1-60 yrs			ova/10ml	
Sudan*	strips	78		filtration	not available
Feldmeier 1982	Rapignost	10h00-11h00			
	Total screen A				
	6-11				
Ghana	Strips	79.5	85.2	Filter	72.3
Mott 1983	strip 1+	98	80		
	(Ames)				
	5-14				
Kenya	strips	88	97	nucleopore filter	47%
Stephenson 1984	trace	10h00-14h00			
	Ames				
	6-16yrs				gm=11.7
Zambia	Colour			Millipore filters	62%
Mott et al 1985	Quest				
	strips	81	95		
	5-14	10h00-14h00			
Ghana	Strips	80	85	Millipore filters	88%
Mott et al 1985	5-14				
Zimbabwe	strips	78	83	filtration	70%
Murare & Taylor 1987		10h00-12h00			
South Africa	strips	83.1	89.7	helminth filter	80.9%
Cooppan et al 1987	4-20yrs	12h00-14h00			
Pemba Island	strips	90	80	filtration	54.1%
Mott 1989					
Zimbabwe	strips	88.5	63.2	13mm Nytrel filters	65.9%
Taylor 1990	Ames				
	6-20yrs				17-49eggs
Tanzania	strips	90	78.7	25mm	60.4%
Lengeler 1991		12h00		Nucleopore	
		87.5	90	filters	
		14h00			gm=19.4
Tanzania	strips 1+	72	88.5	25mm	23.5%
Lengeler 1993	2+	57.8	94.9	polycarbonate	
	Combur9 multistick			strips	
Pemba Island	strip 1+	98.0	51.3	single filtration	
Lwambo et al 1997	strip 2+	78.9	81.7		
Nigeria	strips	69	80	filtration	57.3%
Mafe 1997	Ames				

* Values obtained from Murare & Taylor (1987)

Appendix 3.1 : Summary of results given by the qualitative and quantitative *Schistosoma haematobium* detection techniques used at Mpolweni Mission, Empangeni and Verulam. Lens = Lenstrip-5®, Ecur = Ecur-4®, Ames = Ames multistix-9®.

	Mpolweni		**Empangeni**		**Verulam**	
	Frequency (n)	(%)	Frequency (n)	(%)	Frequency (n)	(%)
Sedimentation (x2) 0	258	80.1	103	52.8	112	53.1
1	64	**19.9**	92	**47.2**	99	**46.9**
Filtration (x1) 0	180	55.9	136	69.7	59	28.0
1	142	**44.1**	59	**30.3**	152	**72.0**
Geometric mean Filtration (eggs/10ml)	**44.8**		**23.6**		**67.1**	
Geometric mean Sedimentation (eggs/10ml)	**39.5**		**22.9**		**61.7**	
Chemical urinalysis strips						
Haematuria						
Lens A (10 ery/µL)	147	**45.7**	90	**46.2**	132	**62.6**
Lens B (50 ery/µL)	112	34.8	64	32.8	115	54.5
Lens C (250ery/µL)	93	28.9	47	24.1	96	45.5
Ecur A (10 ery/µL)	125	**38.8**	84	**43.1**	121	**57.3**
Ecur B (50 ery/µL)	117	36.3	71	36.4	109	51.7
Ecur C (250 ery/µL)	92	28.6	55	28.2	90	42.7
Ames A (10 ery/µL)	165	**51.2**	80	**41.0**	143	**67.8**
Ames B (25 ery/µL)	91	28.3	56	28.7	111	52.6
Ames C (80 ery/µL)	85	26.4	52	26.7	101	47.9
Ames D (200 ery/µL)	79	24.5	43	22.1	90	42.7
Proteinuria						
Lens A (30 mg/dl)	81	**25.2**	60	**30.8**	94	**44.5**
Lens B (100 mg/dl)	62	19.3	35	17.9	82	38.9
Lens C (500 mg/ dl)	19	5.9	8	4.1	21	10.0
Ecur A (30 mg/dl)	111	**34.5**	83	**42.6**	106	**50.2**
Ecur B (100 mg/dl)	39	12.1	12	6.2	44	20.9
Ecur C (500 mg/dl)	5	1.6	2	1.0	12	5.7

Appendix 3.1: Continued.

Ames A (10 mg/dl)	237	**73.6**	120	**61.5**	131	**62.1**
Ames B (30 mg/dl)	107	33.2	54	27.7	91	43.1
Ames C (100 mg/dl)	54	16.8	17	8.7	54	25.6
Ames D (300 mg/dl)	18	5.6	1	0.5	18	8.5
Ames E (2000 mg/dl)	5	1.6	1	0.5	5	2.4
Urine colour analysis red	20	**6.2**	7	**3.6**	22	**10.4**
Questionnaire 0 Question 1	164	67.8	139	71.6	106	62.7
1	78	**32.2**	55	**28.4**	60	**35.5**
Question 2 0	165	68.2	141	72.7	101	59.8
1	73	**30.2**	53	**27.3**	67	**39.6**

Appendices 3.2 A, B,C: Comparative data for three brands of chemical reagent strips at haematuria cut-off values A, B,C,D at Mpolweni Mission (A), Empangeni (B) and Verulam (C) where A, B, C, D represents 10ery/μl, 50ery/μl, 250 ery/μl for Lenstrip-5® and Ecur-4® but 10ery/μl, 25ery/μl, 80ery/μl and 200ery/μl for Labstix®.

A

Sensitivity (%)	Lenstrip-5®	Ecur-4®	Labstix®
A	76.1	74.6	80.3
B	69	71.1	59.2
C	60.6	59.9	56.3
D	-	-	52.8
Specificity (%)			
A	78.3	89.4	71.7
B	92.2	91.1	96.1
C	96.1	96.1	97.2
D	-	-	97.8
Negative predictive value (%)			
A	80.6	81.7	82.2
B	79.0	80	74.9
C	75.5	75.2	73.8
D	-	-	72.4
Positive predictive value (%)			
A	73.5	84.8	69.1
B	87.5	86.3	92.3
C	92.5	92.4	94.1
D	-	-	94.9
Efficiency (%)			
A	77.3	82.9	75.5
B	81.9	82.3	79.8
C	80.4	80.1	79.2
D	-	-	77.9

B

Sensitivity (%)	Lenstrip-5®	Ecur-4 ®	Labstix®
A	91.5	93.2	88.1
B	76.3	83.1	64.4
C	55.9	62.7	61.0
D	-	-	50.8
Specificity (%)			
A	73.5	78.7	79.4
B	86.0	83.8	86.8
C	89.7	86.8	88.2
D	-	-	90.4
Negative predictive value (%)			
A	95.2	96.4	93.9
B	89.3	91.9	84.9
C	82.4	84.3	83.9
D	-	-	80.9
Positive predictive value (%)			
A	60	65.5	65
B	70.3	69.0	67.9
C	70.2	67.3	69.2
D	-	-	69.8
Efficiency (%)			
A	78.9	83.1	82.1
B	83.1	83.6	80
C	79.5	79.5	80
D	-	-	78.5

C

Sensitivity (%)	Lenstrip-5®	Ecur-4®	Labstix®
A	79.6	73.7	82.9
B	71.1	69.1	69.1
C	61.2	57.9	63.2
D	-	-	57.9
Specificity (%)			
A	81.4	84.7	71.2
B	88.1	93.2	89.8
C	94.9	96.6	91.5
D	-	-	96.6
Negative predictive value (%)			
A	60.8	55.6	61.8
B	54.2	53.9	53.0
C	48.7	47.1	49.1
D	-	-	47.1
Positive predictive value (%)			
A	91.7	92.6	88.1
B	93.9	96.3	94.6
C	96.9	97.8	95.0
D	-	-	97.8
Efficiency (%)			
A	80.1	76.8	79.6
B	75.8	75.8	74.9
C	70.6	68.7	71.1
D	-	-	68.7

Appendices 3.3 A, B,C: Comparative data for three brands of chemical reagent strips at proteinuria cut-off values A, B,C,D at Mpolweni Mission (A), Empangeni (B) and Verulam (C) where A, B, C, D represents 30mg/dl, 100mg/dl, 500mg/dl for Lenstrip-5® and Ecur-4® but 10mg/dl, 30mg/dl, 100mg/dl, 300mg/dl and 2000mg/dl for Labstix®.

A

Sensitivity (%)	Lenstrip®	Ecur®	Labstix®
A	46.5	61.9	92.9
B	38.0	26.0	60.6
C	11.9	3.5	33.8
D	-	-	11.3
E	-	-	3.5
Specificity (%)			
A	91.7	87.2	41.7
B	95.6	98.9	88.3
C	98.9	100	96.7
D	-	-	98.9
E	-	-	100
Negative predictive value (%)			
A	68.5	74.4	88.2
B	66.2	62.9	73.9
C	58.7	56.8	64.9
D	-	-	58.6
E	-	-	56.8
Postive predictive value (%)			
A	81.5	79.3	55.7
B	87.1	94.9	80.4
C	89.5	100	33.8
D	-	-	11.3
E	-	-	3.5
Efficiency (%)			
A	71.7	79.2	64.3
B	70.2	66.7	76.1
C	60.5	57.4	68.9
D	-	-	60.2
E	-	-	57.4

B

Sensitivity (%)	Lenstrip®	Ecur®	Labstix®
A	54.2	72.9	89.8
B	33.9	11.9	52.5
C	5.1	1.7	11.9
D	-	-	0
E	-	-	0
Specificity (%)			
A	79.4	70.6	50.7
B	88.9	96.3	83.1
C	96.3	99.3	92.6
D	-	-	99.3
E	-	-	99.3
Negative predictive value (%)			
A	80	85.7	92
B	75.6	71.6	80.1

Appendix 3.3b: Continued.

Negative predictive value (%)			
A	80	85.7	92
B	75.6	71.6	80.1
C	70.1	69.9	70.8
D	-	-	69.6
			69.6
Positive predictive value (%)			
A	53.3	51.8	44.2
B	57.1	58.3	57.4
C	37.5	50.0	41.2
D	-	-	0
E	-	-	0
Efficiency (%)			
A	71.8	71.3	62.6
B	72.3	70.8	73.8
C	68.7	69.7	68.2
D	-	-	69.2
E	-	-	69.2

C

Sensitivity (%)	Lenstrip®	Ecur®	Labstix®
A	58.6	72.9	75
B	51.3	11.9	55.3
C	13.8	1.7	35.5
D	-	-	11.8
E	-	-	3.3
Specificity (%)			
A	91.5	70.6	71.2
B	93.2	96.3	88.1
C	100	99.3	100
D	-	-	100
E	-	-	100
Negative predictive value (%)			
A	46.1	85.7	52.5
B	42.6	71.6	43.3
C	31.1	69.9	37.6
D	-	-	30.6
E	-	-	28.6
Positive predictive value (%)			
A	94.7	51.8	87.0
B	95.1	58.3	92.3
C	100	50.0	100
D	-	-	100
E	-	-	100
Efficiency (%)			
A	67.8	70.6	73.9
B	63.0	48.8	64.5
C	37.9	33.6	53.6
D	-	-	36.5
E	-	-	30.3

Appendix 3.4: Diagnostic performance of urine colour scales of cloudy yellow, cloudy brown and red at Mpolweni, Empangeni and Verulam.

Sensitivity (%)	Mpolweni	Empangeni	Verulam
Red	13.4	5.1	13.8
Cloudy brown	83.3	54.2	38.2
Cloudy yellow	72.9	76.3	57.2
Specificity (%)			
Red	99.4	97.1	98.3
Cloudy brown	67.2	79.4	98.3
Cloudy yellow	78.0	58.8	86.4
Negative predictive value (%)			
Red	59.3	70.2	30.7
Cloudy brown	93.3	80.0	38.2
Cloudy yellow	78.9	85.0	43.9
Positive predictive value (%)			
Red	95	42.9	95.5
Cloudy brown	42.3	53.3	98.3
Cloudy yellow	71.8	44.6	91.6
Efficiency (%)			
Red	61.5	69.2	37.4
Cloudy brown	70.8	71.8	55.0
Cloudy yellow	75.7	64.1	65.4

Appendix 3.5: Diagnostic performance of questions (1) and (2) at Mpolweni, Empangeni and Verulam where (1) represents the question - Do you have blood in your urine?, and (2) - Do you have bilharzia?

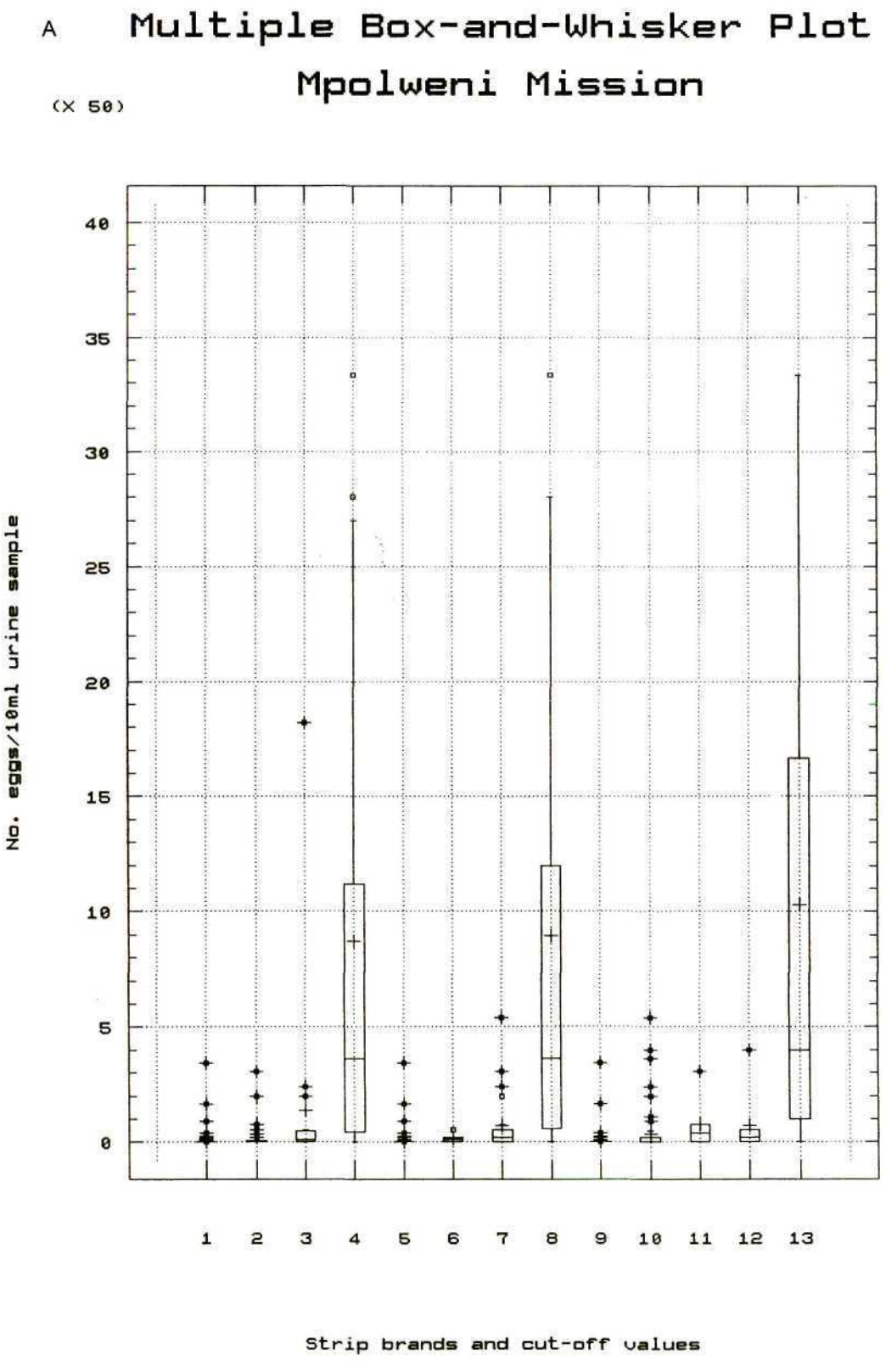
Sensitivity (%)	Mpolweni	Empangeni	Verulam
A	49.0	62.7	46.7
B	48.5	62.7	50.4
Specificity (%)			
A	80.4	86.6	93.2
B	82.5	88.1	88.9
Negative predictive value (%)			
A	67.7	84.2	38.7
B	68.5	84.4	39.6
Positive predictive value (%)			
A	65.4	67.3	95
B	67.1	69.8	92.5
Efficiency (%)			
A	66.9	79.4	59.8
B	68.1	80.4	60.7

Appendix 3.6: Comparative data for three brands of chemical reagent strips at haematuria cut-off values A, B,C,D at Empangeni where A, B, C, D represents 10ery/μl, 50ery/μl, 250 ery/μl for Lenstrip-5® and Ecur-4® but 10ery/μl, 25ery/μl, 80ery/μl and 200ery/μl for Labstix®. The 'gold standard' is sedimentation.

Empangeni	Lenstrip-5®	Ecur-4®	Labstix®
Sensitivity	79.3	79.3	75
A	63.0	69.6	54.3
B	50	54.3	52.2
C			45.7
D			
Specificity			
A	83.5	89.3	89.3
B	94.2	93.2	94.2
C	99.0	95.1	96.1
D			99.0
Positive predictive value			
A	81.1	86.9	86.2
B	90.6	90.1	89.3
C	97.9	90.9	92.3
D			97.7
Efficiency			
A	81.5	84.6	82.6
B	79.5	82.1	75.4
C	75.9	75.9	75.4
D			73.8

Appendix 3.7a,b,c: Multiple Box-and-Whisker plots of No. of eggs/10ml urine sample against the three individual chemical urinalysis strips and their cut-off values for Mpolweni (A), Empangeni (B) and Verulam (C). 1, 2, 3, 4 = Lenstrip-5® (0 ery/µl, 10 ery/µl, 50 ery/µl 250 ery/µl, respectively); 5, 6, 7, 8 = Ecur-4®(0 ery/µl, 10 ery/µl, 50 ery/µl 250 ery/µl, respectively); 9, 10, 11, 12, 13 = Ames® (0 ery/µl, 10 ery/µl, 25 ery/µl, 80ery/µl, 200 ery/µl, respectively).

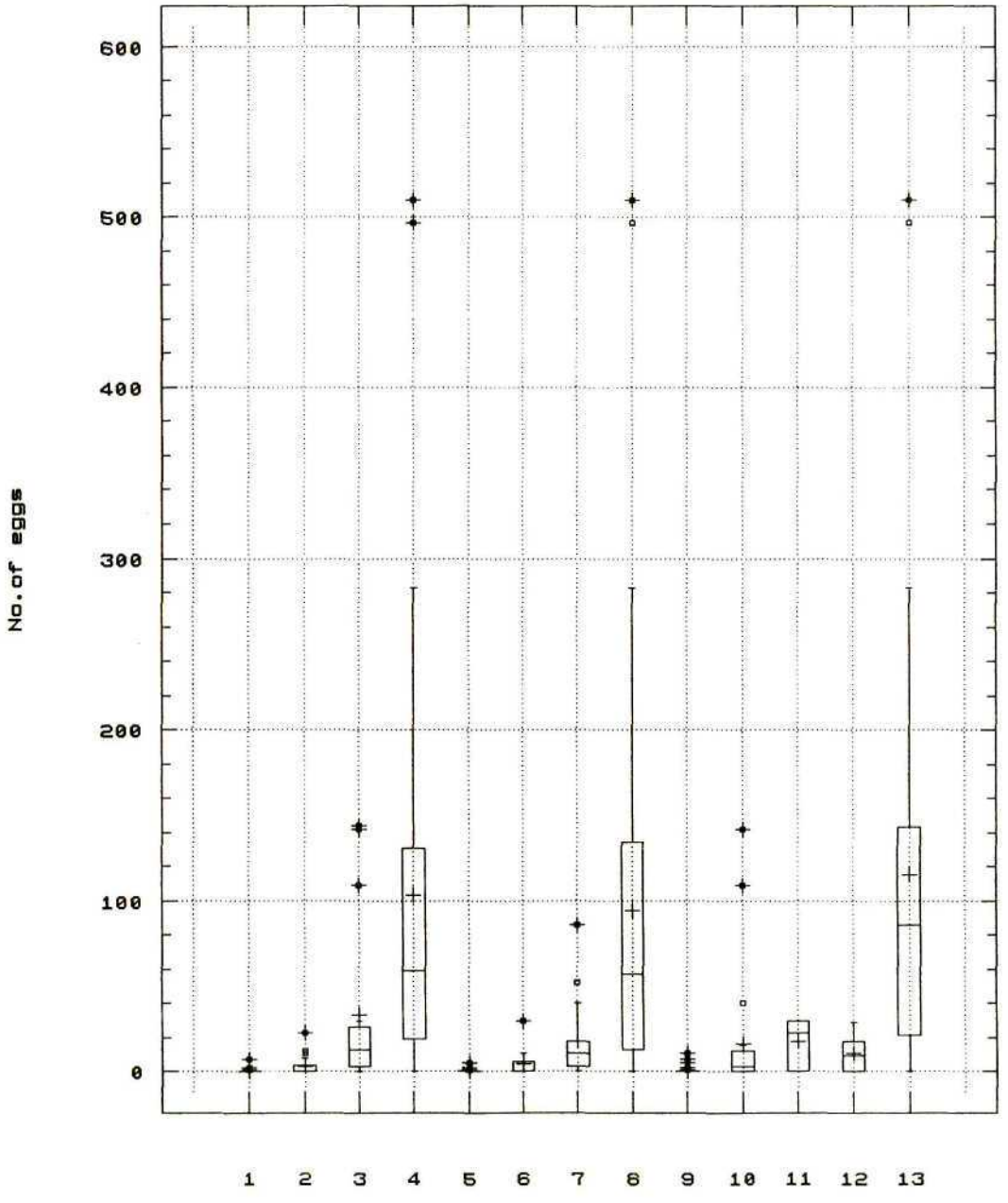
A



B

Multiple Box-and-Whisker Plot

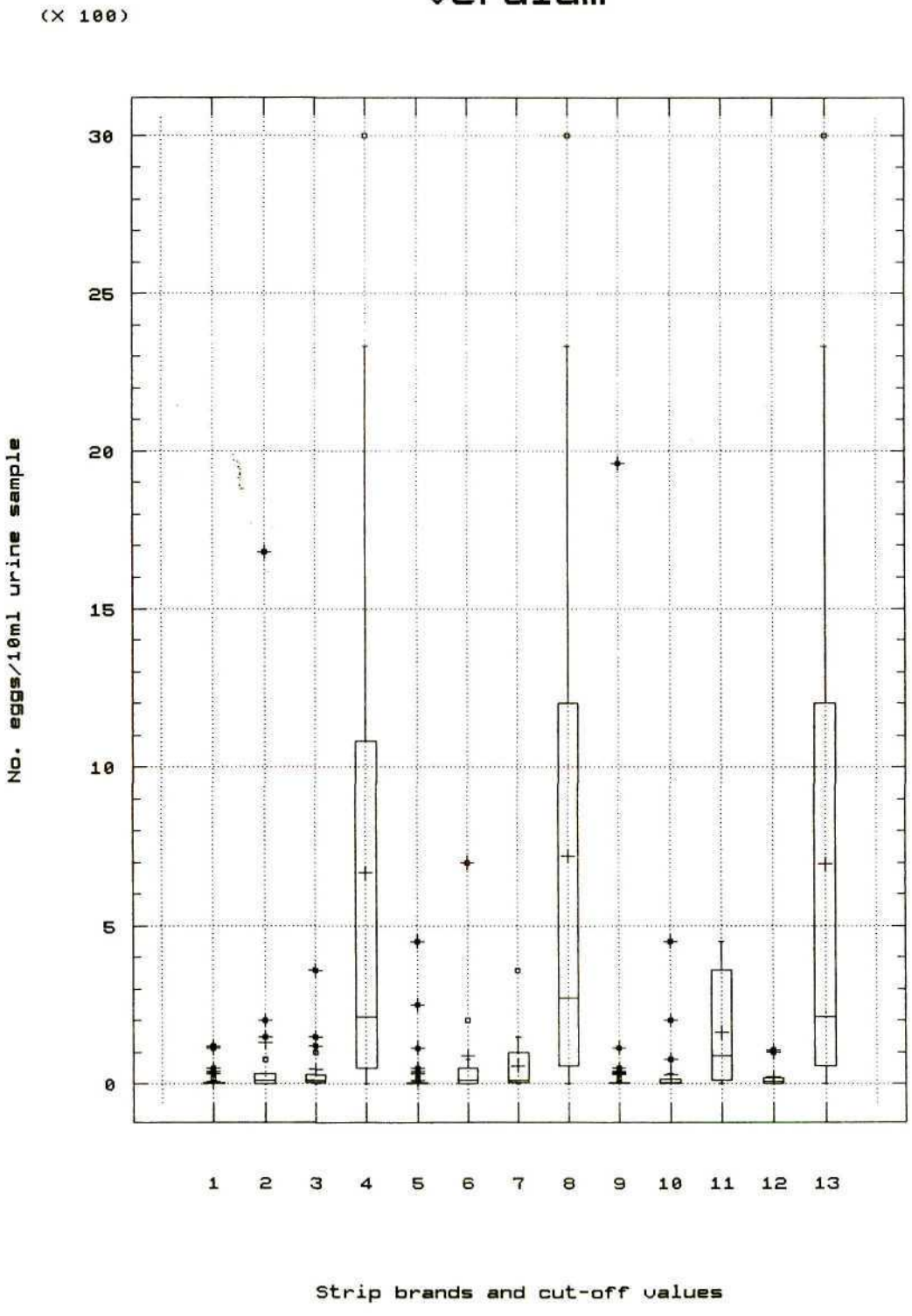
Empangeni



C

Multiple Box-and-Whisker Plot

Verulam



Appendix 4.1a: Mpolweni Mission Schistosomiasis Education Poster.

BILHARZIA

Many people in our community have Bilharzia. But most people don't even know that they have it. It is not a disease that will kill you fast, but it can make you feel very tired and sick at the same time. You learn that anyone who swims or walks in rivers or dams can get it.

WHAT IS BILHARZIA?

A Bilharzia is a disease caused by worms. These worms spend part of their life in people and part in specific freshwater snails.

B In people the worms live in the blood around the bladder and intestine. These worms produce eggs.

male

female

C The eggs come out of the person's body when they urinate or defecate. If people urinate/defecate into the water, these eggs hatch into small worms.

D The small worm looks for freshwater snails and move into them. They grow into bigger worms and come out of the snails and into the water. They are very small. They look for people, go into the peoples' blood and grow.

How can we know if we have Bilharzia?

THERE ARE SOME SIGNS THAT WARN US THAT WE MIGHT HAVE BILHARZIA. THESE ARE:

- Blood in the stools or in the urine.
- It is painful to urinate
- Tiredness and feeling rundown
- If the disease is not treated, after some years it can cause problems in the blader and liver

Who can get Bilharzia?

- Anyone who swims, baths or plays in the water can get Bilharzia.

I think I have Bilharzia. What can I do?

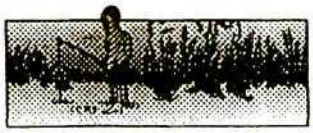
- You should go to the clinic. The nurse will have to find out if the worm's eggs, which cause Bilharzia, are in our urine. She will send some of your urine for testing.
- You will have to come back to the clinic to hear if you have the worm's eggs in your urine.
- If you are infected, the Doctor will give you some pills to take. These pills will kill the worms inside your body. You need to finish all the pills the Doctor gives you.

How can I make sure my children don't get Bilharzia?

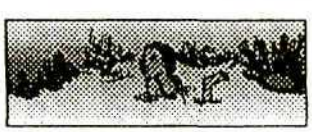
There may be some people in your area that are infected with Bilharzia. If they use the river, the river banks or the dam as a toilet the Bilharzia eggs will go into the water. Your community should discuss this problem. If you build latrines, it will help prevent the disease.

Your children can get infected if they play in the water where the worms are living. You can also get the disease if you use the water for washing or cleaning. If there are people in your area who have Bilharzia, try not to go into the water.

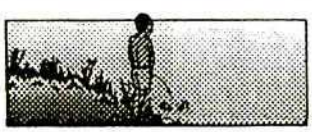
HERE ARE SOME IDEAS YOU CAN DISCUSS WITH YOUR COMMUNITY:



- AVOID PROLONGED CONTACT WITH THE WATER



- AVOID BATHING OR SWIMMING IN THE WATER



- DON'T URINATE IN THE WATER

- AS A COMMUNITY, CREATE AN AWARENESS THROUGH EDUCATION

EXTERNAL EDUCATION SERVICES - Tel: (0331) 411111 (for further water education)

INFORMATION SUPPLIED BY:

THE CENTRE FOR INTEGRATED HEALTH RESEARCH - UNIVERSITY OF NATAL Tel: (031) 2601187

WORKSHEET
Bilharzia in South Africa

1. Does Bilharzia occur in South Africa? If yes, list the regions it occurs in.

2. What is Bilharzia?

3. How do people CAUSE the spread of Bilharzia?

4. How do people CATCH bilharzia?

5. Underline the THREE most important requirements for the transmission of bilharzia:
AIR, WATER, VEGETATION, PEOPLE, SOAP, ROCKS, FRESHWATER, SNAILS, RAIN.

6. List the 4 stages of the parasites lifecycle:

7. Which stage affects people?

8. Is bilharzia an important disease one should try to prevent people from getting? Why?

9. How can bilharzia be diagnosed in people?

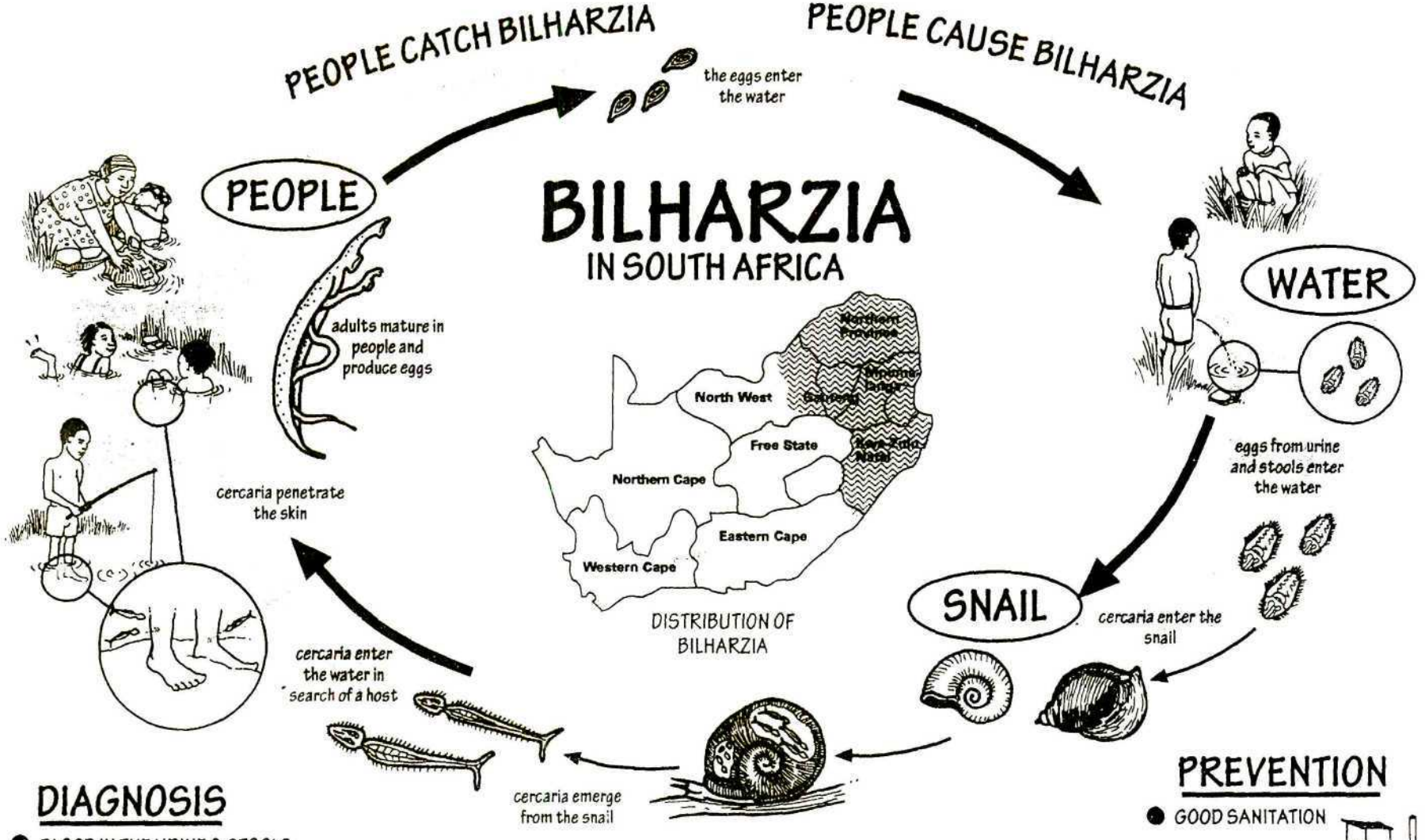
10. What does one do if one suspects one has bilharzia?

11. Do you think bilharzia is a problem in your community?

12. What can be done to reduce the spread of bilharzia in your community?

TASK TO DO:

Go out and find someone in the community who does not know about bilharzia and teach them about it.



DIAGNOSIS

- BLOOD IN THE URINE & STOOLS
- TIREDNESS
- SKIN RASHES
- PAINFUL URINATION

PREVENTION

- GOOD SANITATION
- EDUCATION
- PIPED/PUMPED WATER FOR WASHING
- LIMITED WATER CONTACT

GO TO THE CLINIC IF YOU THINK YOU HAVE BILHARZIA

UMGENI WATER EXTERNAL EDUCATION SERVICES
For further information TEL: (0331) 411111

INFORMATION SUPPLIED BY: THE CENTRE FOR INTEGRATED HEALTH RESEARCH - UNIVERSITY OF NATAL Tel: (031) 2601187

Appendix4.2: Mpolweni Mission Primary School Health Test

Health and Sanatation Test (Std 1-Std 5)

Germs are found everywhere. Germs can make people sick if they do not have good health and sanitation behaviour. Sipho and Gladness will ask you some questions about good or bad health behaviour.

1. Can anyone get sick from drinking unpurified water?

.....

2. Should all water be purified being used?

.....

3. List two methods for water purification?

.....

.....

4. Should food be kept covered at all times?

.....

5. Why should food be kept covered at all times?

.....

.....

6. Should Gladness wash her hands before eating?

.....

7. Should Sipho wash his hands after he has been to the toilet?

.....

8. If someone in your family has diarrhoea, should they go to the doctor as soon as possible?

.....

9. How much salt and how much sugar should you give someone who has diarrhoea?

.....

Appendix 4.2. Continued

10. If Gladness throws rubbish into the river will it affect her friends that live further down the river?

.....

11. Sipho is walking along the river and he needs the toilet, should he urinate in the water?

.....

12. Does bilharzia occur in your river?

.....

13. List 4 activities where you can catch bilharzia?

.....

.....

.....

.....

.....

14. Tick 4 ways to prevent bilharzia

- urinate and deficate in toilets
- educate people about bilharzia
- wash in the river with soap
- stand in fast flowing water
- use piped water to wash clothes, drink and bathe
- don't have any water contact, i.e. no swimming

15. How will Sipho know he has bilharzia?

.....

.....

16. Can bilharzia be treated?

.....

17. Where did you learn about bilharzia?

.....

18. Where did you learn about diarrhoea?

.....

19. Should you tell all your friends and family about the importance of good health?

.....

20. Can disease like bilharzia, diarrhoea be prevented?

.....

Remember good health starts with your own behaviour, then your families behaviour and then your communities behaviour. All behaviour affects everyone. Take care of yourself and your environment and keep healthy.

Appendix 4.3: Mpolweni Mission High School Health Test.

Health and Sanitation test (Std 6 to Std 9)

Health is a very important issue and it begins with your own personal hygiene and behaviour. Good health requires good clean water, sanitation, nutrition and a clean environment.

Please answer the following questions regarding health behviour.

1. Should all water that is obtained from rivers, springs and dams be purified? Yes or No.

.....

2. List three methods to purify water.

.....

.....

.....

3. Is river water unpolluted and clean after it has rained? Yes or No.

.....

4. Should water containers be kept clean? Yes or No.

.....

5. Should water containers be kept covered? Yes or No.

.....

6. Circle ALL the disease obtained from unpurified water.

* Flu *Cholera *Bilharzia *Dysentery

7. What is bilharzia?

.....

.....

8. List two human activities that CAUSE the spread of Bilarzia.

.....

.....

.....

9. List four activities whereby people can CATCH bilharzia.

10. List three symptoms of Bilharzia.

11. List four methods of preventing the spread of biharzia.

12. Does the river at Mpolweni have Bilharzia? Yes or No.

13. Where did you first learn about Bilharzia?

14. List two treatment methods for diarrhoea.

15. What should one always do before eating, preparing food or after going to the toilet?

16. Why should food be kept covered at all times?

17. Where should toilets NOT be built?

18. Should one urinate or deficate in the water? Yes or No.

Appendix 4.3: Continued.

19. Does cattle dung contain diseases? Yes or No.

.....

20. Is it a good idea to allow cattle and people to use the same areas along a river? Yes or No.

.....

21. Can cattle pollute the river with their faeces? Yes or No.

.....

22. Tick the statement which will improve your communities health.

- Educate your friends and family about good health behaviour.
- Don't pollute the river nor litter the areas around your homestead.
- Work together with members of your community to improve your environment.
- work as a group and raise money to improve your environment.
- Change begins with you, nobody is going to improve your community for you.

Appendix 4.4a: Total operational expenses of the Mpolweni Mission *S. haematobiuim* case-study.

ITEM	PRICE/UNIT	UNITS REQUIRED	AMOUNT
URINE ANALYSIS			
Honey jars 250ml	R274.40/280	350	548.80
Plastic sample bottles 40ml	R230.00/500	1000	460.00
Syringe 10ml	R 1.75/1	20	35.00
Pipettes	R 30.00/280	1000	120.00
Glass slides (26mm x 76mm)	R 9.50/50	2500	475.00
Cover slips	R 14.00/100	2500	350.00
Disposable gloves	R 33.50/100	100	33.50
Formalin	R25.00/2.5L	>2.5L	25.00
Boehringer Mannheim (Ecur[4]- Test®)Combur 10	R 35.70/50	350	
Ames (Labstix®) Multistix	R116.00/100	350	
Benmore Diagnostics (Lenstrip 5®)	R 28.50/100	350	114.00
filters (Swinnex 13)	R180.00/10	10	180.00
holders			
8 μm membranes	R202.00/100	350	808.00
filters (25mm)	R347.00/12	-	
8 μm membranes	R223.00/100	-	
Disenfectant			
COMMUNITY EDUCATION PROGRAMME			
DramAidE			7000.00
Acorn Toilet hire Company			963.00
Photostats			1000.00
Food			3500.00
Audiovisual			550.00
Umbrella Star Hiring Company			362.31
SCHOOL EDUCATION PROGRAMME			
Production poster			17 000.00
Photostats			860.00
Newspaper article	R950.00/pg		1900.00
CHEMOTHERAPY			
Biltricide®	R372.32/100	4500	16754.40
Scale			
Paper cups 175ml	R 45.10/500	1065	135.30
Black bags	R8.59/20	20	8.59
MOLLUSCICIDE			
Bayluscide®	R368.00/1kg		-
Sprayer 20L	R515.71		-

Appendix 4.4a: Continued.

FOLLOW-UP STUDY 22/10/97			
Boehringer Mannheim (Ecur[4]- Test®)	R 53.75/ 50	1500	-
Ames (Labstix®)	R130.20/100	1500	-
Promex Diagnostics (Urichek 5N®)	R 25.00/100	1500	427.50
Savlon liquid	R 6.69/250ml	250ml	6.69
Black bag roll	R 8.59/20	40	17.18
Plastic honey jars 250ml	R274.40/280	1065	1097.60
Biltricide®	R1.25/tablet	1500	1875.00
Photostats	20c/copy	R90.00	90.00
TOTAL			**56 696.87**

Appendix 4.4b: Quotations for the Community Health Education Play.

	Fee	Total
Hexagon theatre		
direction fee	R6000.00-R7000.00	
actor fee/ actor (x3)	R800.00	
script production	R1500.00	
		R9 900.00
Natal Witness		
direction fee	R4000.00	
script production	R4000.00	
stage hire	R2000.00	
actor fee/actor	R600.00	
		R11 800.00
KLF Productions		
stage hire	R3500.00	
car hire	R180.00/day + 91c/km	
Generator	R170.00/day	
PA system	R2500.00	
Microphone	R180.00	
		R6 990.00
DramAidE		
Play	R6000.00	
workshops (x3)	R2000.00 each	
		R12 000.00

Appendix 4.5: DramAidE/Go Grow organisational details.

'DramAidE' is an existing four-year state-funded programme in which a drama approach to health, sexuality, life skills and HIV/AIDS education is offered in secondary schools in KwaZulu-Natal. The DramAidE programme has been running successfully in KwaZulu-Natal secondary schools since October 1992.

Contents and Breakdown of the play

Go Gro felt that due to the nature of the environment in which we will have to perform this play, i.e. large number of people, poor audibility, people arriving and leaving all the time, our play had to concentrate on short scenes rather than a long involved drama.

The team decided that the play and all the workshops needed to be performed in Zulu as it is crucial that the messages are understood. Our focus , in the play, is to activate the audience to listen to the information given, using bright vivid colours, dramatic energy, humour and contextual situations. We felt that each individual situation needs to be assessed and the edutainment adjusted to their own community needs.

From discussions with the community during the workshops our concentration naturally fell on the Umshwati River as the primary water source for that community. People were also worried about levels of visible pollution, mentioning dead cattle lying in the river up stream and people still using the water down stream.

From discussion with the Task team at Umgeni Water we felt our emphasis should be on faecal contamination, poor livestock practises, the use of untreated water for bathing, washing, drinking and cooking, effective purification of water, use of latrines in the community and the symptoms of bilharzia and waterborne diarrhoeal diseases.

Due to DramAidE's experience in working with rural and peri-urban communities we felt that the most important emphasis of the whole project needs to be on the use of context based education, making the information found in the plays and workshops interesting, relevant and empowering. This participatory approach needs to be combined with the use of existing infrastructures and available resources to reinforce the initial information.

Breakdown of each Scene

Scene One:

Our focus in the first scene was to highlight the community's participation in the pollution of their river, their life source. This pollution takes the form of faecal contamination, deliberate "cleansing" of the body through vomiting and use of :African syringes" and poor livestock management practises. The focus is on "bad" practises in a humorous manner and contrasting this with someone in the play who has some knowledge of the right sanitary practises but need the audience's participation to further her own knowledge. In this way the audience is an active participant in the transferring of knowledge to the characters and within their own community.

Scene Two:

This scene involves the use of contaminated water, specifically for the purposes of drinking and washing. The women in the community need to be directly emphasised as they are the care-givers in his community , run the household in terms of washing, supplying water and ensuring the education of the young girls in the community, the mothers of the next generation. Our focus in this scene is to introduce the topic of bilharzia and the need to purify the water that is used in the household as well as emphasise the dangers of immersing oneself in a contaminated river. This role-play develops into a forum theatre workshop where the audience participate and are responsible for the enlightenment of the characters and through this, their own community.

Scene Three:

This scene highlights the use of the correct water vessels, those with a small opening and lid, as opposed to big communal buckets with the high risk of contamination. It is set in the context of a communal structure where the entire family is reliant of communal water for their needs. The risks of infection through incorrect sanitation practises and through not purifying water are stressed.

Scene Four:

This scene looks at the infection and treatment of diarrhoea in infants. It looks at the common practise of consulting a sangoma for suspected witchcraft and emphasises treatment of diarrhoea through oral rehydration solution . The audience are again asked to participate in the education of the characters in how to make this solution.

Scene Five:

Bilharzia and the risk of infection through children swimming in the river is highlighted in this scene. The children themselves are the educators and discuss the symptoms of bilharzia and diarrhoea.

The Songs:

Songs are used throughout the performance to reinforce the messages given in the play. They are all very well known traditional songs that have been adapted to convey a specific message. The audience will be invited to join in all the songs and the team will teach everyone our "theme" song, "Amanzi".

The Workshops after the Play

The workshops are based on the scenes in the play and take the previously incorrect sanitation or purification issue and involves the audience in creating a "new" scene that shows the correct practise.

Workshop One:

Based on scene one, the audience is asked to stop the scene when they feel that an incorrect sanitary practise occurs. If they do not stop the action the characters will continue until the end of the scene and the facilitator will adapt her questions to include questions like:

"Why should this man not use the river to defecate, the water washes away all the pollution."

"Why shouldn't we drink this water, I'm sure some of you have been drinking this water all your life and you are not ill?"

Workshop Two;

Using the purification of water scene, the audience are again asked to interrupt the scene. Facilitation of these workshops are based on the principle that people need to find the answers to the questions themselves and challenging existing stereotypes and established beliefs opens up discussion and promotes thinking about the topic.

Workshop Three:

This workshop is based on the scene in which the infant is infected with untreated river water. Questions that could arise are:

"All babies get diarrhoea, it is not a serious disease . Do you really think that babies should be taken to the clinic if they have blood in their stools?"

"We rely on this water - how can we solve this problem?"

Appendix 4.7: Sponsors of the Mpolweni Mission *S. haematobium* case study.

I would like to thank all sponsors of the programme. Without their support the programme would not have continued as long as it did. Many valuable lessons were learnt during the running of the programme. Thank you.

- Health Systems Trust
- Umgeni Water External Education Services
- Umgeni Water Pollution Prevention Division
- Development Facilitation - inland region
- KwaZulu-Natal Department of Health
- University of Natal, Zoology department
- Suncrush Limited
- Bayer-Miles Pharmaceutical Company
- Benmore Diagnostics Pharmaceutical Company
- Boehringer-Mannheim Pharmaceutical Company

HEALTH SURVEY

Name of School:_____ **Class:**_____ **Date:**_____

PUPILS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
AGE																																									
SEX (M/F)																																								

Question 1. Which of the Following Symptoms did you Experience in the Last 2 Weeks?

Coughing																																									
Itching																																									
Headache																																								
Fever																																								
Abdominal Pain																																								
Blood in Urine																																								
Blood in Stool																																								
Diarrhoea																																								

Question 2. Which of the Following Diseases did you Experience in the Last 2 Weeks?

Worms																																								
Respiratory Infection																																								
Skin Disease																																								
Eye Disease																																								
Bilharrzia																																								
Dental Problems																																								
Discharging Ears																																								

Mark Each Square with the Following

Yes ☑
No o
Don't Know –