niversity
in International Nutrition

SCHISTOSOMIASIS AND MALNUTRITION

Edited by Lani S. Stephenson

I. Schistosomiasis and Human Nutrition
by Lani S. Stephenson
with assistance from Michael C. Latham and Betty Mlingi

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This monograph is dedicated to
the millions of schistosomiasis infected
children in the world

because

...this insidious and chronic disease lacks the drama usually associated with other spectacular infections... The parasite relies on co-existence rather than elimination of its hosts, and this results in chronic debility...with underestimated overt morbidity and mortality. But the damage done to the individual and the community is much more than meets the eye. Our present difficulties relate mostly to the measurement of the invisible damage done."

M. Farooq, 1964

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I. INTRODUCTION

For over 35 years, researchers have reported statistically significant relationships between schistosomiasis and nutritional status in human populations (1), but the public health importance of these relationships in schistosomiasis-infected communities is still unclear. The nutritional effects of schistosomiasis deserve careful evaluation for 3 reasons: 1) schistosomiasis is most common in developing countries where various forms of malnutrition, particularly protein-energy malnutrition and nutritional anemias, are prevalent; 2) the infection tends to reach its peak prevalence and intensity in children, who are vulnerable to malnutrition because of their extra nutrient requirements for growth; and 3) schistosomiasis can cause various forms of pathology (*eg*, hematuria, proteinuria, splenomegaly, hepatomegaly, and lesions in the urinary and gastrointestinal tracts) all of which have nutritional implications. The purpose of this paper is three-fold: 1) to discuss mechanisms by which schistosomiasis could cause or aggravate malnutrition; 2) to review the current scientific evidence that schistosomiasis does affect human nutrition in the cases of *S. haematobium*, *S. mansoni*, and *S. japonicum* infections; and 3) to suggest study designs useful in determining the effects of schistosomiasis on human nutrition. Relationships between *S. mansoni*, *S. japonicum* and other schistosome infections and nutrition have also been studied in animal models; a list of key references appears in Appendix I. Extensive reviews of the pathology of experimental infections with *S. haematobium* and *S. japonicum* and comparisons with human infections with those parasites have also been published recently (2,3). Excellent discussions of the parasitology, pathology, immunology, epidemiology, malacology treatment,diagnosis, and control strategies for human schistosome infections are available elsewhere (4-16).

II. MECHANISMS BY WHICH SCHISTOSOMIASIS COULD AFFECT HUMAN NUTRITION

The negative effects of schistosomiasis on nutritional status are important to identify and quantitate in order to assess the total benefit to community health which might result from schistosomiasis control.

If the disease adversely affects nutritional status, four or more mechanisms may be involved: a) a decrease in nutrient intake, eg. anorexia; b) a decrease in nutrient absorption from the GI tract; c) a decrease in nutrient utilization in the body, and/or d) an increase in nutrient excretion from the body. Regarding nutrient intake, any of the 3 major species of schistosomes could cause anorexia due to either a feeling of general malaise or due to fever, particularly in the acute or in the late chronic stages of the infection. In *S. mansoni* or *S. japonicum* infections, nutrient absorption from the GI tract could decrease due either to diarrhea or to GI lesions, changes in cell morphology, or to decreases in digestive enzyme levels; and nutrient utilization could be interfered with due to poor metabolism and transport of nutrients by the diseased liver or due to increased destruction of essential physiological components, *eg*. increased destruction of erythrocytes in the enlarged spleen. Any of the 3 species of schistosomes can increase nutrient losses from the body; for example, blood (which contains proteins, iron, and other micronutrients) is lost in the urine or stool; diarrhea could increase nutrient and electrolyte losses;

and fever elevates urinary nitrogen excretion. The hematological consequences of the different stages of schistosomiasis and the possible connections between anemia and splenomegaly have been reviewed by Mahmoud (17) and Foy and Nelson (18).

These possible negative effects become especially important if they are present not only in the heavily infected persons (who constitute a minority of the population and clearly need treatment to arrest proven pathology) but also in the more lightly infected persons, who constitute the majority of cases in an endemic area. Even if the nutritional effects in the average lightly infected person are relatively small, the total impact on a population with a high prevalence of schistosomiasis could be quite substantial and handicap general societal development by reducing growth, hemoglobin levels, general health status, physical fitness, and school attendance and performance in children, and by reducing general nutritional wellbeing and productivity of adults.

III. S. HAEMATOBIUM AND NUTRITION - URINARY NUTRIENT LOSSES, ANEMIA, GROWTH, AND PHYSICAL FITNESS

The common occurrence of hematuria and proteinuria in S. haematobium infections has been well documented (19-23) as has the widespread prevalence of anemia and of poor growth in children in many communities where urinary schistosomiasis is endemic (18,24,25). In fact, hematuria and proteinuria are so common and easy to detect, particularly in infected children in endemic areas, that screening methods which use urinary reagent strips to semi-quantitatively measure hematuria and proteinuria are being developed to select infected persons for antischistosomal treatment and check them for reinfection while saving much of the cost, time, and equipment needed for microscopic examination of the urine (19,20,26-38). Community studies in Kenya and the Gambia have indicated that the prevalence of hematuria can be up to 85% in school children passing 400-999 eggs/10 ml urine (21) and 76% in persons of all ages passing 100-999 eggs/10 ml (20). Daily urinary blood loss, quantitated in 3 small studies of hospital patients with heavy chronic infections, has varied from 0.5 ml to 125 ml/day (39-41). Patients with severe or persistent hematuria were losing a mean of 22 ml blood/day. Blood losses of this magnitude, if they persist, are more than sufficient to increase dietary iron requirements for males above even the high levels advised for women during the childbearing years (24,42) and will clearly cause anemia if these dietary requirements are not met. These studies were unfortunately not able to relate varying severities of schistosomiasis to degree of anemia in the community as a whole.

The association between S. haematobium infection and proteinuria has also been well documented. In the Gambia, 54% of persons passing 100-999 S. haematobium eggs/10 ml urine had proteinuria of 100 mg/100 ml urine or more, and 12% had proteinuria of 300 mg/100 ml urine (20). If these individuals pass about 1 liter of urine per day, daily urinary protein loss was about 1 g in 54% and about 3 g or more in 12% of subjects. This degree of protein loss is undesirable, particularly in growing children in developing countries where diets may be marginal in protein content and where other common infections may increase nitrogen losses.

The relationship of *S. haematobium* infection to anemia has not previously been definitively studied with a well controlled longitudinal design; a number of cross-sectional and a few longitudinal studies report conflicting results. One cross-sectional study in 630 Zambian primary school children reported that *S. haematobium* infected children had significantly lower hemoglobin levels than uninfected children (11.6 vs 12.5 g/dl, respectively), however intensity of infection was not compared with hemoglobin level (1). Greenham found that *S. haematobium* infection was cross-sectionally associated with severe anemia in unhospitalized Kenyan Somali nomads (43). The differences were particularly striking in adolescent boys; 48% of 67 infected boys had hemoglobin levels below 8 g/dl compared with only 6% of 69 uninfected boys (Chi square $p<.01$). This very high prevalence of anemia was almost certainly compounded by the Somalis' milk diet which is very low in iron. Another cross-sectional study of 99 males aged 12-40 years from the Hausa and Maguzawa tribes in Northern Nigeria found that *S. haematobium* infection was significantly associated with lower hemoglobin levels (44). Several studies of drug efficacy and morbidity included measurements of hemoglobin levels before and after treatment but the data for hemoglobin change were not separately examined in the anemic children (45-48). Four other cross-sectional studies in Zambia, Zimbabwe and Liberia which either had small sample sizes and/or did not measure intensity of infection reported no cross-sectional association between *S. haematobium* infection and anemia (49-52). An additional cross-sectional study in Nigerian primary school children found no relationship between hemoglobin level and intensity of *S. haematobium* infection, but anemia was uncommon since only 4.6% of children had hemoglobin levels below 10 g/dl (35).

A number of studies have related *S. haematobium* infection to growth and weight for height of children and adults. Jordan and Randall's major study of the relationships of *S. haematobium* and *S. mansoni* infections to nutritional status and physical fitness in Tanzanian school children found higher weight and height gains in boys treated for *S. haematobium* than in those refusing treatment, poorer physical fitness or tolerance to exercise in infected compared to uninfected children, and improved exercise tolerance in treated compared to untreated infected children (53). Unfortunately the numbers studied were rather small, the authors did not separate lightly from more heavily infected children, and the differences found were not statistically significant. Our previous work has also shown that metrifonate treatment of *S. haematobium* infected adult male Kenyan roadworkers was associated with weight gain (54). Forsyth and Bradley (55) found that primary school children in Tanzania infected with *S. haematobium* gained less height and weight per year than uninfected children and that the decreases in growth rates increased as egg count group increased. The possibility that age differences may have caused differences in growth rate could not be ruled out. Their second study (48) of growth over a one year period in infected children who were either treated with sodium antimonyl dimercaptosuccinate (Astiban) or untreated did not find differences between groups, however sample sizes were small and reinfection rates were high.

Abdel-Salam and Abdel-Fattah (56), in a cross-sectional study of 800 Egyptian children, noted statistically significant differences in percent skinfold thickness and hemoglobin level in heavily infected children (>350 eggs/10 ml urine) compared to uninfected ones. Weight, height, and arm circumference were also lower than uninfected children but not significantly different. Children with "moderate" infections (100-350 eggs/10 ml) also exhibited a mean height, weight, arm circumference, skinfold thickness, and hemoglobin which were lower but not significantly different from controls and higher than those of heavily infected children. Four other cross-sectional studies have also linked S. haematobium infection to poor child growth or low adult weight for height. Chandiwana (57) has reported a significant association between S. haematobium infection and low weight for height in Zimbabwean school children, but the role of differences in socioeconomic status between infected and uninfected children is not clear. Oomen et al (44) found S. haematobium infection to be significantly associated with a lower Quetelet index (a measure of body fatness) in Northern Nigerian adolescent and adult males. Similarly, Holzer et al (52) reported that infected Liberian villagers and outpatients had a significantly greater height to weight ratio and were therefore significantly thinner for their height than uninfected persons; 40% of infected and only 27% of uninfected subjects had weights below 10% of the standard, but this difference was not statistically significant. In addition to the above differences in anthropometric measurements, Ibrahim et al (58) have found a greater delay in pubertal development in infected vs uninfected Egyptian males 9-20 yr of age, judged by a higher mean chronological age at various developmental stages in infected children.

Four other studies in Africa have reported no significant cross-sectional relationship between S. haematobium and children's anthropometric measurements; in three of the studies intensity of infection was not considered, in two studies the sample size was small, and in one study the prevalence of infection was low (35,49,50,59).

These studies pointed to the need for measurement of infection intensity, longitudinal rather than cross-sectional studies, and selection of a large number of children, and experimental designs and data analysis techniques which can control for confounding factors such as age, sex, and differences in diet, socioeconomic status and other diseases, in order to assess more precisely the effects of S. haematobium infection and its treatment on child nutrition.

In 1981-1983, we conducted a series of studies to quantitate the effects of S. haematobium infection on nutritional status (judged by growth, hemoglobin level, urinary iron loss, and physical fitness) of Kenyan school children before and after treatment with metrifonate. The study of changes in growth and hemoglobin level in 400 children showed that the 202 children treated with a standard course of metrifonate for light-moderate infections of S. haematobium (1-500 eggs/10 ml adj), when compared with the 198 children in the randomly assigned placebo group, exhibited: 1) significantly better growth 6 months after treatment, judged by increases in weight (0.8 kg or a 50% increase over placebo group), weight for height squared, arm circumference (0.4 cm), and triceps and subscapular skinfold thicknesses (60); 2) significantly larger increases in hemoglobin level (0.3 g/dl or 30% increase) (61); 3) significant decreases in the prevalence and degree of splenomegaly and hepatomegaly (62). Within the treated group, children with higher S. haematobium egg counts or higher hookworm egg counts showed more improvement in growth and hemoglobin levels than more lightly infected children. (See second paper in this volume for discussion of changes in S. haematobium and hookworm egg counts and changes in hemoglobin level and growth at 6 and 16 months after treatment.)

The study of urinary iron loss and physical fitness on a subsample of 45 boys and girls was conducted in 3 groups of children (low-medium, high egg count, and uninfected groups) which did not differ significantly in age, sex ratio, initial hemoglobin level, anthropometric measurements, or prevalence or intensity of other parasitic infections (63). Children with relatively high egg counts (>200 eggs/10 ml adj) lost 4 times as much iron in their urine as did uninfected children, and children with low-medium egg counts lost about twice as much iron. Iron loss in infected children was linearly related to egg count, and extra iron loss in the relatively heavily infected children (0.5 mg/day extra) would be sufficient to produce anemia if it persisted. The high egg count group represents over 12% of the infected children in school standards 1-4 in this area of Kenya, so S. haematobium clearly can contribute significantly to anemia in endemic areas, particularly if dietary iron intakes are low and other pathological causes of anemia, such as hookworm infection and malaria, are prevalent. However, urinary iron losses returned to normal levels in infected children within 6 weeks after beginning a standard course of metrifonate.

The study of physical fitness showed that S. haematobium infected children were less physically fit as judged by the Harvard Step Test. They had higher heart rates after completion of the Step Test than did uninfected children. Children with high egg counts were significantly less fit than controls; those with low-medium egg counts also had lower fitness scores but were not significantly different from controls. However, after treatment with metrifonate, physical fitness scores increased significantly in both the low-medium and high egg count groups and were then similar to uninfected values, while scores did not change in the uninfected group, suggesting that decreased physical fitness is rapidly reversible with treatment. (See second paper in this volume for detailed discussions of iron loss, physical fitness and hematuria and proteinuria.)

None of the above findings have previously been conclusively demonstrated in longitudinal studies. These results show that metrifonate treatment of even light and moderate infections of S. haematobium may result in a much greater improvement in general health status of children than was previously thought to be the case. Thus, there may be greater benefits than previously believed in treating moderate infections rather than targetting chemotherapy only to heavily infected children.

These studies show significant improvements in growth and in hemoglobin levels of children treated with metrifonate. However, metrifonate in the doses given was found in this study also greatly to reduce hookworm egg counts, producing egg reduction rates of 65-80%, even though it cured only a minority of children (64-65). This effect of metrifonate has been previously reported (46,47,54,66), although the public health importance of this finding for control of hookworm infection and iron deficiency anemia in S. haematobium control programs has not been sufficiently studied or appreciated. The statistical analyses, including multiple regression analyses, clearly show a role for urinary schistosomiasis in retarding growth and in causing anemia, but because of concurrent hookworm infections, the contribution of each disease is difficult to quantify precisely.

IV. S. MANSONI AND NUTRITION - FECAL NUTRIENT LOSSES, ANEMIA, GROWTH, PHYSICAL FITNESS AND OTHER NUTRITIONAL INDICATORS

There is no doubt that S. mansoni infection causes blood loss in the stool, but the magnitude of blood loss over time in the average infected person in endemic communities and its significance for their nutritional status remains unclear. Fecal blood loss, quantitated in 7 chronically infected Egyptian patients with colonic and rectal polyps, was estimated to be 12.5 ml per day (range 7.5-25.9 ml) which is equivalent to 3.3 mg of iron per day (range 0.6-6.7 mg) (67-68). Three of the 7 patients were severely anemic. Iron losses of this magnitude are clearly sufficient to produce anemia if the iron losses persist and dietary intakes of iron are not abnormally high. Studies on patients with chronic heavy infections with or without colonic polyposis or hepatic involvement have also reported abnormally high fecal losses of albumin (2.2 g/da), zinc, and vitamin A; decreased d-xylose absorption, elevated fecal fat excretion, impaired glucose tolerance, and depressed levels of serum vitamin A, carotenoids and retinol-binding protein, serum carnitine, and plasma zinc (69-74). Aminoaciduria, apparently due to deranged liver function, has also been studied in Egyptian patients (75). Since most of these studies were carried out on relatively small numbers of heavily infected adult patients who often had complications of late chronic schistosomiasis, it is neither clear what proportion of a population they represent, nor (except in the case of fecal losses from polyps) that S. mansoni itself was actually the cause of each nutritional problem.

A number of population-based or large scale studies have examined whether S. mansoni infection is related to anemia (hemoglobin level), growth, physical fitness, and other indicators of nutritional status such as serum albumin levels. All of the studies measured nutritional status cross-sectionally, rather than longitudinally, some had relatively small sample sizes, and some were conducted in areas where the prevalence of malnutrition (protein-energy malnutrition or anemia) was relatively low.

A study of 511 S. mansoni infected Sudanese adult males showed that heavily infected patients (>400 epg) had significantly lower hemoglobin levels by 0.9 g/dl than more lightly infected ones (76). Of the 77 relatively heavily-infected adult male Egyptians selected for study from the community by Pope et al. (77), the 9 subjects who were anemic (hemoglobins below 12 g/dl) had very high egg counts (740-3,580 epg) and 12% of all subjects had recto-colonic polyposis which, as noted above, can cause abnormal fecal nutrient losses. S. mansoni infected Tanzanian school children were found to have significantly lower hemoglobin levels than their uninfected classmates, and they also had lower weights and heights than pupils without S. mansoni infection (53). Infected Ugandan villagers did not show significantly lower hemoglobin levels than did uninfected ones, however those with ascites, a complication of S. mansoni infection, had much lower mean hemoglobin levels than the community as a whole (8.1 g/dl vs 10.7 g/dl) (78). Ethiopian school boys with S. mansoni infection exhibited significantly lower physical fitness during a 12 min walk-run test than uninfected boys (79); there were no differences in hemoglobin level or weight for height between infected and non-infected children, however this is not surprising since very few of the children were anemic (dietary iron intakes are unusually high in Ethiopia due to the high iron content of tef, the local staple) and since mean weight for height values (close to 100% of the Harvard Standard) showed that acute protein-energy malnutrition was also uncommon.

Three separate cross-sectional population-based studies have been conducted in St. Lucia (80), Puerto Rico (81), and Northeastern Brazil (82). Neither the St. Lucian nor Puerto Rican studies found significant differences in hemoglobin or hematocrit levels. In St. Lucia, anthropometric measurements also did not differ between S. mansoni infected and uninfected children, even when intensity of infection was taken into account (80). However, heavily infected St. Lucian children did have significantly lower serum albumin levels and higher serum globulin levels than uninfected children matched for age and sex. In the St. Lucia study, there were heavily infected children but the extent of protein-energy malnutrition appeared low. Larger sample sizes may be needed to detect cross-sectional differences in nutritional status. In the Puerto Rican study, the sample sizes were larger but the level of infection was relatively light, and the amount of malnutrition was likely to be much less than commonly found in most endemic areas in rural Sub-Saharan Africa. The study in Northeastern Brazil found no differences in anthropometry of children aged 5 to 18 years who were uninfected or had light, moderate or heavy infections. However since younger children (5-9 years) are most likely to suffer from protein-energy malnutrition from all causes and the older children studied 10-14 yr) were twice as heavily infected, the role of age as a potential confouding variable is unclear. These three studies have provided much other important data which has advanced our knowledge of schistosomiasis and were not designed primarily to study schistosomiasis and nutrition.

One of the most important issues in the discussion of the relationships between schistosomiasis and malnutrition is whether the infection not only causes morbidity but actually reduces work capacity and productivity, particularly in adults who are the most economically productive members of a society. This issue has been studied in a number of countries, the results are conflicting, and they are reviewed and cited extensively by Prescott (83) and Hoffman (11), except for a few recent articles (84-87). An important related issue is whether schistosomiasis in children is related to mental development, school performance, and school absenteeism. These questions have been studied, often with inadequate study designs, and again the results are conflicting (see Appendix II for partial list of references). We will not review these topics except to reiterate that these studies are extremely difficult to carry out, both in terms of methodology and sampling, but are important if we are to estimate the total benefit to a community that control of schistosomiasis can provide.

V. S. JAPONICUM AND NUTRITION

Studies on the effects of *S. japonicum* infection on human nutritional status *per se* appear to be virtually non-existent. One would expect that the effects would be similar to those produced by *S. mansoni*, although more severe when number of worm pairs and baseline nutritional status are controlled for, because *S. japonicum* produces about 10 times as many ova per worm pair as does *S. mansoni*.

Only one clinical study which reported fairly extensive data of direct nutritional significance could be located (88). Seventeen Chinese patients with late chronic *S. japonicum* infection were studied, primarily to examine their endocrine function. All but one case were below normal standard Chinese height and all were "markedly under developed and poorly nourished," had "marked disability," and had anorexia and splenomegaly. Two cases exhibited "schistosomiasis dwarfism," 11 cases had massive ascites, 4 had massive splenomegaly, and all had serum albumin levels below 4 g/dl. All of the 6 females studied had been amenorrheic for 5-6 years.

Three cross-sectional population-based field studies on morbidity in *S. japonicum* infection, in the Philippines and China, have been recently published (89-91). Prevalences of infection in the villages studied were generally low (14-44%). Although none of the studies reported physical or biochemical measures of nutritional status, one Philippine study found that reports of inability to work, weakness, and abdominal pain were more common in infected than uninfected villagers, and that reports of diarrhea were related to the intensity of *S. japonicum* infection in a village with an overall prevalence of infection of 44% (90). The Chinese study reported that in the brigade which had the higher prevalence of infection (26%), reports of weakness in the past 24 hours and in the previous 2 weeks were much higher in infected compared with uninfected persons (20% vs 3%, 30% vs 7%, respectively) (91). In cross-sectional studies questions regarding symptoms may provide answers of doubtful validity. Persons with chronic infections may under-report symptoms because they have adapted to their disease and no longer perceive symptoms as unusual or unhealthy. In some circumstances over-reporting may occur if exaggeration of symptoms is perceived to bring benefits such as medical attention or free food.

It is clear that more research is needed to establish the relationship between *S. japonicum* and nutritional status. It is possible that certain studies from the Peoples Republic of China have not yet entered the English scientific literature. For example, there may be community data on growth and physical fitness of children before and after control measures were successfully implemented. First hand accounts, recorded by Horn (92), of the severity of *S. japonicum* infection in China before and after their most impressive control schemes were implemented strongly imply that *S. japonicum* was a major cause of morbidity and mortality but that the disease manifestations have drastically decreased along with the decline in prevalence and intensity. Horn states that *S. japonicum* causes intestinal

> "bleeding, anaemia, malnutrition and sometimes intestinal obstruction or perforation...Children fail to develop both in height and sexually; women cease to menstruate and men become incapable of parenthood. Thus

> the death rate increases while the birth rate decreases giving rise to serious depopulation."

To substantiate this statement, Horn quotes from his interviews with villagers in Ren Tun, a village where S. japonicum used to be highly endemic:

> Wu Hai Qan, vice director of Ren Tun production brigade:
>
> > "'In the old days, in addition to the burdens which weighed us all down, we had the burden of schistosomiasis. It pressed us sorely and all but wiped us out. In the twenty years from 1930 to 1949, 500 died in this village. The living hardly had the strength to bury the dead. Ninety-seven families died out completely and twenty families had only one survivor each. By the time of liberation only 461 people were left of whom 449 had schistosomiasis. We didn't know anything about the disease, not even its name. We just called it big belly disease.
> >
> > 'The survivors were so weak that they could hardly grow enough grain for their needs. No child was born here for seven years before Liberation...People used to write verses about our village.
> >
> > > "Ren Tun folk all grow on vines
> > > Faces yellow like old pumpkins
> > > Scrawny limbs like unripe gourds,
> > > Swollen bellies, water filled
> > > Tight and smooth as water melons."
> >
> > > "This dread disease has brought disaster to our village.
> > > Death stalks the land and puts a ban on birth.
> > > Our daughters long to leave and marry into healthier climes."
>
> and Guan, an elderly village resident:
>
> > "'To put it briefly, there have been four big changes since liberation.
> > Firstly, the population has risen from 461 to 671.
> > Secondly, rice production has gone up from 400 to 786 jin per mu...
> > Thirdly, income has gone up from an average of 40 yuan per able-bodied worker per year to 137 yuan.
> > Fourthly, all our children now go to school,...
> > As for health, there is simply no comparison. It's true that we still have some cases of schistosomiasis but there are hardly any new ones and we haven't found live snails for months. Seven of our youths have been accepted by the People's Liberation Army and everyone knows how high their physical requirements are. We have two basket ball teams...Just imagine! Ren Tun folk running about for the

> fun of it! In the old days we could hardly run if there was a tiger on our heels.'"

These and other first-hand accounts quoted by Horn provide compelling evidence that S. japonicum at its worst has been capable of decimating entire villages and causing serious malnutrition, decreased agricultural production, and high mortality and low fertility rates, even though the improvements in population growth, rice production, income and health which old Guan speaks of are most likely due in part to increases in socioeconomic status, and health care and food availability as well as to control of schistosomiasis. However controlled studies in animal species which are good nutritional models for humans show that S. japonicum infection can produce malnutrition and death. Yason and Novilla (93) reported that piglets infected percutaneously with 5,000-6,000 S. japonicum cercariae exhibited signs, coincident with egg production, of loss of appetite, diarrhea, progressive emaciation and dehydration, lethargy, and pallor of the mucous membranes. One of the 9 infected piglets was moribund when killed for necropsy at 40 days post-infection and another died at 59 days post-infection. We do not know how much malnutrition is presently being caused or aggravated by S. japonicum infection, but it is clearly worth finding out.

VI. STUDY DESIGNS TO DETERMINE THE EFFECTS OF SCHISTOSOMIASIS ON HUMAN NUTRITION IN FIELD STUDIES

Suggestions for study designs will concentrate on field studies to evaluate the nutritional significance of schistosomiasis in an endemic community or in specific age groups of an endemic community. We chose to concentrate on field studies because a) relatively few large scale field studies have been designed specifically to evaluate the nutritional consequences of schistosomiasis, and b) definitive studies of this type will help determine the full range of health benefits from schistosomiasis control and the differences in total morbidity reduction achieved by mass chemotherapy vs. targetted chemotherapy control programs. Clinical research based on hospital cases, while very important, cannot answer these questions. Excellent detailed guides to diagnosis, chemotherapy, data collection, and statistical methods applicable in schistosomiasis control programs are now available from WHO (6,7,44); these guides list many of the general principles and specifics that must be dealt with in conducting field research on schistosomiasis.

There are 5 important issues which should be addressed when designing a field study to evaluate the effects of schistosomiasis on nutritional status: population, experimental design and measurement techniques, sample size, drug regimen, and data analysis techniques (95). The prevalence of both schistosomiasis and the types of malnutrition of interest must be relatively high in the population chosen for study. The most important and most common types of malnutrition to study are protein-energy malnutrition and nutritional anemias, particularly iron deficiency anemia. The key age groups are usually school age children (because they are nutritionally vulnerable, tend to have the most active infections, and are often most likely to transmit schistosomiasis), and adults in their economically productive years. Adult males and females are equally important; indeed, women in Sub-Saharan Africa are usually responsible for growing most of a family's food crops, but they are more difficult to study because their frequent repeated cycles of pregnancy and lactation cause large fluctuations in their nutritional status and because the wisdom of treating pregnant or lactating women with antischistosomal drugs is questionable (96).

Measurement techniques must include estimates of the intensity of schistosome infection and appropriate measurements of the specific nutritional deficiencies of interest. In measurement of the intensity of S. haematobium infection, it is important to consider adjusting egg counts per 10 ml of filtered urine according to each subject's total urine specimen volume (19). This is because total urine specimen volumes can vary widely between subjects and between exams; this variation will introduce unnecessary error when one attempts to correlate intensity of infection with degree of morbidity or to determine egg reduction rates between seasons. The best experimental design to detect nutritional improvement after treatment is a longitudinal design with random allocation of subjects to treatment and placebo groups. A longitudinal design is recommended (95,97) because cross-sectional studies can only demonstrate associations, not cause and effect, between schistosomiasis and nutrition and also because cross-sectional studies are likely to underestimate the amount of morbidity (eg. diarrhea) that subjects report after they have adapted to symptoms of chronic schistosomal infection. A placebo group (which is treated at the end of the study and with adequate provisions for screening out and treating heavily infected children at the outset of the study) is often essential (95,97) because there are seasonal variations in disease transmission and health, nutritional and agricultural parameters, especially in malarious areas. Thus, failure to include a placebo group can lead to erroneous conclusions about the magnitude of antischistosomal treatment effects in both objective parameters (eg. growth) and symptom reports.

The sample sizes needed adequately to test the study's hypotheses should, whenever possible, be calculated in advance. They are based on the level of significance (α), the power of the test (β), the coefficients of variation of the changes in the nutritional parameters being examined, and the percent difference between groups that the investigators wish to detect (98). The investigators also must allow sufficient time for the nutritional parameters to change between pre- and post-treatment measurements; the time needed will vary with different parameters.

The drug chosen for treatment of schistosomiasis should produce high cure rates, and re-infection rates during or at the end of the study should be determined. Use of a drug regimen with low efficacy can test whether that particular drug regimen affects nutrition, but it cannot test whether effectively treating schistosomiasis improves nutrition. Possible effects of the drug on other diseases prevalent in the population need to be considered in the choice of drug, in assessment of other parasitic infections, and in the data analysis. For example, metrifonate is moderately effective against hookworm infection (46,47,64,66), and praziquantel is highly effective against a number of trematode and cestode infections (99). Lastly, the data analysis used must be appropriate for the particular study, and it needs to consider confounding factors. In many cases the use of multivariate techniques, such as multiple regression analysis, will be required (60,61,95,97).

VII. CONCLUSIONS

Schistosomiasis occurs mainly in parts of the world where malnutrition is prevalent, and often the same families are at greatest risk of having both the infection and nutritional problems. The synergism between malnutrition and certain infections has been well studied, but the relationship between schistosomiasis and malnutrition has not received the attention it deserves. Our knowledge of the epidemiology, pathology, treatment and control of schistosomiasis has advanced considerably in recent years and now new evidence suggests that the disease may contribute more to malnutrition than was previously believed.

Longitudinal interdisciplinary field studies now need to be conducted in communities where malnutrition and schistosomiasis are both prevalent. While such research is important, the treatment and control of schistosomiasis, as part of primary health care, deserves a high priority, and if successful may reduce morbidity, improve nutritional status, and improve the wellbeing of people in many tropical communities.

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APPENDIX I

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APPENDIX II

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RELATIONSHIPS OF *SCHISTOSOMA HAEMATOBIUM*, HOOKWORM, AND MALARIAL INFECTIONS AND METRIFONATE TREATMENT TO NUTRITIONAL STATUS OF KENYAN COASTAL SCHOOL CHILDREN: A 16-MONTH FOLLOW-UP

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I. INTRODUCTION

The following study was conducted at the Kenya Coast over a 16 month period in 1981-1983 as part of a project to assess the nutritional effects of *S. haematobium* infection and its treatment in school age children. The major aims of this project were:

1) to determine changes in hemoglobin level and growth rate of children with light-moderate *S. haematobium* infections before and up to 16 months after treatment with metrifonate (heavily infected and uninfected children were also followed)

2) to measure daily urinary iron loss and physical fitness in subsamples of *S. haematobium*-infected and uninfected children before and after metrifonate treatment

3) to evaluate the reliability and cost of using urinary reagent strips (which measure hematuria and proteinuria) to screen school children for *S. haematobium* infection

4) to monitor re-infection rates in children treated for *S. haematobium* and prevalence of new infections in previously uninfected children during an entire school year.

We have previously published most of the findings from the first 6 months of this 16 month project, including changes in hemoglobin, growth, and splenomegaly and hepatomegaly 6 months after metrifonate treatment of the light-moderate and heavy *S. haematobium* infections (1-3); urinary iron loss and physical fitness in subsamples of infected and uninfected children and improvements after treatment (4); and the sensitivity and specificity of reagent strips in screening children for *S. haematobium* infection (5). A review of the literature on *S. haematobium* in relation to nutrition and our rationale for these studies appears in our first paper in this volume (Schistosomiasis and Human Nutrition) and in our previous publications from this project (1-5). The aims of this paper are:

1) to report the changes in parasitic infections (*S. haematobium*, hookworm, and malaria) and hemoglobin levels and growth in over 500 children in the infected treated and uninfected untreated groups for the entire 16 month period of study.

2) to report in detail the iron losses and physical fitness of *S. haematobium* infected and uninfected children before and after metrifonate treatment and to present new information on rough estimates of urinary blood and protein loss and their importance in relation to estimated dietary intakes of iron and protein of children from this community.

II. MATERIALS AND METHODS

A. Hemoglobin-Growth Study

1. Study Population, Experimental Design, and Treatment

All subjects were children in the lower grades (termed Standards I-IV) in 4 adjacent primary schools (Mvindeni, Mwakigwena, Galu, and Makongeni) in Kwale District, Coast Province, Kenya, an area endemic for S. haematobium (6). Parental consent for the children's participation was obtained, and all were free to withdraw from the study at any time. Children were first seen in Aug 1981 (Pre-exam) and then were examined three times: once in Sept-Nov 1981 (Exam 1), in March-May 1982 (Exam 2) and again in Jan-Mar 1983 (Exam 3). At the pre-exam, name, age, and sex were recorded and each child received a standard dose of bephenium hydroxynaphthoate (Alcopar - 5 gm satchet) to decrease the potential contribution of hookworm infection as a confounding variable in the subsequent analysis of hemoglobin change after metrifonate treatment.

At Exam 1, children were divided into 4 groups based on their urine exam for S. haematobium eggs: 1) light-moderate S. haematobium infection, to be treated immediately (MIT group, n = 185), 2) light-moderate S. haematobium infection, receive placebo (MIP group, n = 181), 3) heavy S. haematobium infection, to be treated immediately (HIT group, n = 19), and 4) uninfected, untreated (UIU group, n = 136). The MIT and MIP groups were allocated at random; see parasitology for definitions of egg count groups. The MIT and HIT groups all received metrifonate at Exam 1 and also received it 6 months later at Exam 2 if their urine specimens still showed viable S. haematobium eggs. The MIP group received a placebo at Exam 1 and was treated with metrifonate at Exam 2; it was not considered ethical to have a placebo group for the entire 16 month period of the study. Children who were uninfected at Exam 1 but S. haematobium positive at Exam 2 also received metrifonate; 16 initially uninfected children were not included in the UIU group discussed in this paper for this reason. All infected children were treated at Exam 3 to assist the subjects and as a community service. The dose of metrifonate used was the standard 7.5 mg/kg of body weight given 3 times, 1-2 weeks apart. All doses of metrifonate and placebos were consumed in the presence of project staff. Two other small groups of children (those with initial hemoglobin levels below 8 g/dl with and without S. haematobium infection) were given ferrous sulfate immediately after Exam 1; their results are not reported here. The UIU group came only from Mvindeni and Mwakigwena schools; uninfected children from the other two schools were not followed due to time constraints and the need to focus on infected children.

In this paper, we report on a statistical analysis which compares the MIT and MIP groups (which were designed to be statistically comparable through random assignment), and which compares the HIT group with the UIU group (these groups are younger than the MIT and MIP groups but not significantly different in age from each other). The HIT group was included because we were interested in following the heavily infected children's responses to treatment, and the UIU group was included particularly because it was the only group which received no treatment from us after the initial dose of Alcopar and thus might provide information on seasonal trends in disease transmission. The main comparative analysis is however between the MIT and MIP groups.

2. Parasitology

All three examinations were carried out with the same team of workers, each doing the same set of examinations, and were done in a blind fashion. To determine S. haematobium infection, children were given 200 ml of fruit drink at about 9 A.M. to stimulate urination, then were asked to empty their bladders once between 10 A.M. and 2 P.M. The volume of each specimen was measured to the nearest 5 ml. The nuclepore filter method of Peters et al (7) was used to filter and count the number of S. haematobium eggs/10 ml of urine. Egg counts were all performed by the same investigator within 2-5 hours of urine passage. Directly prior to counting, one drop of 0.5% trypan blue dye in physiological saline solution (8) was added, and a coverslip was placed on the slide to improve visibility of eggs and accuracy of counts. At Exams 2 and 3 the obviously non-viable S. haematobium eggs were excluded from egg counts, e.g. eggs that were shrunken and black inside.

Total urine specimen volumes varied from 5 to 200 ml. Therefore, egg counts per 10 ml of filtered urine actually measure concentration of eggs per 10 ml but not total eggs or intensity of infection per bladder-voiding (9,10). To improve precision of the measurement of intensity of infection, S. haematobium counts/10 ml of urine were adjusted to account for total specimen volume by multiplying the egg count/10 ml by the actual specimen volume divided by a theoretical 100 ml specimen volume, and were called "eggs/10 ml adj." Heavy infections were defined as 500 or more eggs/10 ml adj, and light-moderate infections were defined as 1-500 eggs/10 ml adj. Note that the total number of eggs per bladder voiding equals the number of eggs/10 ml adj. multiplied by 10.

Examinations of fecal specimens for intestinal parasites were performed on fresh stool specimens using a modified Kato technique (11), which utilizes templates to measure approximately 50 mg of stool and cellophane soaked in a glycerine-malachite green solution (12). Hookworm eggs were counted 30-60 minutes after preparation of the Kato smears (after clearing and before the hookworm eggs began to disappear) (13); egg counts were expressed as eggs per gram of feces (epg). Malarial infection was determined by an experienced technologist from thick blood films stained with Giemsa stain and thin films stained with Leishman's stain. Parasite density was estimated by counting the number of parasites per 100 leukocytes in thick films; and thin films were used to identify Plasmodium species (14).

We also obtained records of the rainfall and temperature each month in the study area to monitor seasonal variations which might affect the transmission of S. haematobium, hookworm, and malarial infections.

3. Anthropometry and Hemoglobin Levels

Baseline anthropometric measurements, performed using the methods of Jelliffe (15), included weight (to the nearest 0.25 kg on a portable Salter model 209 balance), standing height (to the nearest 0.1 cm with a Microtoise portable anthropometer), mid upper arm circumference (to the nearest 0.1 cm on the left arm), and triceps and subscapular skinfold thicknesses (in triplicate, to the nearest 0.1 mm with Lange calipers). Raw anthropometric values for weight, height, arm circumference and skinfold thicknesses were converted to percent of the median for age for each sex separately with the NCHS growth references (16-18). Weight for height was expressed as weight for height squared, since growth references were not available for the children in the sample over 11 years of age. Hemoglobin determinations were done in duplicate on finger prick blood using the cyanmethemoglobin method (19) on a Spectronic 20 spectrophotometer.

4. Statistical Analyses

Data were coded and statistically analyzed on the IBM-3081 computer at Cornell University with SPSS-9 programs (20). Statistical tests used included Chi-square tests for association, McNemar's test for changes in prevalence, and paired and unpaired t-tests. Heteroscedastic or negative binomial distributions were transformed to common logarithms with the n+1 transformation before applying differential statistical tests, as recommended by Sokal and Rohlf (21).

Growth increments between exams were computed for each child and then adjusted to the mean interval for all children examined, e.g. 180 days or 6 mo for Exam 1 to 2, 300 days or 10 mo for Exam 2 to 3, and 480 days or 16 mo for Exam 1 to 3; this was done to minimize error due to differences between subjects and groups in length of time between exams and interventions.

B. Urinary Iron Loss - Physical Fitness Study

1. Subject Selection

Forty-five subjects were recruited from a group of approximately 150 children who were in standards I-IV in Mvindeni Primary School in March 1982 and who were participating in the large study on the effects of treatment for urinary schistosomiasis on child growth and anemia. Children in the low-medium and high egg count groups were selected by screening over 100 children at Exam 2 in March 1982 and selecting 19 children for the low-medium group and 14 for the high group so that the 2 groups were comparable in age, sex ratio, hemoglobin level, and anthropometry. Other criteria for selection included relatively light hookworm infections (preferably <5,000 epg) and likelihood of cooperation in the urine collection and fitness tests. Twelve children who did not have *S. haematobium* infection but who were comparable to the other 2 groups in all other respects were then chosen to serve as the control group. Parental consent was obtained and children were free to withdraw from the study at any time. Children with hemoglobin levels below 8 g/dl were not included in the study for ethical reasons and were immediately treated with ferrous sulfate and, if necessary, metrifonate.

2. Urine Collections and Determination of Iron Loss

Children were instructed to collect all of their urine for 3 consecutive days (under strict supervision) and nights (at home) in iron-free plastic bags. Total urine volumes were measured, and urinary creatinine determinations were conducted in duplicate. These were performed separately on each day (10 hr) and night (14 hr) collection of urine, in part as a check on completeness of urine collections. A 50-ml aliquot of each child's total 72-hr urine collection was preserved with 5 ml of concentrated HCl and later analyzed at Cornell University for total iron concentration.

At Cornell, the urine aliquots were transfered quantitatively to 200-ml iron free beakers and evaporated to dryness on a hotplate. Quantitative transfer was insured by rinsing the tubes twice with 5 ml of concentrated nitric acid and adding the rinse to the beaker. After evaporation of the nitric acid, the beakers were placed in a muffle furnace and ashed at 400°C for 7 hr. The ash was dissolved in 5 ml of 5 N HCl and transfered quantitatively to 25-ml volumetric flasks using 0.1 N HCl to rinse and to bring to volume. Iron concentrations were determined using a modification of the ICSH (22) recommended method for measuring serum iron in blood. Reagents included: (a) chromagen solution: 0.5 mmoles bathrophenanthroline sulfonate, sodium salt plus 0.4 moles thioglycolic acid plus 4.0 mmoles sodium acetate per liter of aqueous solution; (b) iron standard solutions prepared by diluting a 1,000 ppm iron standard to 0.5, 1.0, 2.0 and 4.0 ppm with 1.0 N HCl. Iron was measured by mixing 2 ml of the sample with 1 ml of the chromagen solution, waiting for at least 10 min, and reading absorbance at 533 nm. Standard curves were prepared using the standard solutions. Iron concentration of the original sample was then calculated.

Urinary blood loss in selected infected children was calculated by first subtracting the mean urinary iron loss per 24 hr in the control (uninfected) group from the infected child's iron loss per day then using the equation: urinary blood loss in ml per day = (mg urinary iron loss per day ÷ child's hemoglobin level in g/dl) x 34 mg hemoglobin/mg Fe. (23).

3. Physical Fitness Tests

Physical fitness was assessed with the Harvard Step Test (24) modified to measure submaximal performance. A clinical examination including heart auscultation was done on all children before testing. No children were excluded because of abnormalities detected in this examination. After a practice session to acquaint each child with the test procedure, the child stepped up and down on a step 30 times per minute for 5 min while wearing a backpack containing bags of sand equal to 20% of his/her body weight. The step height was adjusted to the child's leg length, and a metronome was used to set the child's stepping rhythm. His/her radial pulse rate (as a measure of heart rate) was determined in the resting state (before the test) and for 30 sec at 1, 2, 3 and 4 min after completion of the test while the child was seated.

All tests were done in the same room under the same conditions between 9:30 A.M. and 12:30 P.M. All children were sitting at rest for at least 30 min prior to testing, were encouraged to complete 5 min of stepping, and were told that they would receive 1 piece of candy for each minute completed. The investigator conducting the tests did not know to which group each subject belonged. A physical fitness score was calculated as described previously (25): fitness score = duration of test in seconds (in this case 300 sec) x 100 ÷ sum of pulse rates per minute taken at 1, 2, and 3 min after test completion. Ambient temperature and relative humidity were also recorded for each test. See Appendix for form used to record test results.

4. Parasitology, Anthropometry, Hemoglobin Levels, Hematuria, Proteinuria

S. haematobium egg counts were determined before and after treatment with the nuclepore filter technique; hookworm and Trichuris egg counts and malarial parasite counts before treatment were determined with a modified Kato technique; the methods used were those used for the major study described here. Anthropometric measurements and hemoglobin levels were measured before treatment with methods previously reported (4) and described here for the growth study.

Hematuria and proteinuria were measured semi-quantitatively in the midday urine specimens collected for S. haematobium egg counts, as previously described (5). The reagent strips used were Ames N-Multistix (Ames Company, Elkhart, Indiana); hematuria was recorded as negative, trace (non-hemolyzed or hemolyzed), +1 (light), +2 (moderate) or +3 (heavy); a positive urinary blood was defined as trace or more. Proteinuria was recorded as negative, trace (5-20 mg/dl), +1 (30 mg/dl), +2 (100 mg/dl), or +3 (300 mg/dl). A positive or abnormal urinary protein was defined as +1 or more, as the package insert states that a trace result is not necessarily pathological. All urine samples were tested by the same investigator within 2 hours of passage. Very rough estimates of daily urinary protein loss before and after treatment were calculated from the urinary reagent strip proteinuria result on the midday urine specimen and the children's mean urine volumes for 3 days before treatment and 2 days post-treatment.

5. Treatment and Post-treatment Measurements

Within 1 week of completion of the baseline urine collections and Harvard Step Tests, all children were treated with a standard course of metrifonate (Bilarcil, Bayer Pharmaceutical Co.; 7.5 mg/kg body weight given 3 times 1-2 weeks apart). Seven weeks after baseline, the Harvard Step Test was repeated by the same investigator, under similar conditions and using pre-treatment work loads, on 42 of the 45 children. Due to time constraints, only a 1 day (10 hr) urine collection was done on a subsample of 26 children. Anthropometric measurements and hemoglobin levels were not repeated after treatment because the investigators thought it unlikely that significant improvements would be detected in this relatively small number of children over a time period as short as 7 weeks.

6. Iron and Protein Intakes

Approximate intakes of iron and protein and of other nutrients related to anemia (including protein, ascorbic acid, and vitamin A but not folic acid or vitamin B_{12}) by school children in the study area were estimated for 13 12-15 year old girls who were selected at random from the female children in this age group at Mvindeni School who participated in the growth study. Their nutrient intakes were estimated from 3 24-hr recalls administered to each girl by K. Kurz during Exam 3 in March-April 1983 (26). Reference values used here were the U.S. Recommended Dietary Allowances for 11-14 year old females (27).

7. Statistical Analyses

Procedures for the statistical analyses were similar to those described for the growth study but included use of one way analysis of variance, the modified least significant differences procedure for differences between pairs of group means, and linear regression.

III. RESULTS AND DISCUSSION

A. Hemoglobin - Growth Study

1. Study Groups

The two major study groups were the light-moderate infected treated (MIT, n=185) and light-moderate infected placebo (MIP, n=181) groups; they were allocated at random and thus were very similar and did not differ significantly in age or sex ratio (MIT mean age ± SEM 10.7 ± .15 yr, MIP mean 10.6 ± .16 yr, ranges 6-15 yr; MIT group 51% male, MIP group 47% male). The small group of heavily infected children (HIT group, n=19) and the uninfected untreated (UIU) group (n=136) were about a year younger than the MIT and MIP groups (HIT $\bar{X}$ ± SEM = 9.7 ± .40 yr, UIU = 9.3 ± .16 yr, range 6-15 yr) but were not significantly different from each other. Forty-seven percent of the HIT group were male, similar to the two main groups, and only 36% of the UIU group were male, but this difference between the HIT and UIU groups was also not statistically significant.

The children reported on here and seen at all three examinations represented approximately 85% of the children initially seen at Exam 1 and 92% of those followed up 6 months later at Exam 2 and reported on previously (1-3). The small percentage of children who dropped out of the study before Exam 3 usually did so because they moved away or left primary school; there is no reason to believe that they were substantially different from the children who remained. Thus we think that the children examined all 3 times are fairly representative of the *S. haematobium* infected primary school children in standards I-IV in the 4 schools, and in the case of the UIU group, representative of the repeatedly uninfected children in 2 of the 4 schools.

2. Metrifonate Coverage and Changes in Parasitic Infections

a. Metrifonate Coverage

Coverage with metrifonate was excellent at both Exams 1 and 2. The MIT and HIT groups were scheduled to receive 3 doses of metrifonate at Exam 1; all of the HIT group received 3 doses, and 98% of the MIT group did so; the remainder of the MIT group received 1 or 2 doses. At Exam 2, all of the MIP group and only the *S. haematobium*-positive children in the MIT and HIT groups were to receive metrifonate; 91% of MIP's got 3 doses and 9% got 2 doses. All 28% of the *S. haematobium* positive MIT's were treated: 46 of the 52 children got *all 3 doses* and 6 others received 2 doses. All 63% of the *S. haematobium* positive HIT's were treated as well: 8 of the 12 got *3 doses, 1* received 2 doses, and 3 received 1 dose.

b. *S. haematobium* Infection

The changes in prevalence and intensity of *S. haematobium* infection with metrifonate treatment over the 16 month period show that this treatment regimen decreased intensity to very low levels and prevalence to moderately low levels. Reinfection rates in treated children at 6, 10, and 16 months post-treatment (including treatment failures and new infections) were surprisingly low considering the time intervals studied, and most initially uninfected children remained uninfected with S. haematobium throughout the 16 month period. Six months after the initial metrifonate treatment, the prevalence of S. haematobium in the MIT and HIT groups had decreased significantly from 100% to 28% and 63%, respectively; egg reduction rates were 93% and 97%, respectively; and geometric mean egg counts had decreased significantly from 48 to 2 eggs/10 ml adj in the MIT group and 93 to 5 in the HIT group (Table 1). The percentage of children passing over 100 eggs/10 ml adj had decreased from 35% to 2% in the MIT group and from 100% to 10% in the HIT group (Table 2). Although some of this decrease in egg counts was probably due to regression to the mean, the data from the MIP or placebo group suggest that the amount of regression to the mean was much smaller than the treatment effects: the prevalence decreased from 100% to 96% in the 6 month period, the geometric mean egg count decreased from 51 to 42 eggs/10 ml adj, but the frequency distribution of egg counts did not change significantly (Tables 1 and 2). These decreases in prevalence and geometric mean counts were statistically significant but very small in magnitude.

The very low rate of new infections in the initially uninfected children also deserves comment. The 136 children in the UIU group are presented here because they had no evidence of S. haematobium infection and received no metrifonate at Exams 1 or 2; they were selected from 166 children who both did not have S. haematobium infection at Exam 1 and were examined 3 times. Of these 166 initially negative children, only 16 (10%) had S. haematobium eggs in their urine 6 months later at Exam 2 (geometric mean 1 egg/10ml adj). Those 16 received metrifonate at Exam 2, and 10 months later at Exam 3, only 14 children of the 166 (8%) were infected (geometric mean again 1 egg/10 ml adj). (Fourteen other initially negative children of the 166 were excluded from this analysis because they were given metrifonate at Exam 2 when they participated in the study on urinary iron loss and physical fitness (4)). The observations that initially negative children tended to remain negative in spite of living in an apparently homogeneous area with infected children prompted our study on water, sanitation and beliefs about schistosomiasis presented later in this volume.

At Exam 2, all of the MIP (placebo) group received metrifonate, and so did the 28% of MIT children and 63% of HIT children who had an Exam 2 urine specimen with viable S. haematobium eggs. Ten months later, at Exam 3, the prevalence of S. haematobium in the MIP group had decreased significantly from 96% to 39%, the egg reduction rate was 81%, the geometric mean count had decreased from 42 to 3 (Table 1), and the proportion of children passing over 100 eggs/10 ml adj had decreased from 33% to 6% (Table 2). The MIT and HIT groups, despite partial treatment, showed no significant change in prevalence 10 months later: from 28% to 34% in the MIT's and 63% vs 63% in the HIT's (Table 1), arithmetic mean egg counts increased in both groups, and geometric mean egg counts significantly increased from 2 to 3 in the MIT group and increased but not significantly from 5 to 8 in the HIT group (Table 1). However all three groups had shown marked decreases in prevalence and intensity

Table 1. Parasite Prevalence and Intensity up to 16 Months Follow-up in S. haematobium Infected, Metrifonate Treated (MIP, MIT, HIT) and Uninfected Untreated (UIU) Groups

	S. haematobium				Hookworm				Malarial Infection			
Group**	MIP	MIT	HIT	UIU	MIP	MIT	HIT	UIU	MIP	MIT	HIT	UIU
% positive												
0 mo	100.	100.*	100.*	0	79.	83.	95.	88.	39.	40.	53.	35.
6 mo	96.*	28.*	63.*	0	83.	52.	79.	88.	38.	42.	42.	31.
16 mo	39.*	34.*	63.*	8.*	82.	83.	95.	93.	60.	63.	79.	70.
McNemar p												
0 vs 6 mo	.025D	.0005D	.025D	NA	ns	.0005D	ns	ns	ns	ns	ns	ns
6 vs 16 mo	.0005D	ns	ns	.005I	ns	.0005I	ns	ns	.0005I	.0005I	.05I	.0005I
0 vs 16 mo	.0005D	.0005D	.025D	.005I	ns	ns	ns	ns	.0005I	.0005I	ns	.0005I
Arithmetic $\overline{X}$												
0 mo	109	107	1051	0	1776	2124	1864	2509	4.4	3.0	5.3	3.4
6 mo	127	7	29	0	1943	729	389	2362	6.7	7.5	5.4	2.2
16 mo	24	17	58	4	1207	1486	755	2662	5.5	7.5	11.7	14.7
% egg reduc												
0 vs 6 mo	(-16)	93	97	NA	(-9)	66	79	6	NA	NA	NA	NA
6 vs 16 mo	81	(-143)	(-100)	NA	38	(-104)	(-94)	(-13)	NA	NA	NA	NA
0 vs 16 mo	78	84	94	NA	32	30	60	(-6)	NA	NA	NA	NA
Geometric $\overline{X}$												
0 mo	51	48	930	0	212	316	618	524	2.0	1.9	2.8	2.0
6 mo	42	2	5	0	235	27	111	437	2.0	2.0	2.1	1.7
16 mo	3	3	8	1	214	248	452	716	3.1	3.6	5.6	5.1
t-test p												
0 vs 6 mo	.028D	.001D	.001D	NA	ns	.001D	.004D	ns	ns	ns	ns	ns
6 vs 16 mo	.001D	.012I	ns	.002I	ns	.001I	.008I	.01I	.001I	.001I	.003I	.001I
0 vs 16 mo	.001D	.001D	.001D	.002I	ns	ns	ns	.072I bord	.001I	.001I	.025I	.001I

* All cases positive for S. haematobium received metrifonate at that exam.

** n: MIP=181, MIT=185, HIT=19, UIU=136; Egg reduction rates are calculated using arithmetic egg counts and include treatment failures and reinfections. Negative sign with ( ) indicates increase in arithmetic mean egg count; ns = not statistically significant; NA = not applicable; I = increase; D = decrease. McNemar's test results refer to changes in prevalence; (paired) t-tests refer to changes in log values of egg counts.

Table 2. S. haematobium and Hookworm Egg Count Distributions up to 16 Months Follow-up in S. haematobium Infected, Metrifonate Treated (MIP, MIT, HIT) and Uninfected, Untreated (UIU) Groups**

Group	MIP			MIT			HIT			UIU		
Time	0 mo	6 mo*	16 mo*	0 mo*	6 mo*	16 mo*	0 mo*	6 mo*	16 mo*	0 mo	6 mo	16 mo*
						% of group						
S. haematobium												
0 e/10 ml adj	0	4.	61.	0	72.	66.	0	37.	37.	100.	100.	92.
1-29	35.	35.	28.	37.	23.	23.	0	37.	42.	0	0	6.
30-99	30.	28.	5.	29.	3.	7.	0	16.	5.	0	0	2.
100 up	35.	33.	6.	35.	2.	4.	100	10.	16.	0	0	1.
hookworm												
neg 0 epg	21.	17.	18.	17.	48.	17.	5.	21.	5.	12.	12.	7.
1-1999	52.	58.	65.	54.	43.	61.	68.	79.	90.	56.	57.	56.
2000-4999	16.	14.	14.	18.	6.	14.	16.	0.	5.	16.	17.	21.
5000 up	11.	11.	3.	12.	3.	8.	10.	0.	0.	16.	14.	16.

* All cases positive for S. haematobium received metrifonate at that exam.

** n: MIP=181, MIT=185, HIT=19, UIU=136.

compared with Exam 1: the MIP, MIT and HIT groups showed egg reduction rates 16 months later of 78%, 84%, and 94% respectively, and geometric mean egg counts of only 3, 3, and 8 respectively (Table 1). At Exam 3, only 8% of the 136 UIU children had S. haematobium eggs in their urine, with a geometric mean count for all cases of 1 egg/10 ml adj; this confirms that the vast majority of the initially uninfected children remained uninfected for 16 months. The baseline prevalence of S. haematobium infection in the primary schools was only 50%; in areas with higher initial prevalences, higher reinfection rates would be likely to occur.

We estimated the total number of S. haematobium eggs in the midday urine specimens of each group of children at each of the three exams, in order to examine the contribution of each group and its treatment to the number of eggs available to contaminate the environment and transmit S. haematobium. As one would expect from an overdispersed distribution, the 19 heavily infected children passed as many eggs in their urine before treatment (1.997×10^5) as did 180 of the children with light-moderate infections (Table 3). Treating only half or 180 of the light-moderate cases (MIT's) and all of the HIT group decreased the total egg output for all groups by more than half, from 5.95×10^5 at Exam 1 to 2.48×10^5 6 mo later at Exam 2 (Table 3). After 16 months, in spite of time for reinfection, total egg output in noon urine specimens in all groups had decreased from an initial 595,000 eggs to only 91,200 eggs. At this point, the MIT and MIP groups together were passing about 7 times as many eggs as the HIT group, but the egg output per HIT child was of course still greater. These figures reiterate how important it is for schistosomiasis control personnel to locate and treat every single one of the heavily infected children in a community; their urine specimens have by far the greatest infective potential, and they are probably heavily infected primarily because of extensive water contact and thus many chances to urinate in water supplies as well as to catch S. haematobium from them.

c. Hookworm Infection

We were interested in following the changes in the prevalence and intensity of hookworm infection after metrifonate treatment, since we and others have shown that metrifonate does lower hookworm burdens substantially (28-31), but the public health importance of this finding for areas where S. haematobium, hookworm, and iron deficiency anemia co-exist has not been fully evaluated or appreciated. A detailed report of our findings on changes in intensity of hookworm infection in children receiving either 1 or 2 doses of metrifonate at two different dose levels (7.5 and 10.0 mg/kg body weight) appears in reference 31.

The results over the full 16 months show that although metrifonate did temporarily decrease hookworm burdens, these benefits were not as large nor as long lasting as the decreases in S. haematobium infection. This is probably due in part to the very high initial prevalence of hookworm in the children (95% before Alcopar) and also due to constant exposure to hookworm larvae. Most households did not have latrines, indiscriminant defecation is common, and children went barefoot virtually all of the time (See following paper in this volume for details of latrine use and availability).

Table 3. Total S. haematobium Eggs Passed in Single Midday Urine Specimens of S. haematobium Infected Metrifonate Treated and Uninfected Untreated Groups

Group	n	Total eggs passed per group ($x10^5$)* 0 mo	6 mo	16 mo
MIP	181	1.973	2.299	0.434
MIT	185	1.980	0.130	0.314
HIT	19	1.997	0.055	0.110
UIU	136	0	0	0.054
All groups		5.950	2.484	0.912

* Total eggs passed = arithmetic group mean of eggs/10 ml adjusted to total urine specimen volume of 100 ml, times 10 times *n* of children in group.

Six months after the initial metrifonate treatment, at Exam 2, the prevalence of hookworm infection in the MIT and HIT groups had decreased from 83% to 53% and from 95% to 79%, respectively; egg reduction rates were 66% and 79%, respectively; and geometric mean egg counts had decreased significantly from 316 to 27 epg in the MIT group and 618 to 111 epg in the HIT group (Table 1). The percentage of children with hookworm egg counts over 2000 epg of feces (the level above which hookworm infection is likely to be associated with iron deficiency anemia) had decreased from 30% to 9% in the MIT group and 26% to 0% in the HIT group (Table 2). Prevalence and intensity did not change significantly in this period in the MIP and UIU groups which did not receive metrifonate at Exam 1.

The changes in prevalence and intensity in the somewhat longer 10 month period between Exams 2 and 3 were disappointing however. Even though all of the MIP children received metrifonate at Exam 2, the prevalence of hookworm infection did not differ significantly between exams (83% vs 82%) nor did the geometric mean egg counts (235 vs 214 epg). The egg reduction rate was a modest 38%; this was primarily due to a shift of children in the 5,000 epg egg count category at Exam 2 to the more preferable 1-1999 epg category at Exam 3 (Tables 1 and 2). The MIT and HIT groups were not fully treated at Exam 2, and the prevalence and intensity of hookworm infection in those groups had increased at Exam 3 so that their values were not significantly different from Exam 1 (Table 1). The significant increase in geometric mean egg counts that occurred in the untreated UIU group between Exams 2 and 3 (437 to 716 epg) but not between Exams 1 and 2, and the extremely heavy rainfall during and after Exam 2, imply that the high reinfection rates in the 3 treated groups seen at Exam 3 were promoted in part by the heavy rainfall which may have favored transmission (Table 1, Figure 1). However, the MIP, MIT, and HIT groups did show egg reduction rates between Exams 1 and 3 of 32%, 30%, and 60%, respectively (Table 1); it is also important to note that the percentage of children with egg counts over 5,000 epg had decreased by Exam 3 in all 3 treated groups (from 11% to 3% in MIP's, from 12% to 3% to 8% in MIT's, from 10% to 0% in HIT's) while it had remained stable at 16% in the untreated UIU group (Table 2). Thus, although reinfection occurred much more rapidly with hookworm than with <u>S. haematobium</u>, metrifonate treatment did benefit the children by reducing the number of months children spent with the relatively high hookworm egg counts (which in turn are related to worm burdens) that are most likely to cause measurable anemia and other morbidity and transmit infection to others. Had we only given metrifonate and collected stools every 12 months, we might not have seen any effect of metrifonate on hookworm egg counts, even though it had occurred and had probably decreased morbidity. On the other hand, if all children had received metrifonate every 6 months for one year, the decrease in hookworm burdens probably would have been much larger than shown here.

d. Malarial Infection

It seemed important to follow malarial infections because they were significantly related to hemoglobin levels and growth between Exams 1 and 2 (1-2), and because they appeared to show a marked seasonal variation in all 4 groups at Exam 3 when compared with the 2 previous exams.

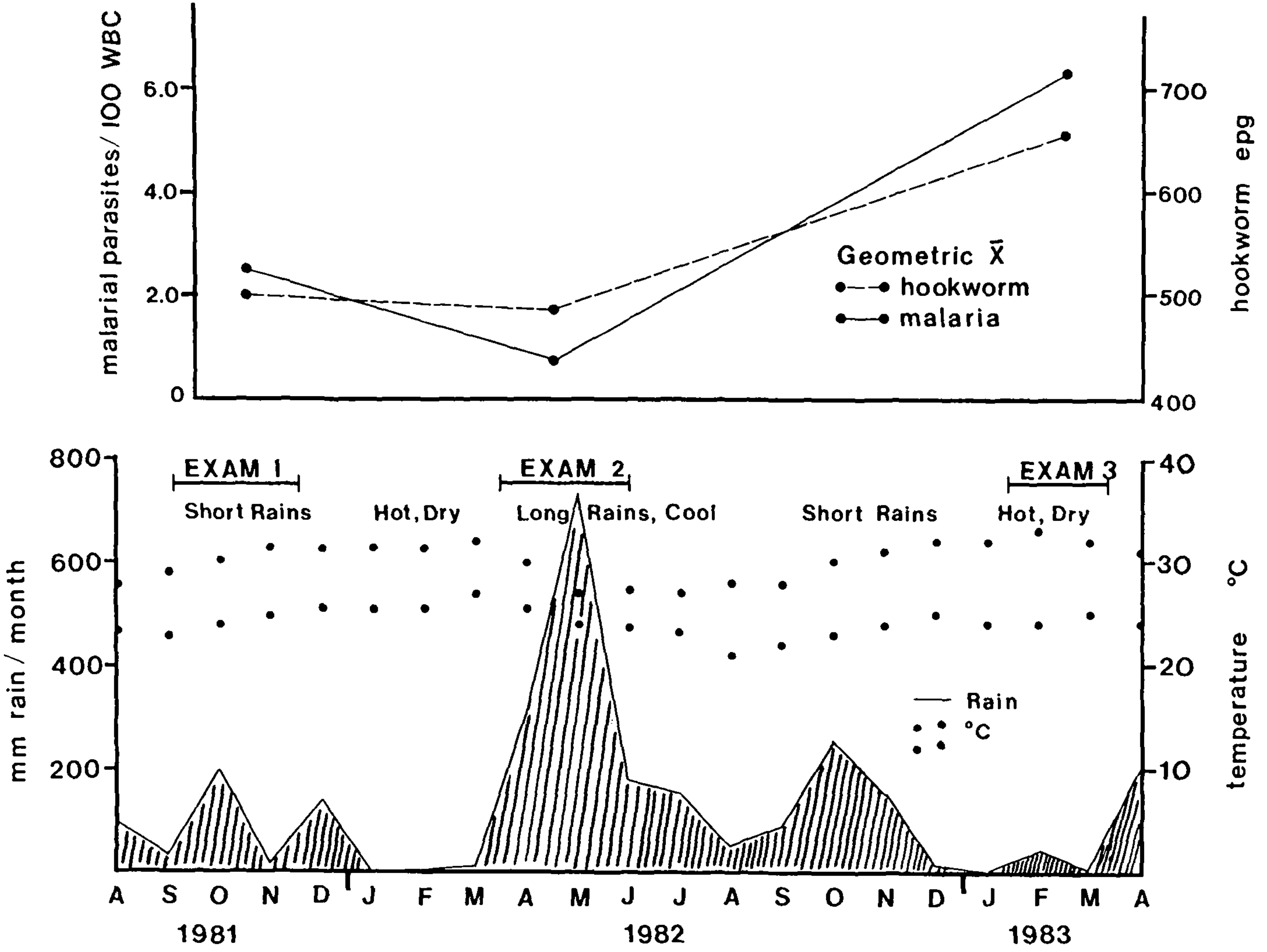

Figure 1. Seasonal Variation in Malarial and Hookworm Infections, Rainfall and Temperature from Exam 1 through Exam 3. Upper figure: Geometric means of malarial parasite counts (parasites per 100 leukocytes) and hookworm infection (epg) in untreated uninfected group (UIU, n=136) at Exams 1, 2, and 3. Lower figure: Rainfall (total mm per month) and air temperature (mean minimum and maximum per month) plotted at midpoints of months from August 1981 through April 1983.

At both Exams 1 and 2 the percent of children having blood slides positive for Plasmodium spp and the geometric mean number of parasites per 100 leukocytes per group were very similar between groups and did not differ significantly within groups between Exam 1 and Exam 2. The percent of positive slides was 39 to 53% per group at Exam 1 and 38 to 42% per group at Exam 2; geometric mean parasite counts ranged from 1.9 to 2.8 at Exam 1 and 1.7 to 2.0 at Exam 2 (Table 1). At Exam 3, however, the percent of positive slides and the geometric mean counts had increased by 50 to 100% in all 4 study groups: the percent of positive slides ranged from 60 to 79% per group, and the geometric mean parasite counts were 3.1 to 5.6 per group (Table 1). This increase in parasitemias seems most likely to be due to an increase in mosquito breeding sites resulting from the unusually heavy "long" rainy season that occurred during Exam 2 (the total rainfall in May 1982 was over 700 mm), followed by a relatively long and heavy "short" rainy season in the fall of 1982, just before Exam 3 (see Figure 1). The amount of rainfall during this period was much greater than usual (the total rainfall in May of 1980 was only 99 mm) and may have resulted in an increase in malarial attacks and parasitemias which began shortly after Exam 2, continued through the next 6 to 8 months, and was only measured by us in blood slides made in early 1983. There is no evidence that metrifonate treatment for S. haematobium or decreases in S. haematobium infection affected malarial parasitemias; both the MIT and MIP groups had almost identical parasitemias at Exams 1 and 2 even though the MIP group received a placebo at Exam 1, while the MIT group received metrifonate at Exam 1 and had much less S. haematobium infection between the 2 exams.

3. Growth and Hemoglobin Levels

A comparison of growth rates in the 4 study groups over the 16 month period showed basically that the three metrifonate treated groups displayed catch-up growth in all or most anthropometric measurements while the uninfected untreated group, which had the best initial nutritional status, either deteriorated or grew more slowly than the other three groups. The improvement in nutritional status in the infected treated groups was larger in intervals when initial nutritional status was lowest, and when more S. haematobium and hookworm infection were both present and treated. Growth in all groups, especially the untreated group, was much slower in the last 10 months of the study (Exam 2 to 3) compared to the first 6 months; the most likely explanation for this phenomenon, of the variables we measured, is the dramatic increase in malarial infection that had occurred by Exam 3 and that probably began soon after Exam 2. See references 1 and 2 for discussion of mechanisms through which S. haematobium, hookworm, and malarial infections could affect hemoglobin levels and growth.

The two main study groups, the MIT and MIP groups, did not differ significantly in anthropometry at Exam 1, and the children followed for the full 16 months and reported on here showed the same pattern in the first 6 months of the study as did those seen only at Exams 1 and 2 and reported on previously (2): the MIT group had grown faster than the placebo group 6 months after treatment, judging by all anthropometric measurements ($p<.001$) except height and % height/age ($p<.10$, Table 4). The MIT group's anthropometric measurements increased significantly ($p<.007$) between Exams 1 and 2 for all parameters listed except for %

Table 4. Anthropometric Measurements and Hemoglobin Level up to 16 Months Followup in *S. haematobium* Infected Metrifonate Treated and Uninfected Untreated Groups

		$\bar{X}$ ± SEM				t-test p (MIP vs MIT) (HIT vs UIU)		
		0 mo	Increase 0-6 mo	Increase 6-16 mo	Increase 0-16 mo	0-6	6-16	0-16
wt, kg	MIP	29.6 ± .53	1.5 ± .09	3.6 ± .14	5.1 ± .19	.001	.001	ns
	MIT	28.8 ± .51	2.3 ± .08	2.8 ± .12	5.0 ± .17	T	P	
	HIT	27.0 ±1.76	2.1 ± .26	2.5 ± .48	4.5 ± .54	ns	ns	ns
	UIU	26.0 ± .52	1.8 ± .08	2.0 ± .14	3.8 ± .18			
% wt/age	MIP	81.2 ± .80	-0.6 ± .22	0.9 ± .28	0.3 ± .40	.001	.001	ns
	MIT	79.0 ± .89	1.6 ± .19	-1.0 ± .26	0.7 ± .35	T	P	
	HIT	81.7 ±2.09	1.8 ± .63	-1.5 ± 1.13	0.3 ± 1.21	ns	ns	.065
	UIU	83.8 ± .97	1.0 ± .22	-2.9 ± .36	-1.7 ± .42			bord-H
% expected wt gain	MIP	NA	73.8 ± 4.31	94.2 ± 3.28	86.8 ± 3.02	.001	.001	ns
	MIT	NA	112.1 ± 3.90	75.9 ± 4.46	88.7 ± 3.52	T	P	
	HIT	NA	114.0 ±12.25	65.6 ±12.01	82.7 ± 9.14	ns	ns	ns
	UIU	NA	103.5 ± 4.25	56.9 ± 3.79	73.3 ± 3.05			
ht, cm	MIP	137.6 ± .84	2.7 ± .07	5.0 ± .13	7.6 ± .17	.095	.001	.041
	MIT	136.9 ± .83	2.9 ± .07	4.3 ± .12	7.2 ± .16	bord-T	P	P
	HIT	132.6 ±2.20	2.6 ± .18	4.1 ± .29	6.7 ± .39	ns	ns	ns
	UIU	131.4 ± .96	2.6 ± .06	4.1 ± .11	6.7 ± .14			
% ht/age	MIP	95.7 ± .31	0.0 ± .06	0.1 ± .08	0.2 ± .11	.10	.006	ns
	MIT	95.1 ± .34	0.1 ± .05	-0.1 ± .08	-0.0 ± .11	bord-T	P	
	HIT	95.7 ± .76	-0.0 ± .09	-0.5 ± .13	-0.4 ± .16	ns	ns	ns
	UIU	96.6 ± .34	0.0 ± .05	-0.5 ± .08	-0.4 ± .10			
wt/ht^2	MIP	1.54 ±.012	.02 ± .004	.06 ± .005	.08 ± .006	.001	.001	.069
	MIT	1.51 ±.011	.05 ± .003	.04 ± .005	.09 ± .006	T	P	bord-T
	HIT	1.50 ±.042	.06 ± .011	.04 ± .018	.09 ± .019	.068	ns	.029
	UIU	1.48 ±.012	.04 ± .004	.01 ± .005	.05 ± .006	bord-H		H
arm circ cm	MIP	18.0 ± .15	0.1 ± .04	1.3 ± .05	1.3 ± .07	.001	.001	.088
	MIT	18.0 ± .16	0.5 ± .03	0.8 ± .05	1.2 ± .07	T	P	bord-P
	HIT	17.6 ± .59	0.6 ± .14	0.8 ± .17	1.4 ± .16	.001	ns	.001
	UIU	17.6 ± .18	0.2 ± .04	0.6 ± .05	0.8 ± .07	H		H

Table 4 (continued)

		$\bar{X}$ ± SEM				t-test p (MIP vs MIT) (HIT vs UIU)		
		0 mo	Increase 0-6 mo	Increase 6-16 mo	Increase 0-16 mo	0-6	6-16	0-16
% arm/age	MIP	84.8 ± .56	-1.4 ± .19	2.2 ± .22	0.8 ± .29	.001	.001	ns
	MIT	84.6 ± .60	0.2 ± .16	0.1 ± .22	0.3 ± .30	T	P	
	HIT	86.1 ±1.67	1.3 ± .66	0.1 ± .74	1.4 ± .74	.002	ns	.002
	UIU	88.0 ± .68	-0.8 ± .20	-0.4 ± .24	-1.2 ± .32	H		H
triceps skinfold, mm	MIP	7.6 ± .19	-0.0 ± .07	1.4 ± .08	1.3 ± .11	.001	.001	.022
	MIT	7.4 ± .17	0.9 ± .06	0.7 ± .07	1.6 ± .10	T	P	T
	HIT	7.7 ± .79	1.2 ± .18	0.8 ± .15	2.0 ± .22	.001	.064	.001
	UIU	7.9 ± .22	0.4 ± .08	0.4 ± .10	0.8 ± .11	H	bord-H	H
% triceps /age	MIP	72.6 ±1.42	-1.4 ± .67	12.4 ± .70	10.4 ± 1.01	.001	.001	.048
	MIT	70.3 ±1.31	7.3 ± .58	5.5 ± .63	12.7 ± .91	T	P	T
	HIT	75.6 ±6.64	10.2 ± 1.86	5.2 ± 1.25	15.3 ± 2.20	.001	.077	.001
	UIU	76.5 ±2.03	2.7 ± .77	1.6 ± .92	4.5 ± 1.06	H	bord-H	H
subscap skinfold, mm	MIP	5.9 ± .12	0.1 ± .06	1.4 ± .06	1.4 ± .09	.001	.001	ns
	MIT	5.9 ± .12	0.8 ± .05	0.7 ± .06	1.5 ± .07	T	P	
	HIT	6.0 ± .47	0.9 ± .13	0.8 ± .12	1.7 ± .17	.001	.059	.001
	UIU	6.2 ± .16	0.3 ± .07	0.5 ± .09	0.8 ± .10	H	bord-H	H
% subscap /age	MIP	95.9 ±1.62	-2.0 ± .96	14.5 ± .80	11.9 ± 1.18	.001	.001	ns
	MIT	95.6 ±1.54	8.8 ± .81	4.1 ± .84	13.0 ± 1.05	T	P	
	HIT	103.2 ±5.97	12.2 ± 2.25	6.8 ± 2.09	19.0 ± 3.18	.001	.073	.001
	UIU	107.5 ±2.69	2.2 ± 1.18	0.7 ± 1.52	3.4 ± 1.69	H	bord-H	H
hemoglobin g/dl	MIP	11.2 ± .10	1.0 ± .08	-.4 ± .09	0.6 ± .10	.018	.021	ns
	MIT	11.2 ± .10	1.3 ± .08	-.7 ± .08	0.6 ± .10	T	P	
	HIT	10.9 ± .28	1.9 ± .28	-.9 ± .29	1.2 ± .30	.001	ns	.001
	UIU	11.7 ± .09	0.6 ± .08	-.7 ± .11	-0.0 ± .10	H		H

n = MIP=181, MIT=185, HIT=19, UIU=136. NA=not applicable; ns=not statistically significant. T-test results: no significant differences between MIP and MIT groups at 0 mo; no significant differences between HIT and UIU groups at 0 mo except for hemoglobin level ($p<.002$, UIU higher).

arm circumference for age (borderline p<.079, data not shown), while four of the MIP group's measurements decreased, including % weight for age, % arm circumference for age, and both % skinfolds for age. We attribute this difference between groups primarily to the decreases in S. haematobium and hookworm infections that followed metrifonate treatment, although multiple regression analysis showed that malarial infection within the MIT group was also related to growth increments (2).

At Exam 2, all MIP children were treated, and the 28% of the MIT's (those who were still S. haematobium positive) received a second course of metrifonate. As would be expected, the MIP group grew more rapidly in the 10 month interval between Exams 2 and 3 than did the MIT group, presumably because the MIP's were worse off nutritionally at Exam 2 and were able to display the catch-up growth after treatment that the MIT group had shown in the previous 6 month interval. The MIP group's growth increments were highly significantly larger than those of the MIT group for all parameters measured, including height (p<.001) and % height for age (p<.006, Table 4). The MIP group's Exam 3 measurements were all significantly larger than their Exam 2 measurements (p<.001 except for % height for age where p=.038, data not shown), while the MIT group increased in most measurements but decreased slightly in % weight for age and % height for age, presumably partly because of increased malarial transmission.

The growth increments over the entire 16 month project period differed very little between the MIT and MIP groups; of the % anthropometry for age, only % triceps skinfold differed significantly (Table 4). In fact the differences between the 2 groups in the first 6 months and in the second 10 months, when one group was fully treated with metrifonate, were much larger. This observation is heartening because it implies that the benefits of metrifonate treatment were about the same in both groups at the end of the project even though the MIT group had been treated 6 months earlier than the MIP group and had received more metrifonate. It appears then that the benefits of full treatment of the MIT's at Exam 1 and partial treatment at Exam 2 had not worn off by Exam 3; we presume this is because the intensity of S. haematobium remained low in the MIT group even though hookworm infection had reasserted itself and malarial infection had increased.

We compared the HIT and UIU groups statistically because they were comparable in age and sex ratio, although younger than the MIT and MIP *groups. The HIT and UIU groups did not differ significantly in initial* nutritional status (Table 4) although this was partly because there were only 19 children in the HIT group. The UIU group initially had higher anthropometric measurements for age than the 3 infected groups, as one would expect if S. haematobium infection aggravates protein-energy malnutrition. The HIT group grew faster than the UIU group for all parameters measured except height and height for age between Exams 1 and 2, after the HIT's had received their first course of metrifonate, and their growth rate was similar to or better than that of the MIT group which had also just received their first full course of metrifonate (Table 4). The HIT group continued their superior growth compared to the UIU group in the 10 months between Exams 2 and 3, particularly for arm and skinfold measurements, but many of the differences between groups were not statistically significant probably because of the small sample size in the HIT group, slower growth rates, and in some cases deterioration in both groups which probably resulted from malarial infection and other seasonal influences.

Overall, the UIU group, who had the best initial nutritional status, but no S. haematobium infection, no metrifonate treatment for S. haematobium or hookworm infections, and who contracted more malaria after Exam 2 along with the other 3 groups, had fared worst by the end of the project. Their % weight for age and % arm circumference for age had decreased while that of the other three groups increased, their % height for age decreased while that of the MIT and MIP groups increased and the HIT group decreased only slightly, and they showed the smallest increases in % triceps and subscapular skinfold thicknesses. These observations imply that metrifonate treatment for S. haematobium and, secondarily, hookworm infection, are beneficial for infected children because they do produce relatively long-lived improvements in nutritional status and provide infected treated children with catch-up growth which can help offset the negative effects that other infections, e.g. malaria, are having on child growth in a community.

The changes in hemoglobin level followed interesting patterns which again illustrated that S. haematobium, hookworm, and malarial infections all played a role in determining nutritional status (1). About 60% of the children were initially anemic (1); hemoglobin levels rose in all groups between Exams 1 and 2, fell in all groups between Exams 2 and 3, and over the 16 month period, rose in the 3 treated groups but did not change significantly in the untreated group. In the first 6 month period, the MIT and HIT groups exhibited the largest increases in hemoglobin level, and the HIT group, which had the heaviest initial S. haematobium and hookworm infections and the lowest initial hemoglobin level, improved the most. In the 10 months following Exam 2, hemoglobin level fell in all groups, presumably because of malarial infection, but fell least in the MIP group, which had just received a full course of metrifonate. Over the entire 16 months, the MIP and MIT groups exhibited the same improvement in hemoglobin level (0.6 g/dl), the HIT group's rise was twice as high (1.2 g/dl), and the untreated group's hemoglobin level did not change. These data, like the growth data, show that metrifonate treatment can provide significant relatively long term improvements in nutritional status despite the presence of other infections and general seasonal variability in factors influencing health.

B. Urinary Iron Loss - Physical Fitness Study

1. Background Data and Results of Treatment

There were 12 children in the control (C) or uninfected group, 19 in the low-medium egg count (LM) group, and 14 in the high egg count (H) group (See Figure 2). S. haematobium egg counts before treatment ranged from 16 to 177 eggs/10 ml adj in the low-medium group and from 200 to 1,194 in the high egg count group (arithmetic means 91 and 512, geometric means 80 and 439, respectively, Table 5). Treatment with metrifonate produced marked reductions in egg counts (98.8% in LM group of 19 children, 99.2% in H group of 14 children), and modest cure rates of 73% in the low-medium and 40% in the high egg count group. However the reduc-

Figure 2. Twenty-one of the 45 children who participated in the study on urinary iron loss and physical fitness. Note all children have bare feet.

tions in egg counts showed that essentially 99% of the infected children's passage of schistosome eggs had ceased.

The three groups did not differ significantly before treatment in terms of any of the potential confounding variables measured, including mean age (range 7-15 yr), hemoglobin level (Table 5), anthropometry, or mean 24 hr urinary creatinine excretion (range of group means 576 to 581 mg/24 hr, data not shown). There were also no significant associations with X^2 tests between groups in sex ratio (range 50% to 75% male per group), or parasitic infections other than schistosomiasis including hookworm (74% to 100% positive), Trichuris trichiura (84% to 93% positive), or malaria (32% to 42% positive). The intensity of hookworm infection did not differ significantly between groups (arithmetic means for C, LM, and H groups: 2,097, 1,846 and 1,718 respectively); and only one child each in the C and H groups and two children in the LM group had baseline hookworm egg counts greater than 5,000 epg.

2. Urinary Iron Loss

Before treatment the control group was losing a mean of 149 ug of iron per 24 hr while the group with low-medium S. haematobium egg counts lost almost twice as much (278 ug) and the high egg count group lost 4 times as much iron per 24 hr (652 ug, see Table 5). Iron loss in the high egg count group was significantly greater than in the control and low-medium groups. Iron loss per 24 hr was linearly related to S. haematobium egg count in the 33 infected children (Pearson $r=0.40$, $P<0.01$), and the log of iron loss was even more strongly correlated with the log of egg count (Pearson $r=0.56$, $P<0.0003$, $R^2=32\%$) (Figure 3). Even though iron loss correlated with egg counts, there was marked individual variation in iron loss between subjects that was not related to egg counts, with some uninfected children excreting more iron in their urine than some of the children with low-medium S. haematobium egg counts (Table 5). This variation was probably due to variation between children in the chronicity of their infections and condition of their urinary tracts including their bladders, and of course to individual variation and experimental error.

The high egg count group was losing approximately 0.5 mg more iron in their urine per 24 hr than was the uninfected group. This finding has important implications for iron requirements of S. haematobium-infected children because it shows that iron losses in infected children can be comparable to menstrual blood losses in women. Hallberg et al (32) estimated menstrual iron losses to be on the order of 0.5 mg/day when averaged over an entire month, and these findings are to a large extent responsible for the Recommended Dietary Allowance (RDA) (27) for iron for women of child-bearing age to be 18 mg/day, or almost twice as high as the 10 mg/day recommended for adult males. The RDA for iron for children 11-14 years of age (without S. haematobium infection) is 18 mg/day. Since S. haematobium infection tends to reach its peak prevalence and intensity in the 10-15-year-old age group in endemic areas, an RDA which would prevent iron deficiency anemia in almost all infected children, assuming at least a 10% absorption of food iron, should perhaps be closer to 26 mg/day. The importance of urinary iron losses in relation to likely dietary iron intakes in children in this part of Kenya is discussed in a following section.

Table 5. Background Data and Pre-treatment Urinary Iron Losses in *S. haematobium*-Infected and Uninfected Groups In Order of Ascending Egg Count

	Age		hemoglobin	S.haematobium	hematuria[1]		Fe loss		
ID	yr	Sex	g/dl	eggs/10ml adj	pre	post	ug/10 hr (daylight)	ug/14 hr (night)	ug/24 hr
Control group									
39	9	M	11.8	0	neg	-	21.	46.	67.
33	9	M	11.6	0	neg	-	28.	60.	88.
156	11	M	9.5	0	neg	-	107.	47.	154.
123	10	F	11.8	0	neg	-	48.	28.	76.
118	9	F	11.3	0	neg	-	41.	53.	94.
149	7	M	12.9	0	neg	-	80.	45.	125.
151	7	M	11.3	0	neg	-	125.	70.	195.
152	7	M	11.3	0	neg	-	114.	86.	200.
161	10	M	12.4	0	neg	-	46.	63.	109.
34	10	M	13.3	0	neg	-	31.	90.	121.
25	15	M	13.9	0	neg	-	59.	148.	207.
10	11	F	12.9	0	neg	-	192.	156.	348.
$\bar{X}$[2]	9.6		12.0	0[3]		arith $\bar{X}$	74.	74.	149.
SEM	.64		.34			geom $\bar{X}$	60.	66.	133.
Low-medium group									
57	10	F	13.3	16	+3	neg	55.	30.	85.
47	11	F	12.5	40	+2	neg	96.	121.	217.
143	7	F	12.1	40	+1	neg	328.	145.	472.
68	8	F	12.3	41	+3	neg	104.	81.	185.
23	14	M	13.8	56	+1	neg	21.	34.	55.
19	14	M	11.8	60	+1	neg	82.	160.	242.
170	7	F	13.8	61	+3	neg	70.	15.	85.
906	7	M	12.6	90	+3	neg	59.	39.	98.
916	9	M	10.3	92	+3v	trace	388.	403.	791.
93	9	M	12.0	93	+3	neg	212.	66.	278.
100	13	M	12.2	97	+2	neg	92.	228.	320.
905	9	F	12.8	105	+3	+2	1068.	165.	1233.
216	9	F	13.0	107	trace	+1	20.	28.	48.
901	10	M	10.1	116	+3v	trace	63.	141.	204.
223	13	M	12.6	122	+3	neg	85.	69.	154.

Table 5 (continued)

	Age		hemoglobin	S.haematobium	hematuria[1]		Fe loss		
ID	yr	Sex	g/dl	eggs/10ml adj	pre	post	ug/10 hr daylight)	ug/14 hr (night)	ug/24 hr
126	8	F	9.0	122	+3	neg	139.	97.	236.
129	12	F	12.4	132	+2	neg	161.	71.	232.
94	10	M	8.0	166	trace	-	34.	48.	82.
200	15	M	14.4	177	+1	neg	107.	155.	262.
$\bar{X}$	10.3		12.0	91[3]		arith $\bar{X}$	166.	110.	278.
SEM	.59		.38			geom $\bar{X}$	94.	81.	193.
High egg count group									
64	11	F	11.9	206	+2	neg	126.	242.	368.
910	7	F	11.3	228	+3	neg	118.	314.	432.
95	10	M	11.2	268	+3	neg	96.	190.	286.
164	7	F	13.4	270	+3v	+2	217.	216.	433.
50	11	M	9.7	290	+3	+2	760.	595.	1355.
159	11	M	12.4	302	+3	neg	282.	133.	415.
212	10	F	11.4	400	+2	neg	210.	353.	563.
86	14	M	11.9	422	+3v	trace	711.	588.	1299.
97	8	F	12.3	442	+3	neg	350.	133.	483.
911	9	F	11.0	600	+3v	neg	256.	388.	644.
915	13	M	10.6	723	+3v	+1	447.	362.	809.
178	8	M	11.4	887	+3v	+1	443.	202.	645.
117	10	M	13.3	940	+3v	neg	146.	1010.	1156.
214	14	F	10.9	1194	+2	trace	75.	164.	239.
$\bar{X}$	10.1		11.6	512[3]		arith $\bar{X}$	303.	349.	652.
SEM	.59		.27			geom $\bar{X}$	238.	292.	568.

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[1] Determined with Ames Multistix; v = visible blood in urine, - = not measured.

[2] No significant differences between groups in mean age or hemoglobin level; iron excretion per 10 hr, 14 hr, and 24 hr significantly greater in H group than C and LM groups (ANOVA $p<.0004$, and least significant differences tests $p<.05$ on logs of values); no significant differences between iron loss in 10 hr daylight vs 14 hr of night within any of 3 groups with paired t-tests.

[3] Arithmetic means; geometric means = 80 (LM group) and 439 (H group).

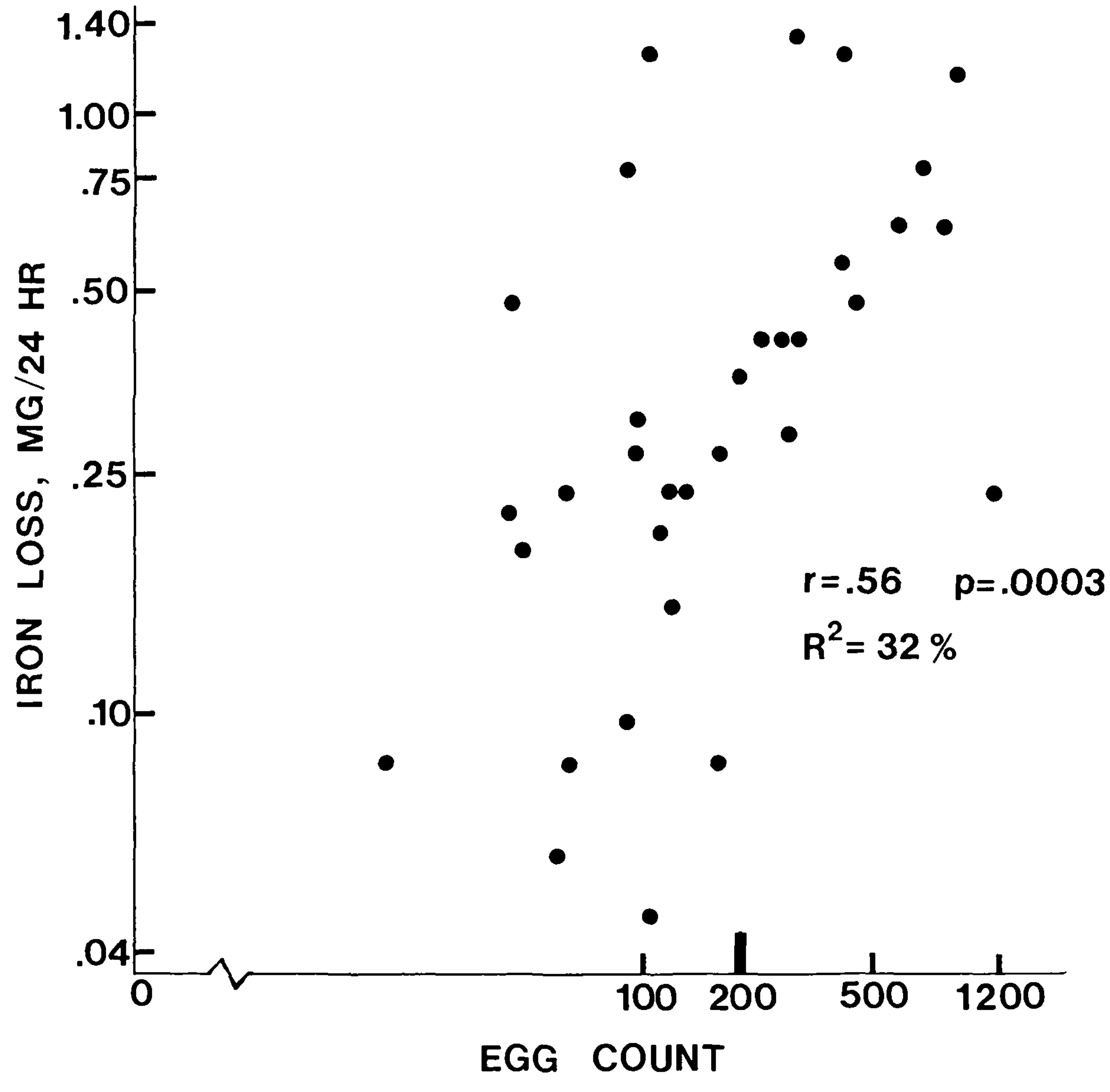

Figure 3. Relationships Between Log of Urinary Iron Loss per 24 hr and Log of *S. haematobium* Egg Count in 33 Infected Children Before Treatment. Pearson r was calculated from log values of both variables. Regression line for logs of values: $y = 0.497(X) - 1.617$. (Adapted from Stephenson *et al.*, Am. J. Trop. Med. Hyg. 34: 322-330, 1985.)

The urinary iron lost from the infected children was probably mainly from hemoglobin, but serum iron and iron in shed epithelial cells almost certainly contributed as well, since the urine of uninfected persons contains small quantities of iron, generally less than 100 ug per day (33,34), but no blood. We calculated the approximate amount of blood lost in the urine for the three children with the highest pretreatment iron losses, in order to compare our results with those of three previous studies (23,35,36). The estimated blood losses were 2.6, 3.3, and 4.2 ml per day. These figures are similar to those obtained in South Africa (1.3-6.1 ml/day) (23), and Egypt (0.44-6.0 ml/day) (35), although a study of Egyptian patients with severe persistent hematuria reported that they lost considerably more on average than our most severe cases (2.6-126.0 ml/day) (36).

It is unclear how long the hematuria persists and how much iron losses vary as S. haematobium infection progresses; this is an important question (37) because the total amount of hematuria per unit time determines in part whether a person's iron stores become depleted, when iron deficiency anemia develops, and how severe it becomes. Hematuria is thought to decrease or disappear with time in most infected school children and young adults in endemic areas, but the studies in Egypt and South Africa show that adults can have physiologically important hematuria as well. However, without knowing the precise course that hematuria follows, we agree with others that "this loss of blood is a good reason for the treatment of urinary bilharziasis in an endemic area, for even if it is slight, this extra loss of blood in an individual whose diet is not very good may precipitate him into a state of anaemia" (37). (For a full list of references on measurement of hematuria and proteinuria in S. haematobium infection, see paper on Schistosomiasis and Human Nutrition in this volume.)

Seven weeks after treatment for S. haematobium infection, iron losses in the two infected groups were similar to those of the control or uninfected group in the subsample studied, so that there were no statistically significant differences among the three groups in iron loss after treatment (Table 6). Iron losses decreased significantly in the high egg count group from 1,250 to 344 ug/g creatinine ($P<0.002$) and decreased from 341 to 226 ug/g creatinine in the low-medium group (borderline $P=0.086$).

The marked reductions in iron loss after treatment occurred along with very marked reductions in S. haematobium egg counts (see Table 6). This implies that the extra iron loss was caused by reversible lesions in the bladder which, at least in children of this age and intensity and chronicity of infection, are capable of healing within a 7-week period.

3. Urinary Protein Loss - Rough Estimate

We were interested in estimating urinary protein losses due to S. haematobium infection because a) the infection is endemic in areas where protein-energy malnutrition (PEM) is common, b) we have found that treatment for S. haematobium improves growth (2), and c) we wanted to determine whether the amount of protein lost in the urine might be sufficient to cause or aggravate PEM. Very rough estimates of protein

Table 6. Pre- and Post-treatment Egg Counts and Urinary Iron Losses in S. haematobium-Infected and Uninfected Groups

Group	ID[1]	S. haematobium eggs/10ml adj pre	post	Fe, ug/g creatinine, 10 daylight hr pre	post	decrease
Control	33	0	0	120	329	-209
	118	0	0	207	161	46
	34	0	0	112	120	88
	186	0	0	567	624	-57
	10	0	0	855	227	628
$\bar{X}$ ± SEM[2]		0[3]	0[3]	372 ± 147	308 ± 84	64 ± 147
Low-medium	68	41	0	485	261	224
	23	56	0	78	48	30
	19	60	0	233	70	163
	170	61	0	356	11	345
	906	90	0	318	894	-577
	93	93	0	933	0	933
	100	97	0	209	235	-25
	216	107	7	97	438	-340
	901	116	2	268	178	90
	223	122	1	270	230	40
	126	122	0	508	122	387
$\bar{X}$ ± SEM[2]		88[3]	1[3]	341 ± 72	226 ± 77	115 ± 118
High	64	206	16	552	397	155
	95	268	0	476	200	276
	164	270	5	1,488	78	1,410
	50	290	6	2,890	365	2,525
	212	400	0	882	519	363
	86	422	4	1,968	444	1,524
	97	442	0	1,812	614	1,198
	915	723	0	1,679	173	1,506
	117	940	2	480	425	55
	214	1,194	9	278	224	55
$\bar{X}$ ± SEM[2]		516[3]	4[3]	1,250 ± 269	344 ± 54	907 ± 267

[1] For sex and age of subjects see Table 5.

[2] Iron loss before treatment significantly greater in H than in C and LM groups (ANOVA $p<.002$ and least significant differences tests $p<.05$ on logs of values); post-treatment values ns; decreases in iron loss with paired t-tests: H ($p<.002$), LM ($p=.086$), C(ns).

[3] Arithmetic means; geometric means before treatment in LM and H groups: 84 and 439, post-treatment: 1 and 3, respectively.

loss were calculated from the urinary reagent strip proteinuria result on a midday urine specimen and the children's mean urine volumes for 3 days (Table 7). For this calculation, which was based on daytime samples only, to be reasonable, it was assumed that the ratio of protein to iron entering the urine is similar in the daytime and at night. Urinary iron excretion did not vary significantly between the 10-hr daylight and 14-hr night specimens even though the maximum egg excretion is known to occur at midday (Table 5), and we assume that there is no marked diurnal variation in protein excretion as well. These estimates are very rough because the urinary reagent strips only produce semi-quantitative results, and the test area of the strips is more sensitive to albumin than to globulin, hemoglobin, Bence-Jones protein, and mucoprotein. They are presented only to provide an idea of the order of magnitude of protein losses and to encourage others to study this subject more fully in appropriately selected groups.

Before treatment, the estimated mean protein loss per 10 hr in the C group was only 10 mg, while it was 746 mg in the LM group and 740 mg in the H group (Table 7). Although the mean losses in the two infected groups were surprisingly similar, the H group had twice as many children with losses over 1 gram/10 hr as did the LM group (29%, 16%, respectively). Seven weeks after treatment, protein losses in both infected groups had markedly decreased to only 2 or 3 times that of the C group (LM = 22 mg/10 hr; H = 31 mg/10 hr). If the losses per 10 hr are doubled to give an estimate of protein losses per 24 hr, none of the children in the C group was losing more than 1 g of protein per day, while 4 of 19 or 21% of the LM did so and 9 of 14 or 64% of the H group did. The maximum loss in the H group was 2.5 g/10 hr or about 5 g/24 hr. A loss of 5 g/24 hr is somewhat disturbing, but on the whole the quantity of protein lost, assuming our estimates are reasonable, is not likely to have as great a negative impact on child nutritional status as are the iron losses. This is mainly because iron is deficient in the diets of children in this area, and, as the next section shows, protein is not particularly deficient. However, protein losses of this magnitude would be harmful in seriously ill patients, persons with protein deficiency per se, those consuming diets with a marginal protein content, or in children who have had fevers and other infections, many of which are known to cause increased urinary nitrogen losses. To corroborate the impression from our estimates, Norden and Gelfand (38) precisely measured urinary protein excretion per 24 hr with the Lowry method in 130 Zimbabwean children and adults with varying but unspecified intensities of S. haematobium infection; in only one subject did protein excretion exceed 1 gram per 24 hr. They concluded that "protein loss in the urine in S. haematobium would appear to make little contribution to the severity of malnutrition except perhaps in extreme cases of kwashiorkor and marasmus." It also seems unlikely that protein losses of these magnitudes are responsible for growth deficits in S. haematobium infection and improved growth after treatment in the average infected child; the mechanisms very likely lie elsewhere.

4. Dietary Iron and Protein Intakes

The importance of the hematuria and proteinuria occurring in S. haematobium infection depends to a large extent upon whether infected children are consuming enough iron and protein to compensate for abnormal

Table 7. Proteinuria, Urine Volumes, and Rough Estimate of Protein Loss Pre- and Post-Treatment in *S. haematobium*-Infected and Uninfected Groups in Order of Ascending Egg Count

ID[1]	Proteinuria[2]		Urine volume, ml per 10 hr[3]	Urine volume, ml per 10 hr[4]	Urine volume, ml per 24 hr[3]	Rough estimate of protein loss/10 hr, mg[5]	
	pre	post	pre	post	pre	pre	post
Control group							
39	neg	-	385	-	863	0	-
33	neg	-	414	690	842	0	-
156	trace	-	288	-	658	35	-
123	neg	-	245	-	1,080	0	-
118	neg	-	360	300	793	0	-
149	neg	-	548	-	920	0	-
151	neg	-	577	-	987	0	-
152	trace	-	403	-	892	48	-
161	trace	-	320	-	615	38	-
34	neg	-	160	153	768	0	-
25	neg	-	188	-	1,262	0	-
10	neg	-	303	410	1,055	0	-
$\bar{X}$			349	388	894	10	-
SEM			36.8	113.6	52.8	5	-
Low-medium group							
57	trace	+1	398	-	755	48	-
47	+2	neg	520	-	1,172	1,040	-
143	+1	trace	368	-	892	221	-
68	+1	trace	412	470	833	247	56
23	+1	neg	177	418	780	106	0
19	+2	neg	224	408	777	447	0
170	+1	trace	512	535	817	307	64
906	trace	neg	605	383	1,088	73	0
916	+1	trace	435	-	973	261	-
93	+2	neg	637	660	1,105	1,273	0
100	+1	trace	247	475	1,027	148	57
905	+1	neg	1,267	-	1,885	760	-
216	+1	trace	273	275	632	164	33
901	+2	trace	143	255	538	287	31
223	+1	neg	572	790	1,182	343	0

Table 7 (Continued)

	Proteinuria[2]		Urine volume, ml per 10 hr[3]	per 10 hr[4]	per 24 hr[3]	Rough estimate of protein loss/10 hr, mg[5]	
ID[1]	pre	post	pre	post	pre	pre	post
126	+1	neg	307	415	705	184	0
129	+3	+2	1,170	-	2,138	7,605	-
94	+2	-	209	-	585	417	-
200	+1	neg	415	-	1,210	249	-
$\bar{X}$			468	462	1,005	746	22
SEM			69.4	47.1	94.3	388	8
High egg count group							
64	+2	trace	292	393	999	584	47
910	trace	neg	349	-	992	42	-
95	+2	neg	303	628	1,067	607	0
164	+2	trace	192	200	497	383	24
50	+1	neg	353	880	1,290	212	0
159	+1	neg	318	-	948	191	-
212	+3	neg	388	363	1,088	2,524	0
86	+2	trace	290	633	1,667	580	76
97	+2	neg	535	423	967	1,070	0
911	+2	neg	508	-	1,235	1,016	-
915	+2	neg	487	335	1,013	973	0
178	+2	neg	212	-	549	424	-
117	+3	neg	170	485	805	1,107	0
214	+2	+1	328	278	885	657	167
$\bar{X}$			338	462	1,000	740	31
SEM			30.0	63.8	78.0	164	17

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[1] For sex, age and egg counts before treatment see Table 5.

[2] Determined with Ames Multistix on midday specimen; - = not measured; estimated protein content on package insert: trace = 5-20 mg protein/dl urine, +1 = 30 mg, +2 = 100 mg, +3 = 300 mg, +4 = >1000 mg.

[3] Mean of 3 days of collection.

[4] Mean of 2 days of collection.

[5] Estimated from proteinuria result (mg/dl) times urine volume (ml) for 10 hr period ÷100 ml, assuming proteinuria readings represent midpoint of interval as follows: trace = 12 mg/dl, +1 = 60 mg, +2 = 200 mg, +3 = 650 mg.

urinary losses. We were not able to collect dietary intake data on the children who participated in the substudy, but K. Kurz estimated nutrient intakes of 13 of the girls who were subjects for the major growth study (26). The 13 girls were 12-15 years of age and were chosen at random from the female study children in this age group at Mvindeni Primary School. Their nutrient intakes were estimated from three 24-hr recalls which were administered during Exam 3 in March-April 1983. We have no reason to believe that the dietary patterns of and foods eaten by boys and girls in this age group in this community are markedly different, and we present the nutrient intakes for nutrients related to anemia in order to help put the hematuria and proteinuria discussed above in perspective.

The results of the 24-hr recalls showed that reported iron intakes were low and protein intakes were generally sufficient (Table 8). The mean intake of total iron was 8.8 mg which is only 49% of the Recommended Dietary Allowance (RDA) (27) of 18 mg for this age group. No girl reported consuming over 80% of her RDA for iron, and 38% reported consuming less than 40% of their RDA. Only 4% of the iron was heme iron; the rest was non-heme iron which is more poorly absorbed than heme iron. Eleven of the 13 or 85% of these girls were anemic (hemoglobin below 12.0 g/dl, Table 8), partly because of low iron intakes but also probably due in part to endemic S. haematobium, hookworm and malarial infections. To eliminate iron deficiency anemia in this population through dietary change using available foods would be nearly impossible; iron intakes are very low, and foods high in readily absorbable heme iron are too expensive for most people to eat more of even though they would like to do so. Iron nutrition in this community is a case in which large scale treatment for S. haematobium can measurably improve nutritional status of many persons. Treatment of parasitic infections which are pathological causes of blood loss, including S. haematobium and hookworm, will at least raise hemoglobin levels and decrease anemia in the short term (1). Consuming foods rich in ascorbic acid at mealtimes would also improve absorption of non-heme iron.

Protein intakes estimated from the 24-hr recalls were favorable, due mainly to the high protein content of maize meal, the most commonly consumed staple. The mean intake of protein was 45 g or 97% of the RDA; only 25% of the girls reported consuming less than 80% of their RDA for protein, and no girl reported consuming less than 60% of the RDA. Thus, it seems that proteinuria caused by S. haematobium infection is probably not a major cause for concern in this population except in isolated cases of protein deficiency or other serious illness in hospital patients. The protein intakes are relatively high, and the protein losses in the urine are likely to be less than 5 g/day in almost all infected children.

5. Physical Fitness Tests

The results of the Harvard Step Test are shown in the Appendix and Figure 4. Before treatment for S. haematobium infection with metrifonate, there were no significant differences in resting heart rate between the three groups. However, the two infected groups had higher post-test heart rates and poorer physical fitness scores than the uninfected group. Thus infected children had higher heart rates after

Table 8. Nutrient Intakes of 13 Girls Estimated with 24-hr Dietary Recall[1]

	Age	Hemoglobin		Protein		Iron, mg				Ascorbic acid		Vitamin A	
ID	yr	g/dl	Kcal	g		total		non-heme	heme	mg		ug RE	
9	14	8.8	1486	40.3		6.2		5.57	0.61	23.7		60	
11	14	11.0	2103	48.3		11.9		11.37	0.54	273.3		175.	
12	15	10.7	2775	64.3		12.0		11.63	0.37	34.3		222.	
16	13	11.6	1504	38.6		7.4		6.87	0.52	23.0		81.	
64	13	12.3	2154	50.2		12.5		12.06	0.42	337.0		268.	
67	14	11.6	1842	45.2		9.0		8.65	0.37	11.3		35.	
123	12	11.7	1433	50.9		7.1		6.69	0.38	5.7		48.	
132	13	13.5	1377	38.4		6.6		6.37	0.19	189.7		97.	
134	12	11.9	2684	60.0		13.9		13.34	0.59	123.0		906.	
204	13	11.2	1927	45.4		7.9		7.59	0.32	36.7		124.	
235	12	10.3	1235	34.2		5.3		5.09	0.25	16.0		77.	
242	13	11.7	1262	29.6		6.5		6.32	0.18	21.3		38.	
459	12	10.3	1751	34.0		8.1		7.92	0.19	180.3		1,707.	
$\bar{X}$	13.0	11.3	1810	44.6		8.8		8.42	0.38	98.1		295.	
SD	1.0	1.1	506	10.2		2.82		2.75	0.15	112.3		483.0	
RDA[2]		-	-	46		18		-	-	50		800	
% RDA, X		-	-	97.0%		48.9%		-	-	196.2%		36.9%	
% of RDA				n	%	n	%			n	%	n	%
120+				2	15	0	0			5	38	1	8
100-119				3	23	0	0			0	0	1	8
80-99				5	38	0	0			0	0	0	0
60-79				3	23	4	31			2	15	0	0
40-59				0	0	4	31			3	23	0	0
20-39				0	0	5	38			2	15	3	23
<20				0	0	0	0			1	8	8	62

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[1] Estimated nutrient intakes are means of 3 24-hr recalls except for subject nos. 16 and 134 (2 days of recalls).

[2] RDA's are US RDA's for 1980 for 11-14 year old girls.

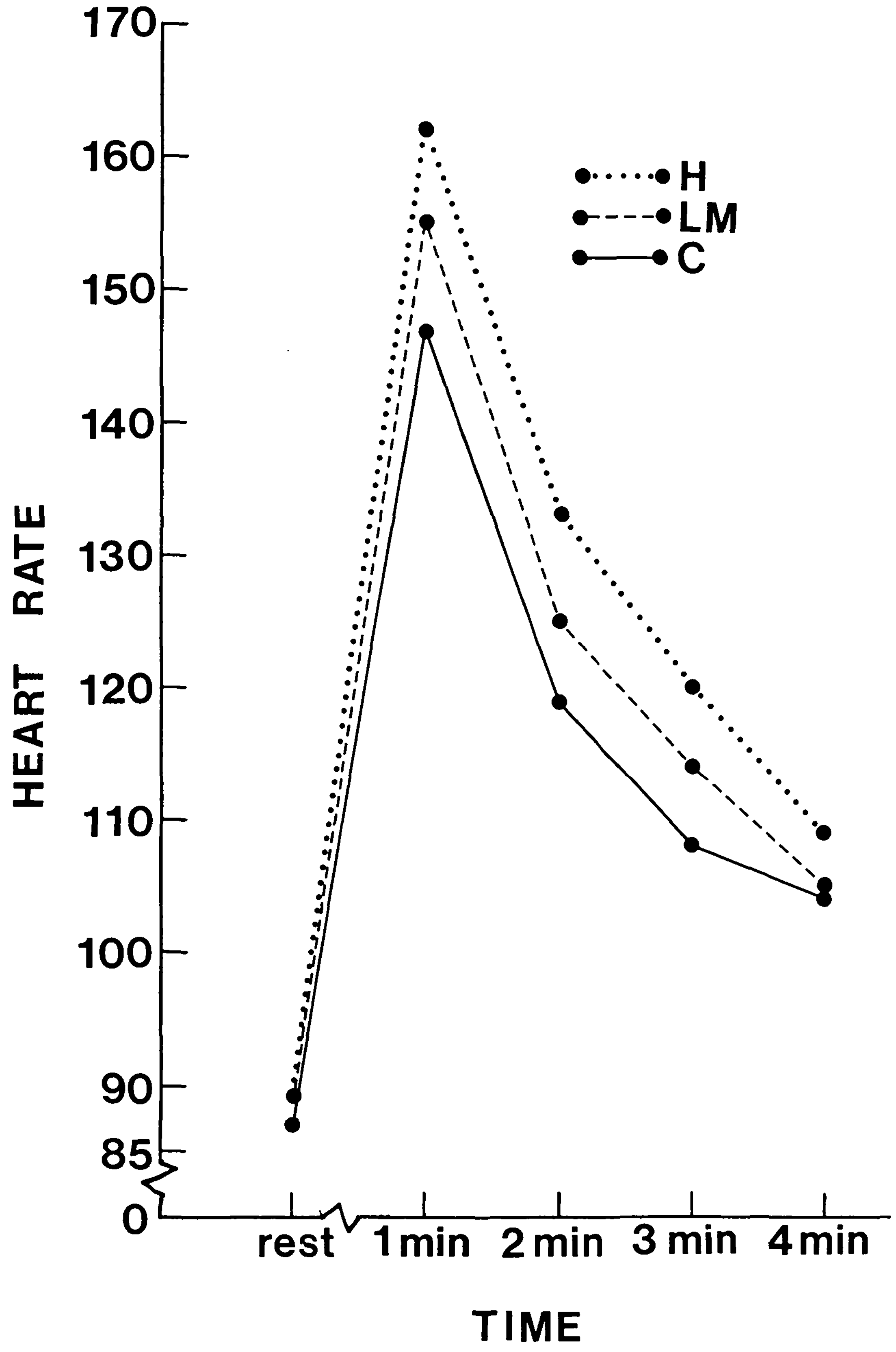

Figure 4. Harvard Step Test - Pre-treatment Heart Rates in High (H), Low-medium (LM), and Control (C) Groups. Heart rates in beats per minute taken in resting state and at 1, 2, 3, and 4 minutes after completion of test. n = 42. (Adapted from Stephenson et al., Am. J. Trop. Med. Hyg. 34:322-330, 1985.)

performing the same relative amount of physical work and were therefore less physically fit than the control group. The appendix table and Figure 4 show that the high egg count group had the highest mean heart rates and the lowest fitness score of 69, that the control group had the lowest heart rate and best fitness score of 81, and that the low-medium group had an intermediate fitness score of 75. The high egg count group had statistically significantly higher heart rates at 1, 2, and 3 min after the test; they also had a significantly lower mean fitness score, which was only 85% of the mean score for the controls. The heart rates and the fitness score of the low-medium group did not differ significantly from the control or high egg count groups.

After treatment, heart rates at 1, 2, and 3 minutes after the test did not differ significantly between groups, and fitness scores improved significantly in the low-medium ($P<0.012$) and high egg count ($P<0.009$) groups, but they did not change in the control group, so that post-treatment scores did not differ significantly between the three groups (see Appendix).

The low-medium egg count group did not differ significantly from the high egg count or control groups in heart rates or fitness scores. However, since their test scores were half way between those of the high egg count and control groups, future studies should repeat similar fitness tests on a larger number of children to determine how heavy S. haematobium infection has to be before physical fitness is significantly decreased. The mechanism by which schistosomiasis can affect physical fitness is unclear. Urinary schistosomiasis could produce iron deficiency, iron deficiency anemia, and/or a chronic feeling of ill health and low energy levels not necessarily related to iron status per se. Since our three groups were chosen so that they did not differ significantly in initial hemoglobin level but were found to differ in initial physical fitness score, hemoglobin level alone cannot account for the effect of schistosomiasis on physical fitness. We did not attempt to measure morbidity and well-being or to perform measurements of iron status other than hemoglobin level; inclusion of these parameters in future studies is strongly recommended. However, since serum ferritin, transferrin saturation, and erythrocyte protoporphyrin levels are affected both by uncomplicated iron deficiency and by chronic inflammation, including malaria (39,40), indicators of iron deficiency must be chosen and interpreted with care, especially in tropical settings where multiple infections are prevalent in the community and can confound the diagnosis of iron deficiency.

IV. SUMMARY

The study on hemoglobin level and growth in children 6 and 16 months after treatment has shown that those treated with a standard course of metrifonate for light-moderate infections of S. haematobium (1-500 eggs/10 ml adj) exhibited, when compared with a randomly assigned placebo group:

1. significantly better growth 6 months after treatment, judged by increases in weight (0.8 kg or a 50% increase over placebo group), weight for height squared (200% increase), arm circumference (0.4 cm or 400% increase), and triceps and subscapular

skinfold thicknesses (2); these benefits appeared to continue for up to 16 months after treatment.

2. significantly larger increases in hemoglobin level 6 months after treatment (0.3 g/dl or 30% increase) (1).

3. within the treated group, children with higher S. haematobium egg counts, higher hookworm egg counts, higher initial malarial parasite counts or poorer initial nutritional status (hemoglobin level or anthropometric measurements) showed the most improvement (1,2).

4. metrifonate's effectiveness in reducing hookworm egg counts has major public health importance for areas where iron deficiency anemia, hookworm infection, and S. haematobium infection are highly prevalent (29-31) although reinfection will occur.

The study of urinary iron loss and physical fitness showed that:

1. Children with relatively high S. haematobium egg counts (>200 e/10 ml adj) lost 4 times as much iron in their urine as did uninfected children, and children with low-medium egg counts lost about twice as much iron. Iron loss in infected children was linearly related to egg count, and extra iron loss in the relatively heavily infected children (0.5 mg/day extra) is high enough to produce anemia in many tropical populations. The high egg count group represented over 12% of the infected children in grades 1-4 in this area of Kenya, so S. haematobium clearly can contribute significantly to anemia in endemic areas, particularly if dietary iron intakes are low and other pathological causes of anemia, such as hookworm infection and malaria, are prevalent. However, urinary iron losses return to normal levels in infected children very soon after a standard course of metrifonate (4).

2. S. haematobium infected children were less physically fit and had higher heart rates when performing the same amount of work than did uninfected children. Children with high egg counts were significantly less fit than controls; children with low-medium egg counts also had lower fitness scores but were not significantly different from controls. However, after treatment with a standard course of metrifonate, physical fitness scores increased significantly in both the low-medium and high egg count groups and were then similar to uninfected values, while scores did not change in the uninfected group, showing that decreased physical fitness is rapidly reversible with treatment (4).

We conclude that metrifonate treatment of even light and moderate infections of S. haematobium results in a much greater improvement in general health status of children than was previously thought. S. haematobium infection can cause enough urinary iron loss to precipitate or aggravate anemia in children, particularly in areas such as the Kenya Coast where other parasitic causes of anemia are prevalent (41-44) and/or dietary iron intakes are inadequate; treatment of S. haematobium infected anemic children will improve their hemoglobin levels. Treatment of S. haematobium infection with metrifonate may improve child growth and physical fitness in areas where protein-energy malnutrition and hookworm infection are common. While heavy S. haematobium infections are likely to respond most to treatment, children with light and moderate infections will also benefit from and deserve to be treated (1,2,4,6). We recommend more widespread use of population-based chemotherapy to control urinary schistosomiasis and hookworm infection and appropriate measures to control malarial infection in communities with high prevalences of protein-energy malnutrition and/or anemia.

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PHYSICAL FITNESS SUB-STUDY STUDY NO. ______

Child's I.D. No. ____________ Child's Standard _____
Child's Name ________________________________ Child's Age _____ years
Father's Name ____________________ Mother's Name ____________________

	Exam 1	Exam 2
1. Date and Time of Test		
2. Humidity and Temp (°C)		
3. Weight (kg)		
4. Height (cm)		
5. Sitting Height (cm)		
6. Leg Length (cm) (4.-5.)		
7. Step Height (40% of 6.)		
8. Back Pack Weight (20% of 3.)		
9. Heart Auscultation		
Pulse Rate (per minute)		
10. (a) Resting		
(b) During Test		
11. (1) 3½ to 4 mins.		
12. (2) 4½ to 5 mins.		
(c) Post-Test		
13. (1) 1-1½ mins. (6-6½)		
14. (2) 2-2½ mins. (7-7½)		
15. (3) 3-3½ mins. (8-8½)		
16. (4) 4-4½ mins. (9-9½)		
17. Duration of Test (seconds)		
18. Haemoglobin (g/dl) & Date		
19. S. haematobium (eggs/10 ml)		
Score		
20. (1) Method A		
21. (2) Method B		
Remarks (if any)		

Appendix Table 1. Heart Rates and Physical Fitness Scores Pre- and Post-Treatment in *S. haematobium*-Infected and Uninfected Groups - In Order of Ascending Egg Count

				Heart rate, beats/min									
	wt	pack	step	pre-treatment				post-treatment				Fitness score^2	
ID^1	kg	wt,kg	ht,cm	rest	1min	2min	3min	rest	1min	2min	3min	pre	post
Control group													
39	27.5	5.5	26	90	146	114	104	88	144	118	106	82.4	81.5
33	27.0	5.5	26	78	152	131	116	74	142	126	98	75.2	82.0
156	30.5	6.0	30	66	124	112	100	74	142	114	90	89.3	86.7
123	36.0	7.0	30	96	134	122	112	96	152	114	112	81.5	79.4
118	24.5	5.0	26	102	166	128	118	98	172	134	110	72.8	72.1
149	21.5	4.5	25	84	126	102	98	86	128	100	94	92.0	93.2
151	22.0	4.5	23	90	152	128	114	94	160	126	112	76.1	75.4
152	21.0	4.0	23	92	160	118	114	82	148	114	110	76.5	80.6
161	25.0	5.0	26	74	122	98	88	72	126	94	96	97.4	94.9
34	32.5	6.5	30	94	158	128	112	78	148	122	110	75.4	78.9
25	48.0	9.5	33	82	148	112	104	72	142	108	110	82.4	83.3
10	32.0	6.5	23	94	172	132	118	88	158	130	114	71.1	74.6
$\bar{X}^3$	29.0	5.8	27	87	147	119	108	84	147	117	105	81	82
SEM	2.21	.43	0.9	3.0	4.8	3.3	2.7	2.8	3.7	3.4	2.4	2.4	2.0
Low-medium group													
57	28.5	6.0	26	112	162	130	128	92	176	144	120	71.4	68.2
47	36.0	7.0	30	84	151	122	112	82	148	126	108	57.1	78.5
143	22.0	4.5	26	112	167	145	124	82	164	150	132	68.8	67.3
68	27.5	5.5	30	80	160	118	106	82	148	126	112	78.1	77.7
23	34.0	7.0	30	70	128	104	93	72	118	98	90	92.3	98.0
19	42.0	8.5	32	64	142	124	106	58	130	104	90	80.6	92.6
170	20.5	4.0	26	88	164	126	120	82	170	122	108	73.2	75.0
906	21.0	4.0	26	92	152	128	120	94	144	132	124	75.0	75.0
916	20.5	4.0	26	96	148	124	120	82	136	110	106	76.5	85.2
93	23.5	4.5	26	82	132	106	98	84	134	106	94	89.3	89.8
100	44.0	9.0	32	88	164	126	121	84	158	122	114	73.0	76.1
905	23.5	5.0	28	88	160	124	118	82	162	132	120	74.6	72.5
216	25.0	5.0	26	100	164	130	122	86	176	144	118	72.1	68.5
901	26.0	5.0	26	90	148	112	102	82	142	110	98	82.9	85.7
223	33.0	6.5	30	74	144	125	115	76	148	118	106	78.1	80.6

Appendix Table 1 (continued)

				Heart rate, beats/min									
				pre-treatment				post-treatment				Fitness score[2]	
ID[1]	wt kg	pack wt,kg	step ht,cm	rest	1min	2min	3min	rest	1min	2min	3min	pre	post
126	29.0	6.0	26	90	180	142	130	86	172	138	122	66.4	69.4
129	39.5	8.0	36	118	162	124	116	92	160	116	110	68.4	72.0
200	47.5	9.5	32	76	156	134	100	78	148	98	89	76.9	89.6
$\bar{X}^3$	30.2	6.0	28	89	155	125	114	82	152	122	109	75	79
SEM	2.03	.42	0.7	3.4	3.0	2.5	2.5	1.9	3.9	3.8	3.0	1.9	2.2
High egg count group													
64	35.0	7.0	30	104	164	146	130	92	160	150	134	68.2	67.6
95	24.0	5.0	28	92	160	142	128	86	162	134	108	69.8	74.3
164	21.0	4.0	23	96	152	134	114	82	156	148	120	75.0	70.8
50	34.0	7.0	32	88	174	136	124	88	156	122	102	69.1	78.9
159	31.5	6.5	30	74	154	132	116	68	146	128	108	74.6	78.5
212	34.0	6.5	26	94	168	132	118	86	156	142	120	71.8	71.8
86	47.0	9.5	35	78	132	112	94	70	152	128	96	45.0	79.8
97	21.5	4.5	26	98	172	138	132	84	154	112	104	67.9	81.1
915	32.0	6.5	30	92	182	132	118	86	168	116	106	69.4	76.9
178	22.0	4.5	26	88	172	138	128	78	148	118	106	68.5	80.6
117	30.0	6.0	30	92	144	118	112	76	132	114	110	80.2	84.3
214	37.5	7.5	36	76	168	140	132	68	142	128	108	68.2	79.4
$\bar{X}^3$	30.8	6.2	29	89	162	133	120	80	153	128	110	69	77
SEM	2.23	.44	1.1	2.6	4.1	2.8	3.2	2.4	2.8	3.7	2.9	2.4	1.4

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1 For sex, age, hemoglobin levels and egg counts see Table 5.

2 Fitness score = duration of test (sec.) x 100 ÷ sum of heart rates at 1, 2, and 3 min after test. All children completed 300 sec. of stepping except for 3 children pre-treatment (ID 129, 275 sec; ID 47, 220 sec; ID 86, 152 sec) and 1 child post-treatment (ID 129, 278 sec). Work performed (kg meters/min) can be calculated from total weight lifted (body wt + pack wt, kg), step height (m), and rate of stepping per min (30 steps/min).

3 No significant differences between groups in body wt, pack wt, step ht, and pre-treatment resting heart rates and post-treatment fitness scores and post-treatment heart rates at rest, 1, 2, and 3 min after test. High egg count group significantly different from control group for pre-treatment fitness score and pre-treatment heart rates at 1, 2, and 3 min after test.

WATER, SANITATION, AND KNOWLEDGE ABOUT URINARY SCHISTOSOMIASIS IN A KENYAN COASTAL COMMUNITY: A STUDY COMBINING ETHNOGRAPHIC AND SURVEY TECHNIQUES

by

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SUMMARY

i. Aims of Study

The ethnography and household survey reported here were undertaken as part of a large study on the Relationships of Urinary Schistosomiasis and Its Treatment to Child Growth and Anemia which began in Kwale District, Coast Province, Kenya in mid 1981. The major aims of the analysis of the household survey and ethnographic data were a) to describe in detail the community's knowledge about schistosomiasis, their water resources, and sanitation, and to answer the following specific questions:

1. Do primary school children with S. haematobium infections and their mothers know less about the cause, prevention and treatment of S. haematobium infection than uninfected children and their mothers?

2. Do the infected and uninfected groups differ in socioeconomic indicators, including father's occupation, household size, construction of house, or fieldworker's assessment of income level?

3. Do the two groups differ in access to or reported utilization of all water resources, including: water sources used in dry and wet seasons, amount available per household member, time needed to fetch water, distance of household to marsh, and mother's report that child goes to marsh to bathe, wash clothes, draw water, or play?

4. Do children who come from households which have latrines differ from those who don't have latrines in prevalence or intensity of hookworm or Trichuris infections?

ii. Methodology

The ethnography consisted of a) in-depth open-ended household interviews with 9 mothers of children from Mvindeni School, b) key informant interviews with school teachers, community leaders, the local health educator, and fieldworkers, c) field observations of water sources and behavior, and d) mapping techniques to compare the locations of the households of infected and uninfected children with the locations of the local marsh and other water sources. The results of the in-depth interviews were used to design an appropriate household survey form which was administered to the parents of 105 children from Mvindeni Primary School. The children for the survey were chosen from the 250 children previously examined at Mvindeni School, to fall into one of two groups: heavy S. haematobium infection or uninfected. The heavily infected children were 54 children who had the highest S. haematobium egg counts in their urine when they were initially examined. Then 51 children were chosen for the uninfected group who a) had not passed S. haematobium eggs in their urine for two subsequent examinations and b) matched the infected group for age and sex.

iii. Survey Groups

The 105 children included in the survey came from 85 households. The infected and uninfected groups were very similar in sex ratio and age (55% vs 52% male, respectively; mean ages of 10.2 and 9.9 years, age range of 7 to 15 years). There were no statistically significant differences between the S. haematobium infected and uninfected groups in the socioeconomic indicators studied. However, trends in father's occupation, construction of walls of the house, income level assessed by the fieldworkers, and stated latrine use implied that the families of the uninfected children were probably slightly better off economically than were families of infected children.

iv. Knowledge about Schistosomiasis

The survey data show that most mothers and children either said they didn't know (and were perhaps confused) about causation and prevention of schistosomiasis, or they gave medically incorrect answers. In either case, the implications for control of S. haematobium are the same: neither mothers nor children know enough about the disease to prevent getting it through behavioral change. Over half or 55% of the parents questioned (mainly mothers) stated that they did not know what caused S. haematobium infections. Only 19% knew that the people get the infection by standing in infected water, 24% thought it came from drinking "dirty" water, and 2% stated that one caught the infection by eating hot peppers or too much sugar. Higher percentages of mothers of uninfected children vs infected stated that bilharzia was caused by standing in "dirty" water (24% vs 14%), and by drinking dirty water (30% vs 18%). In addition, fewer mothers of uninfected as opposed to infected children said they didn't know how bilharzia was caused (46% vs 65%, Kendall Tau C p = .057, borderline). A significantly higher proportion of mothers of uninfected children gave an etiology related to water (either drinking or standing in it) than did mothers of infected children (54% vs 31%, X^2 p = .021) but the percent giving the correct answer (standing in water) did not differ significantly between groups. Most study children (82-83% per group) said they did not know what caused bilharzia, and there were no significant differences between the 2 groups in responses given. The most common etiology given was "eating peppers and/or sugar" (12% of infected and 14% of uninfected groups). The mothers' and children's responses on how to prevent bilharzia were similar to their responses on causation. The ethnography and cross-tabulations of responses on cause and prevention showed that prevention is not a well understood concept.

v. Water Uses and Sources - Ethnography

The ethnography revealed the following major points about water uses and sources in the study area.

Water Uses

1. Main water uses are drinking, cooking, washing dishes, washing clothes, and bathing. In addition, children play in marsh water, and small amounts of water are used to make mud or cement for houses and for ritual ablution.

2. Most water is used at home; the exceptions are bathing and clothes washing, which are sometimes done at the point of collection, and playing, which is done only in the marshes.

3. Women are responsible for providing water for a household and use most of it to perform household tasks. Men are sometimes seen washing clothes but do not normally cook or wash dishes.

4. Men generally only draw and transport water when it is for sale, and the ways they draw and transport water are different from the ways women perform the same tasks.

Water Sources

1. The main water sources in the study area are deep wells, shallow water holes, marshes, water purchased from carts, and piped water bought at public taps or kiosks. In addition a few people use spring water, and in the wet season, many use rain water.

2. There is a distinction between drinking and washing water as far as sources chosen.

3. Most households get at least some of their water from deep wells, and water from these is considered especially good for drinking.

4. Rain water is not generally considered good for drinking, but it is widely used for washing.

5. Few people have access to piped water, regardless of whether it is purchased from the local taps or delivered by the men with water carts.

6. Marsh water is used mostly for washing and is only used for drinking or cooking when other nearby sources (water holes) dry up. The marshes are a common play site for children, and many adults bathe and wash clothes there.

vi. Water Use - Survey

The survey showed that a significantly higher percentage of households of infected children reported having small amounts of water per person per day (5.0-9.9 liters/person) than did households of uninfected children (35% vs 20%), while 22% of both groups of households reported a high daily water use (16.0-37.9 liters/person; Kendall Tau C p = .044). This difference implies that *S. haematobium*-infected children from the households with low water availability may go to the marsh area to bathe either because there is little water available at home or because they want to spare the mother the effort of fetching additional water and can enjoy playing in the marsh at the same time. The mean quantity of water available per person per day for all 85 households was 13.1 liters. The amount of time mothers reported spending to fetch water each day did not differ significantly between the infected and uninfected groups. A map which plotted locations of households in relation to the marsh most likely to transmit *S. haematobium* showed that the percentage of children living within 2000 m of the marsh did not differ significantly between study groups (31% of infected and 37% of uninfected children). However, when the ethnographer further subdivided the study area into sections where alternative bathing sites were scarce or plentiful, we found that of the 24 study children living in the northwest where alternative bathing sites are scarce, 83% of children had S. haematobium infection and only 17% were uninfected; of the 21 children living in the southwest where alternative bathing sites are plentiful, only 10% were infected and 90% were uninfected (X^2 $p<.0005$). These results emphasize the value of the ethnography and detailed knowledge of the study area in interpretation of results and also show that people in this area do choose safer water sources for bathing when they are readily available. Whether they choose safer bathing areas because of convenience or desire to avoid bilharzia is unclear.

vii. Water Sources in Dry and Wet Seasons

We asked mothers in the household survey to name the water sources they used in both the dry and wet seasons for each of the 5 main water uses identified in the ethnography (drinking, cooking, dish washing, clothes washing, and bathing). In the dry season, 91% of households reported using only one water source for all purposes, and 9% reported using two sources. In the wet season, however, when rain water becomes available, only 41% used one source, 56% used two sources, and 2% reported using three different water sources. The number of water sources used in the dry season was almost identical for the infected and uninfected groups. In the wet season, a higher percentage of households with uninfected as compared to infected children used two water sources (59% vs 49%), and a lower percentage of the uninfected group used only one source (39% vs 49%), but this difference was not statistically significant.

In the dry season, wells were by far the most common water source used and were used by 75-78% of households depending on the purpose. The second most common source was water purchased from taps or from water cart vendors (15-18% of households), and water holes or springs were the third most common source (7-8% of households). No one reported using either rain water or water from the marsh area in the dry season. In the wet season, more water sources were reported, and unlike the dry season, the percentage of households using a given source varied markedly between purposes. The most common water sources reported were either well water or rain water. Rain water became the most common source reported for dish washing (41% of households), clothes washing (58%), and bathing (53%), and well water was the second most common source reported for these purposes (26-38%). Well water remained the most commonly reported source for drinking (65%) and cooking (53%), but 12% of households also reported switching to rain water for drinking water and 27% used rain water for cooking in the wet season. The changes in water sources used between seasons seem very sensible indeed, given water scarcity, because the mothers said that they switched from well water (which they have to fetch) to rain water (which they can collect in their yards), and the largest percentages of mothers changed to using rain water for washing dishes, clothes, and bathing. These are tasks which generally require more water than is needed for drinking and cooking, and also the cleanliness of the water is less important than it is for drinking water.

In the dry season, fewer families of infected compared with uninfected children reported using well water, and more families of infected children purchased water from taps or water carts. These differences were of borderline significance for water for cooking and for washing dishes (X^2 p = .064) and were not statistically significant for the other three purposes. In the wet season, fewer mothers of the infected children again used well water and more purchased water from taps and carts for drinking and cooking than did mothers of uninfected children, but these differences were not statistically significant. For dish washing and clothes washing, more mothers of uninfected children used rain water and fewer used well water than mothers of infected children; the differences in the use of rain water between groups were of borderline significance for both purposes. There were no differences between study groups in reported use of water from the marsh area for any of the five water purposes, and only 4% of mothers reported using marsh water for any purpose.

viii. Children's Contact with Marsh

We asked the mothers who participated in the household survey whether or not their study child used the marsh area where *S. haematobium* infection is transmitted for any of five purposes: bathing, washing clothes, drawing water, playing, or any other purpose. Their responses were analyzed between and within study groups for differences in reported marsh contact by sex, age group, distance from households to the marsh area, household water use, and income level. A significantly higher proportion of mothers of infected as compared with uninfected children reported that their child used the marsh for at least one purpose (57% vs 33%, X^2 p = .026), and higher proportions of infected children reportedly used the marsh for each of the five purposes mentioned, including bathing (43% vs 18%, p = .009), washing clothes (41% vs 27%, ns), drawing water (30% vs 16%, ns), playing (36% vs 24%, ns), and other purposes (20% vs 10%, ns). Infected children reportedly used the marsh for a mean of 1.7 activities per child, while the mean for uninfected children was only 0.9 activities per child (p = .014); 27% of infected children were reported to use the marsh for 4-5 activities, compared with only 9% of uninfected children (p = .036). These findings are important because they show that many mothers knew that their children had contact with the marsh, and the children who were infected were also reported to use the marsh more than uninfected ones. Nevertheless, 33% of the uninfected children reportedly used the marsh but did not have patent *S. haematobium* infections in two urine examinations done 6 months apart.

Within the infected group, a higher proportion of older as opposed to younger children used the marsh for some purpose (62% vs 50%, ns) and used the marsh for 4-5 activities (38% vs 11%, borderline p = .076). Within the uninfected group, the opposite pattern emerged: a higher proportion of the younger rather than older children used the marsh (48% vs 18%, p = .035) and used it for 1-3 activities (39% vs 9%, p = .031). Thus the children in the infected group whose mothers knew they used the marsh tended to use the marsh for more activities and tended to be older (and therefore probably had had more years of contact with the marsh) than was true in the uninfected group.

Regarding distance of the child's house to the marsh, a much higher proportion of infected children who lived close to as opposed to far from the marsh used the marsh for some activity (91% vs 46%, p = .005) and used it for both 1-3 and 4-5 activities (p = .018). Within the uninfected group, however, children closer to the marsh tended to use it and to use it for more purposes but these relationships were only of borderline significance. Regarding specific water uses, within the infected group, children living close to the marsh were more likely to use it for all 4 purposes, and these differences were statistically significant for washing clothes (82% vs 27%, p = .001) and for drawing water (54% vs 22%, p = .019). In the uninfected group, children who lived closer to the marsh were also more likely to wash clothes there (43% vs 18%, p = .043), draw water (36% vs 7%, p = .010), and play in the marsh (31% vs 22%, ns) but the children who lived farther from the marsh were more likely to bathe there (25% vs 7%, p = .085). This last unexpected finding was probably due to the availability of alternative water sources for bathing for the uninfected children who lived close to the marsh.

ix. Latrines and Intestinal Helminths

The ethnography revealed the following major points about latrine availability in the study area.

1. Very few households have latrines.
2. The main obstacles to building them are rocky soil that is hard to dig up or sandy soil which collapses and the high cost of hiring someone to build them.
3. There is a wide understanding that people should have and use latrines.
4. This understanding is not firmly enough held to overcome the obstacles of sandy and rocky soil.
5. People do not like to talk about latrines.

About 75% of the 85 households interviewed for the survey did not have a latrine. The presence of latrines and the reported defecation sites for preschoolers and school children did not differ significantly between the two study groups, although a higher percentage of *S. haematobium* infected as opposed to uninfected children came from households where the respondent stated that preschoolers and school children defecated in the bush and not in the latrine (preschoolers, bush: 35% vs 22%, preschoolers, latrine: 2% vs 9%; school children, bush: 43% vs 35%; school children, latrine: 18% vs 26%). Although we could not check the truth of these answers, the implication is that more uninfected children came from better off households which either did use latrines more often or at least said they did because they knew that they were supposed to do so.

Since latrine use was uncommon in this area and the prevalences and intensities of hookworm and *Trichuris* infections in the school children were quite high, we examined the data to determine whether children living in households with latrines had lower worm burdens than those living in households without latrines. The 75 children from households without latrines did not differ in sex or age from the 30 children from households with latrines. The prevalences of hookworm and *Trichuris* infection were higher in children without a latrine than in those with one (hookworm: 85% vs 77%, *Trichuris*: 80% vs 73%) but these differences were not statistically significant. More children from houses without latrines had heavy hookworm infection (≥5,000 epg) than did children from homes with latrines (12% vs 3%, borderline p = .061), but the geometric mean egg counts (380 vs 191 epg) did not differ significantly. *Trichuris* egg counts did not differ significantly between groups.

These data show that possession of a latrine and family wealth in this area do little if anything to protect children from acquiring hookworm and *Trichuris* infections. These findings are not surprising, given the life cycles of the parasites, the constant fecal pollution of the environment, the high prevalences and intensities of the infections, and the fact that most children and some adults are barefoot most of the time, but they may be used to help convince people in the community to use latrines and encourage *all* of their neighbors to do so regularly. The relatively few people who do have latrines and who are relatively wealthy are not managing to protect their children from intestinal helminths any more than are the rest of the community. This point can perhaps be used by health educators to illustrate that sanitation is a community affair that must be dealt with by active participation of all and not just a few members of that community.

I. INTRODUCTION

The ethnography and household survey reported here were undertaken as part of a large study on the Relationships of Urinary Schistosomiasis and its Treatment to Child Growth and Anemia which began in the Kwale District, Coast Province, Kenya in mid 1981. This large study was designed to determine the role of urinary schistosomiasis as a contributory factor in protein-energy malnutrition and anemia by examining infected children in 4 Kenyan coastal primary schools, treating them with metrifonate, and measuring their subsequent growth and hemoglobin levels 6 and 16 months after treatment. The findings of the large study have been published elsewhere and include: the use of urinary reagent strips as a screening device for S. haematobium infection (1), changes in splenomegaly and hepatomegaly (2), hookworm egg counts (3-6), S. haematobium egg counts and hemoglobin levels (6), and growth (7), six months after metrifonate treatment and relationships between S. haematobium infection, urinary iron loss, and physical fitness of children (8). The changes in parasitic infections (S. haematobium, hookworm, and malaria) and hemoglobin levels and growth in over 500 children in the infected treated and uninfected untreated groups for the entire 16 month period of study are also reported in the second paper in this volume.

After we completed two rounds of examinations and treatment for the large study in 1981 and 1982, we decided to conduct a smaller study of factors potentially related to transmission of schistosomiasis and other parasitic diseases. One of the 4 primary schools, Mvindeni School, was chosen for this purpose. This decision was prompted by our finding that most children who were not passing S. haematobium eggs in their urine in September-November of 1981 were still uninfected when examined 6 months later in March-May of 1982, despite our observations that half of the children at Mvindeni School had S. haematobium infection and that most appeared to come from a relatively homogeneous rural community. In medical and nutrition research, the general practice is to study those who have disease or malnutrition (the negative deviants), but for public health there is an advantage in studying those who are at risk of disease or malnutrition but who are healthy (the positive deviants).

This sub-study was carried out in January-March 1983, during the final round of examinations for the large study. The sub-study consisted of an ethnographic component followed by a household survey. The major subject matter areas covered included: mothers' and children's knowledge and attitudes about the cause, prevention, symptoms, and treatment for urinary schistosomiasis; factors related to water use by the families (including water sources, uses, storage, and quantity per household member); the mothers' reports of children's contact with the marsh which transmits schistosomiasis; and latrine availability and its use by family members.

The ethnographic information was collected by Mr. Terry Elliott, assisted by two locally hired fieldworkers, Mohammed Ali and Said Abdallah. The ethnography was based on information collected during 9 in-depth household interviews and 85 household survey interviews, and was supplemented by interviews with school teachers, fieldworkers, and community leaders and observations Mr. Elliott made during 2 1/2 months of investigations in the study area.

Mr. Elliott used the results of the in-depth interviews to design an appropriate household survey form, which he and the two fieldworkers administered to the parents of 105 children from Mvindeni School. Dr. L. Stephenson chose the children for the survey from the 250 children previously examined at Mvindeni School, to fall into one of two groups: heavy S. haematobium infection or uninfected. The heavily infected children were 54 children who had the highest S. haematobium egg counts in their urine when they were initially examined in September-November 1981. Then 51 children were chosen for the uninfected group who a) had not passed S. haematobium eggs in their urine for two subsequent examinations (September-November 1981 and March-May 1982), and b) matched the infected group for age and sex. This allowed us to compare the physical, behavioral, and household characteristics of the two groups, one heavily infected and one uninfected, in an attempt to determine some of the factors encouraging transmission of urinary schistosomiasis in the Mvindeni area. The survey data are presented by study group and also for all households to provide information on differences between groups and on resources and knowledge in the community in general. The household survey data were analyzed by Dr. L. Stephenson and Agathe Pellerin and were combined with and are presented here with an edited version of Mr. Elliott's original ethnographic report.

II. METHODOLOGY

A. Ethnography

The ethnography consisted of a) indepth open-ended household interviews with 9 mothers of children from Mvindeni School, b) key informant interviews with school teachers, community leaders, the local health educator, and fieldworkers, c) field observations of water sources and behavior, and d) mapping to compare the locations of the households of infected and uninfected children with the locations of the local marsh and other water sources.

The 9 mothers selected for indepth interview were chosen from households of children with and without S. haematobium infection and from a variety of geographic locations within the study area. The topics discussed or observed at each interview included:

Description of house (construction, number of persons, presence or absence of shower, latrine, private well)

Description of respondent (clothes, jewelry, attitude and willingness to answer questions)

Income level of household (estimated by fieldworker from house, woman's appearance, husband's job, possessions)

Schistosomiasis - respondent's knowledge of and opinions about cause, prevention, symptoms, and treatment

Water (sources used, seasonal availability by source, who fetches, where used, amount, quality, how stored, ethnographer's description of primary water source)

Latrine (presence, use by adults and children, respondent's opinions about general problems with construction of latrines)

The indepth interviews provided a wealth of information and cultural insights which was used to develop the household survey form as well as to obtain descriptive information that could not have been collected with standard survey techniques. The value for parasitic disease control of employing indepth interview techniques particularly in combination with survey methods has been discussed by Dunn (9) and Popkin (10). Mr. Elliott's notes on the individual indepth interviews are presented in Appendix I. The bulk of the ethnographic information is presented in section III. Results and Discussion and has been integrated, whenever possible, with the results of the household survey.

The indepth interviews were especially useful in developing a survey questionnaire that was most likely to obtain the desired information. The following is a list of issues which the ethnography clarified regarding how the survey would best be conducted:

Respondent: Women were chosen because they know the most about water use and were more likely to be home.

Standardized introduction/explanation for respondents: The ethnographic interviews showed that it was useful to establish a link to "the doctors who were treating the school children for bilharzia," because the large study was popular with the community and identification with it improved the respondents' willingness to answer questions.

Interviewers: The indepth interviews showed that it was perfectly acceptable to employ male interviewers, despite the facts that women were the respondents and the society is mainly Muslim. (We could not find sufficiently educated female interviewers locally because formal education for women has not been encouraged until recently in this part of Kenya.)

Interview atmosphere: It was clearly necessary to separate the wife from neighbors or her husband, if present, because their presence inhibited her responses.

Language: Most women knew some Kiswahili, which is spoken throughout Kenya, but they much preferred to be addressed in their tribal language, Kidigo, so the survey form was translated into and administered in Kidigo.

Timing: A 1/2 hour interview was chosen because women were willing to spare that amount of time.

Order of questions: The order of questions chosen for the survey was: 1) easy, non-threatening questions (number of school children and grade in school), 2) knowledge and attitudes about schistosomiasis, 3) water sources and use, and 4) latrines (put last because latrines are an unpopular subject since people know they should have them and most don't).

Questions to delete: People do not fish in the local marsh and laughed at this question even though they do consume sea fish, so this question was deleted.

Questions to add: A specific question on the availability of traditional medicines for schistosomiasis was added because many people did wear charms (which are often worn to protect a person against disease or other harm) and which they had bought from a traditional practitioner.

Categories of responses: These were clarified for all questions, deleting unnecessary categories and adding unforeseen ones, so that the survey could be precoded.

Local terminology: This was clarified for all questions (see Appendix III for discussion of variation in terms for schistosomiasis over a small geographical area.

Questions to modify: It became clear that questions about income probably would not be answered honestly, often could not be answered precisely and would usually cause suspicion and hostility. We therefore decided to use housing construction and the fieldworker's assessment of socio-economic status as our measures of socio-economic status (see Appendix III for discussion of difficulties in obtaining income data and possible proxy indicators).

Mr. Elliott's detailed observations on how the interview process affected the quality and reliability of the data collected and on collection of income and socio-economic data in the study area are presented in Appendix II. His notes on the Kidigo language for Kiswahili speakers and a glossary of terms relating to water, sanitation, and urinary schistosomiasis are presented in Appendix III and will be an invaluable aid to researchers and health practitioners working in similar areas.

The ethnography also employed key informant interviews to obtain specialized information that could not be gathered in a survey and was often not known by the mothers interviewed. Key informants included school teachers, the local traditional practitioner, the local health educator, men who dig wells and latrines for a living, and other community leaders. The ethnographer also used field observation to obtain detailed descriptions of local water sources (wells, water holes, springs, and the marsh area where S. haematobium is transmitted), and to observe behavior (eg, children were frequently seen playing in the marsh area, and once a mother was seen playing in the marsh with her children). Photographs of water sources, and water use, housing, and sanitation were taken, and some are shown in section III. Results and Discussion.

B. Household Survey

1. Survey Form and Selection of Study Groups

A survey form was developed, translated into Kidigo, the local tribal language, and was administered to 85 parents, preferably mothers, of 105 S. haematobium-infected and uninfected children from Mvindeni School. (See Appendix IV for English and Kidigo versions of survey form.) The information collected with the survey included:

Identity of respondent
Number of children and adults in household
Cause, prevention, symptoms, and treatment for schistosomiasis
Water sources used in dry and wet seasons
Time taken each day to fetch water
Quantity of water used by household each day
Whether or not child bathes, washes clothes, draws water,
   or plays in the marsh area
Whether household has latrine
Where school and preschool children defecate
Material used for walls and roof of house
Income level of household (fieldworker's estimate).

Mr. Elliott also prepared a map of the study area which shows the locations of the study children's homes in relation to the locations of water sources, including the marsh area most likely to transmit S. haematobium infection. This was done in part because Sturrock et al (11) and Kloos et al (12) have shown that the spatial relationship between water sources and households can be a major determinant of water contact, schistosome transmission, and intensity of human infection.

For the household survey, we chose children, matched for age and sex, who were either heavily infected or repeatedly uninfected. This was done to increase the probability of finding factors that predisposed to S. haematobium infection in this community. From the 250 children whom we had previously examined at Mvindeni Primary School in both September-November of 1981 and March-May of 1982, we selected two groups of approximately 50 children each: an S. haematobium-infected group and an uninfected group. For the S. haematobium-infected group we chose the 51 children who had the highest S. haematobium egg counts per 10 ml of urine (adjusted for urine volume) in September-November 1981. For the uninfected group we then chose 54 children whose urine specimens had been negative for S. haematobium eggs for two consecutive examinations (September-November 1981 and March-May 1982) and whose age and sex were similar to that of the infected group. We matched the groups for age and sex because age, in all communities (12-17), and sex (16-18), in some communities, are related through social norms and behavior to both the amount and type of water contact and the intensity of S. haematobium infection. We want to ensure that differences found between the two groups were not related primarily to age or sex *per se*.

Because of limited resources we could not make systematic observations of water contact behavior nor could we document the presence of infected snails. However, the distribution of the immediate hosts for *Schistosoma* spp throughout Kenya has been published recently (19); and interested readers can also obtain a detailed description of the uses of and methodology for conducting human water contact studies in areas where schistosomiasis is endemic (20).

2. Data Used from the Large Study

The data obtained in the household survey were supplemented by detailed physiological data we had collected in September-November of 1981, before children were treated with metrifonate, as part of the large study on *S. haematobium*, anemia, and child growth. A copy of the questionnaire used in 1981 is included as Appendix V. The data collected in 1981 and combined with the household survey data included:

sex of child and age in 1981
father's occupation
child's report of hematuria or dysuria (now or ever)
child's report of cause and prevention of schistosomiasis
   (open-ended responses)
S. haematobium egg count/10 ml urine, adjusted for
   urine specimen volume
hematuria and proteinuria (semi-quantitative, urine
   reagent strips)
presence and degree of splenomegaly and hepatomegaly
hemoglobin level, g/dl
anthropometry (weight, height, arm circumference, 2
   skinfold thicknesses)
hookworm and *Trichuris trichiura* egg counts (epg)
malarial parasites in blood film (*spp* and no./100
   leukocytes).

The methods used have been previously described in detail (1-2, 6-8), and most are described in the second paper in this volume. *S. haematobium* egg counts, degree of hematuria and proteinuria, and hemoglobin determinations were performed by L. Stephenson. Anthropometric measurements and clinical examinations, including assessment of splenomegaly and hepatomegaly, and questioning of children about the symptoms and transmission of schistosomiasis were done by an experienced clinician (M. C. Latham) assisted by a fieldworker fluent in the tribal language (Said Abdalla). Examinations of stool specimens for parasite eggs were done by K. Kurz, and J. Kyobe from the Medical Research Center in Nairobi assessed malarial infection in the blood films.

3. Statistical Analysis and Aims of Survey Analysis

The survey data were coded by project fieldworkers (Said Abdalla, Hassan Juma, and Charles Mwoshi) and were statistically analyzed by L. Stephenson with assistance from Agathe Pellerin on the IBM-3081 computer at Cornell University with SPSS-9 programs (21). Statistical tests used included Chi-square tests and Kendall's Tau B and C statistics for association, t-tests, and Pearson correlation coefficients. The Chi-square statistic was used to test for association except when the expected frequency of one or more cells was less than five cases; in those situations, Kendall's Tau B or C statistics were used. Heteroscedastic or negative binomial distributions were transformed to common logarithms before applying differential statistical tests as recommended by Sokal and Rohlf (22).

The major aims of the analysis of the household survey and ethnographic data were a) to describe in detail the community's knowledge about schistosomiasis, their water resources, and sanitation, and to answer the following specific questions:

1. Do children with *S. haematobium* infections and their mothers know less about the cause, prevention and treatment of *S. haematobium* infection than uninfected children and their mothers?

2. Do the infected and uninfected groups differ in socioeconomic indicators, including father's occupation, household size, construction of house, or fieldworker's assessment of income level?

3. Do the two groups differ in access to or reported utilization of all water resources, *eg*:

   water sources used in dry and wet seasons
   amount available per household member
   time needed to fetch water
   distance of household to marsh
   mother's report that child goes to marsh to bathe,
      wash clothes, draw water, or play

4. Do children who come from households which have latrines differ from those who don't have latrines in prevalence or intensity of hookworm or *Trichuris* infections?

III. RESULTS AND DISCUSSION

A. The Study Area - Ethnographer's Description

The study area was defined by the household locations of children attending Mvindeni Primary School. The school itself is located on the West side of the main coast highway about 25 km south of Mombasa. The drawing area for school children from this school is quite large and covers a circle with a radius of about 4 km. There are other primary schools in adjacent areas (Shamu, Mabokoni, Galu, Mbuani, and Ukunda; see map in Fig. 1) which are closer to some of the Mvindeni children's homes, but there is no requirement that the closest school be attended, and as one of the larger, well run primary schools, Mvindeni has extra appeal (See Fig. 2).

Geographically, the area consists of a wide coastal plain bisected from North to South by the Coast highway which links Mombasa with the Tanzania border. East of the highway is a flat area with vegetation growing over a base of nearly solid coral which extends to the sea. This area (Malalani, Kibarani, and parts of Ukunda on the map) has no surface water and there is very little soil for farming. Along the sea are beach hotels where some of the fathers of the Mvindeni children work. Towards the north of the study area and east of the Coast highway is a small airstrip. West of the Coast highway, the coral gives way to sand as the land rises up into the Shimba Hills. There are both seasonal and permanent marshes in this area, and at the far west edge of the study area, there are some small springs on the sides of the hill leading up to Mabokoni.

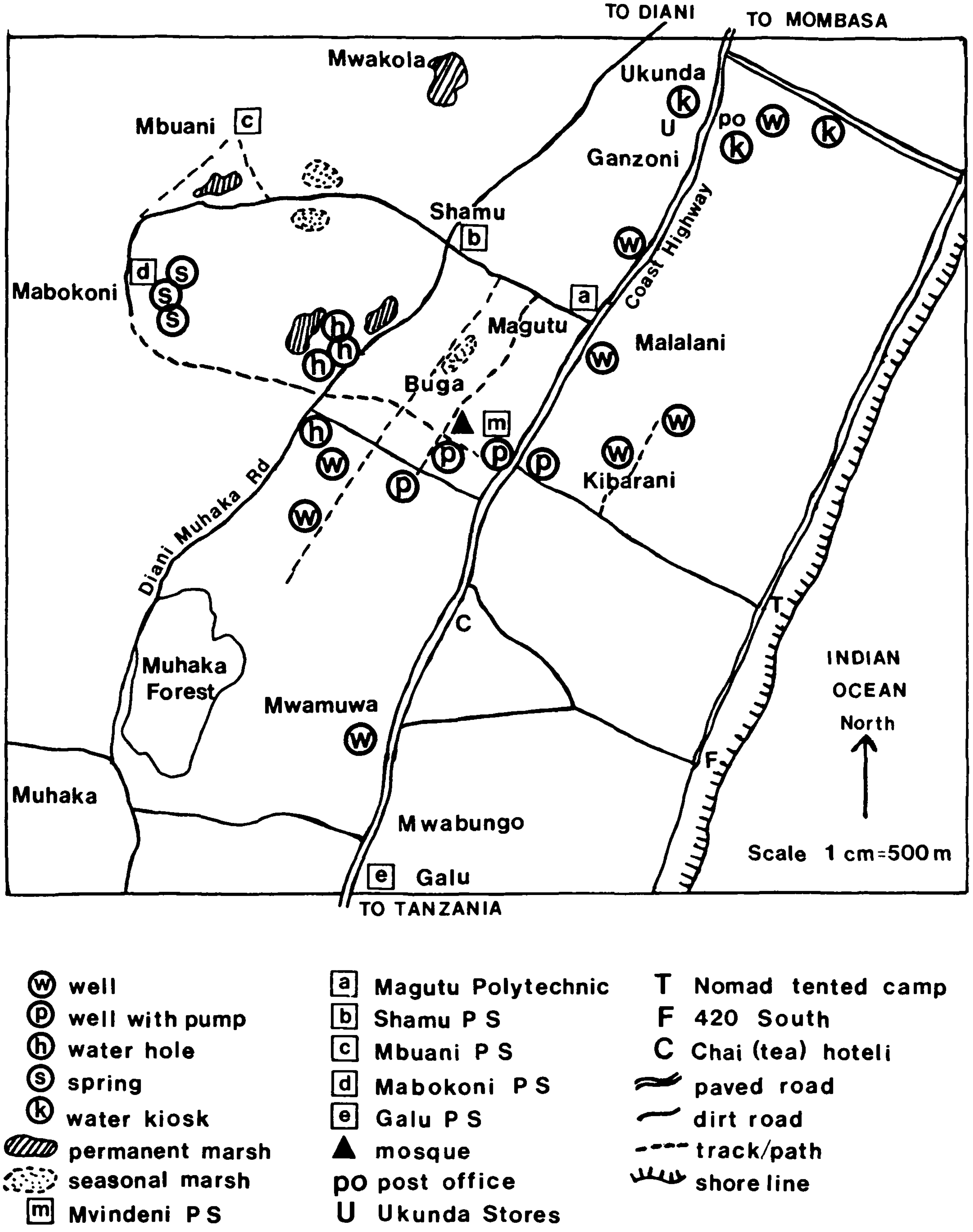
The area surrounding Mvindeni Primary school is the Mvindeni resettlement scheme. This consists of approximately 100 12-acre plots that were made available by the government to people from the area in 1965. A few of the plots, given out at the end of the allotment, are only 6 acres. The land was originally one large holding owned by European settlers who left shortly after Independence. They used the land primarily for grazing sheep and cattle. The school building itself is an expansion of the original owners' home. Virtually all the children living in the scheme that go to school go to Mvindeni Primary School.

Many of the new settlers in Mvindeni came from the Ukunda area, and most have cleared all or some of their plots to grow maize and cassava. The main cash crops are cashew nuts, copra from coconuts, and bixa which is used as a dye. People also grow potatoes, cabbages, tomatoes, onions, papaya, bananas, mangoes, and sesame seeds for home use. A few people have cows or sheep, and almost everyone has chickens. Most of the plots have not been subdivided since their purchase. Almost all of the families in the area are Wadigo by tribe and are Muslims.

B. *S. haematobium* Infected and Uninfected Groups - Physiological Similarities and Differences

1. Households, Age, Sex, Grade in School, and Tribe

Fig. 1. Map of Study Area and Its Water Sources



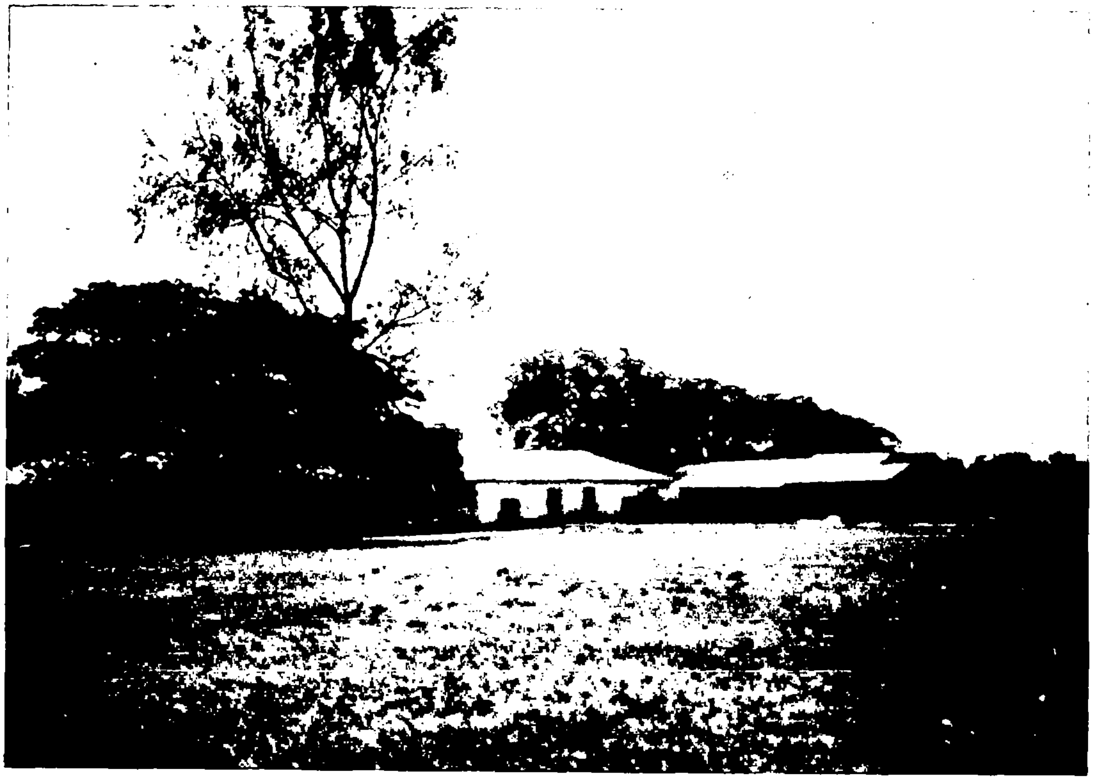


Fig. 2. Mvindeni Primary School, 1983. (Photograph by S. Horner)

Of the 105 children chosen for the household survey, 51 were heavily infected with *S. haematobium* and 54 were uninfected. They came from 85 households; 38 households had only infected survey children, 40 households had only uninfected survey children; and 7 households had an infected and an uninfected survey child residing there. The infected and uninfected groups were very similar in sex ratio and age (55% vs 52% male, respectively; mean ages of 10.2 and 9.9 years, age range of 7-15 years in each group; see Table 1). Within each group, the age by sex distributions were similar, but about 2/3 of the females were in the younger age group (7-9 yr) and about 2/3 of the males were older (10-15 yr). This was also the case for Mvindeni School as a whole. The household survey was conducted in early 1983, so the study children were then 1 1/2 years older than their ages shown in Table 1.

The survey children were in standards 1-4 in 1981 and in standards 2-6 in 1983; there were no significant differences between groups in standards with Chi-square tests. All of the 51 infected children were Digo by tribe; 94% or 51/54 of the uninfected children were Digo and 6% or 3 children were Luo.

2. *S. haematobium* Egg Counts, Hematuria, Proteinuria, Dysuria, Splenomegaly, and Hepatomegaly

The egg counts in the infected children ranged from 50 to 1,099 eggs/10 ml of urine adj, with an arithmetic mean of 180 eggs and a geometric mean of 166 eggs. Only 3 children had egg counts greater than 500 (see Table 2 for frequency distribution). Neither egg count nor log of egg count were significantly correlated with age or sex (data not shown).

As expected (1), hematuria measured with urinary reagent strips was almost universal in the infected group (98% or 50/51) and rare in the uninfected group (2% or 1/54). Proteinuria was also very common in infected children and rare in uninfected ones (88% vs 6%, see Table 3). The children's reports of dysuria and hematuria followed a similar pattern. Forty-three percent of infected children reported dysuria now, in the past, or both compared with only 2-4% of uninfected children; 63-65% of infected children reported hematuria either now or in the past, compared with only 6-7% of uninfected children. Only 4 of 54 uninfected children reported either dysuria or hematuria now or in the past. As our previous work has shown (2), splenomegaly and larger spleens were significantly more common in the infected children (see Table 3).

3. Hemoglobin Levels and Anthropometry

The mean hemoglobin level in the infected group was lower than in the uninfected group (11.3 ± .22 vs 11.7 ± .14 g/dl, t-test p = .068 borderline) (see Table 4). Within the infected group, hemoglobin level was inversely correlated with egg count and log of egg count (Pearson r = -.30, p = .016; Pearson r = 0.38, p.= .003, respectively); and anemia, defined as a hemoglobin level below 12.0 g/dl, was significantly more common in children with higher egg counts (see Table 2).

Table 1. Sex and Age Distribution of *S. haematobium* Infected and Uninfected Groups

	Sh pos		Sh neg		p<
No. of children	51		54		
Sex (n, %)					
male	28	55.%	28	52.%	X^2 ns
female	23	45.%	26	48.%	
Age, yr in 9/81					
$\bar{X} \pm$ SEM	10.2 ± .30		9.9 ± .27		t-test ns
range	7-15		7-15		
Age group in 9/81 (n, %)					
7-9 yr	21	41.%	28	52.%	X^2 ns
10-15	30	59.%	26	48.%	

Age group by sex by study group in 9/81 (n, %)

Sh pos

	male		female		
7-9 yr	6	21.%	15	65.%	X^2p = .002
10-15	22	79.%	8	35.%	

Sh neg

	male		female		
7-9 yr	11	39.%	17	65.%	X^2p = .055
10-15	17	61.%	9	35.%	bord

Table 2. *S. haematobium* Egg Count Distribution and Relationship to Hemoglobin Level in Infected Group in 1981

S. haematobium eggs/10 ml adj	no.	%
50-59	2	3.9
60-79	15	29.4
80-99	5	9.8
100-119	2	4.0
120-139	5	9.8
140-159	4	7.9
160-179	2	4.0
180-199	3	5.9
200-299	5	9.8
300-399	4	7.8
400-499	1	2.0
500-599	0	0
600-699	2	3.9
1,099	1	2.0
arithmetic $\bar{X}$	180	
geometric $\bar{X}$	166	

	egg count group, e/10 ml adj			
	50-122		122-1,099	
hemoglobin, g/dl	n	%	n	%
≥12.0	12	44.	5	21.
<12.0 (anemic)	15	56.	19	79.

Total n = 51. Higher egg count group significantly associated with anemia (Kendalls Tau B p = .038).

Table 3. Hematuria, Proteinuria, Dysuria, Splenomegaly, and Hepatomegaly in Infected and Uninfected Groups in 1981

	S. haematobium				
	positive		negative		p<
	n	%	n	%	
Hematuria (urine reagent strips)					
trace or more	50	98.	1	2.	X^2p<.0001
Hematuria (urine reagent strips)					
neg	1	2.	53	98.	X^2p<.0001
trace	6	12.	0	0	
+	2	4.	0	0	
++	9	18.	0	0	
+++	33	65.	1	2.	
Proteinuria (urine reagent strips)					
+ or more	45	88.	3	6.	X^2p<.0001
Proteinuria (urine reagent strips)					
neg-trace	6	12.	51	94.	X^2p<.0001
+	16	31.	3	6.	
++	28	55.	0	0	
+++	1	2.	0	0	
Dysuria (child's report)					
now	22	43.	1	2.	X^2p<.0001
ever	22	43.	2	4.	X^2p<.0001
now and/or ever	22	43.	2	4.	X^2p<.0001
Hematuria (child's report)					
now	32	63.	3	6.	X^2p<.0001
ever	33	65.	4	7.	X^2p<.0001
now and/or ever	33	65.	4	7.	X^2p<.0001
Dysuria and/or hematuria (child's report)					
now and/or ever	34	67.	4	7.	X^2p<.0001
Splenomegaly					
Hackett 1 or more	43	84.	32	59.	Kendall Tau p<.0045
Splenomegaly					
neg	8	16.	22	41.	Kendall Tau p<.0055
Hackett 1	21	41.	15	28.	(Mann-Whitney U
2	15	29.	16	30.	test on ranks
3-4	7	14.	1	2.	p=.0054)
Hepatomegaly (clavicular)					
0.5 cm or more	11	22.	11	20.	X^2 ns

Sample sizes: *S. haematobium* positive = 51, negative = 54.

Table 4. Hemoglobin Level and Anthropometric Measurements of *S. haematobium*-Infected and Uninfected Groups in 1981

variable	group	$\bar{X} \pm$ SEM	t-test p<
hemoglobin, g/dl	neg	11.7 ± .14	.068 bord
	pos	11.3 ± .22	
wt, kg	neg	27.6 ± .83	ns
	pos	28.1 ± .97	
% wt/age	neg	82.9 ± 1.41	ns
	pos	81.4 ± 1.51	
Ht, cm	neg	134.6 ± 1.56	ns
	pos	136.2 ± 1.62	
% ht/age	neg	96.4 ± .55	ns
	pos	96.4 ± .59	
wt/ht^2	neg	1.50 ± .015	ns
	pos	1.49 ± .020	
arm circ, cm	neg	18.2 ± .28	ns
	pos	17.8 ± .28	
% arm/age	neg	88.5 ± 1.07	.012
	pos	85.2 ± .98	
triceps skinfold, mm	neg	7.6 ± .25	.096 bord on log
	pos	7.1 ± .36	
% triceps/age	neg	76.2 ± 2.50	.056 bord on log
	pos	70.5 ± 2.76	
subscapular skinfold, mm	neg	6.0 ± .18	ns
	pos	5.9 ± .22	
% subscap/age	neg	104.8 ± 3.29	ns
	pos	100.6 ± 2.90	

Sample sizes: Sh pos = 51, Sh neg = 54. T-tests were one-tailed and were done on common logarithmic transformations of skinfold and % skinfold/age data.

Percent arm circumference for age was significantly lower in the infected group (85.2 ± .98 vs 88.5 ± 1.07, p = .012); triceps skinfold and percent triceps skinfold for age were lower but only of borderline significance, and percent weight for age, weight for height squared, and percent subscapular skinfold for age were lower but not significantly different (see Table 4).

4. Hookworm, *Trichuris* and Malarial Infections

Hookworm infection was very common in both groups since most children walk barefoot and most households do not have latrines. The *S. haematobium* negative group had a significantly higher prevalence of hookworm infection (93% vs 72%, p = .0065) and also a significantly higher geometric mean egg count (577 vs 168 epg, p = .035), but an analysis by egg count group showed that this was mainly due to an increase in the proportion of low counts in the 1-1999 epg range (see Table 5). Infection with *Trichuris trichiura* was also very common in infected and uninfected groups (74% and 82% positive), but the prevalence and intensity did not differ significantly between groups. Forty-one to 43% of each group had blood films positive for malarial parasites, primarily *P. falciparum*, but the prevalence and geometric mean counts per 100 leukocytes were very similar (Table 5).

C. Socioeconomic Indicators: Father's Occupation, Family Size, House Construction, Income Level, Latrines

In over 90% of cases, a female (usually the mother or, rarely, another female relative) was the respondent for the household survey, and the relationship of the respondent to the study child did not differ significantly between the two study groups (Table 6). There were no statistically significant differences between the *S. haematobium* infected and uninfected groups in the socioeconomic indicators studied. However, trends in father's occupation, construction of walls of the house, income level assessed by the fieldworkers, and stated latrine use implied that the families of the uninfected children were probably slightly better off economically than were families of infected children.

The most common father's occupations were hotel or domestic worker (33% of households), artisan or craftsman (26%), and farmer (18%). Occupations requiring advanced Western education (office work/government official) were more common in the uninfected group but uncommon in both groups (9.3% vs. 2.0% of fathers). It is interesting to note that all 3 study children belonging to the traditional practitioner or *mganga* did have *S. haematobium* infection, even though the traditional practitioner interviewed by Mr. Elliott stated that he did have medicine which successfully cures *S. haematobium* infection (see section III.D.2).

The number of children per household was large, with means of 4.4-4.7 children per household per group and a range of 1-14 children per household. Polygamy is acceptable in this area on both tribal and religious grounds, although most men cannot afford the bride price to purchase more than one wife, and effective use of modern birth control

Table 5. Hookworm, *Trichuris* and Malarial Infections in Infected and Uninfected Groups in 1981

	S. haematobium				
	positive		negative		p<
	n	%	n	%	
Hookworm					
positive	37	72.	50	93.	X^2p=.0065
negative	14	28.	4	7.	Kendall Tau
1-1999 epg	20	39.	32	59.	p=.084 bord
2000-4999	13	26.	12	22.	
$\geq$5000	4	8.	6	11.	
arithmetic $\overline{X}$	1,853		2,359		
geometric $\overline{X}$	168		577		t-test p=.035
Trichuris trichiura					
positive	38	74.	44	82.	X^2 ns
negative	13	26	10	18.	X^2 ns
1-999 epg	8	16.	7	13.	
1000-4999	19	38.	26	48.	
5000 up	10	20.	11	20.	
arithmetic $\overline{X}$	3,050		3,495		
geometric $\overline{X}$	310		576		t-test ns
Malarial parasites in blood film					
positive	21	41.	23	43.	X^2 ns
arithmetic $\overline{X}$	2.8		4.1		
geometric $\overline{X}$	2.0		2.2		t-test ns

epg = eggs per gram of feces

Table 6. Socioeconomic Indicators: Father's Occupation, Family Size, House Construction, Income Level, and Latrine Use for Households and Infected vs Uninfected Groups

	Households		Children				
			Sh pos		Sh neg		Sh pos vs neg
	n	%	n	%	n	%	$p<$
Respondent							
mom/other female	77	91.	48	94.	49	91.	Kendall Tau
dad/other male	5	6.	2	4.	3	6.	ns
mom and dad	3	3.	1	2.	2	4.	
Father's occupation (see footnote for details of occupations)							
hotel/domestic	28	32.9	19	37.3	17	31.5	Kendall Tau
artisan	22	25.9	13	25.5	12	22.2	ns
farmer	15	17.6	8	15.7	9	16.7	
office/government	5	5.9	1	2.0	5	9.3	
vendor	4	4.7	2	3.9	4	7.4	
shop clerk	2	2.4	1	2.0	1	1.9	
fisherman	1	1.2	0	0	1	1.9	
traditional doctor	1	1.2	3	5.9	0	0	
owns shop (duka)	3	3.5	2	3.9	1	1.9	
laborer	1	1.2	1	2.0	0	0	
dead	1	1.2	1	2.0	0	0	
no answer	2	2.4	0	0	4	7.4	
No. children/household							
1-4	52	61.	27	53.	32	59.	X^2 ns
5-14	33	39.	24	47.	22	41.	
$\bar{X}$ ± SEM	4.3 ± .24		4.7 ± .27		4.4 ± .32		t-test ns
No. adults/household							
1-2	54	64.	30	59.	34	63.	X^2 ns
3-6	31	36.	21	41.	20	37.	
$\bar{X}$ ± SEM	2.6 ±.10		2.7 ±.16		2.6 ±.12		t-test ns
No. household members							
3-6	37	43.	17	33.	23	43.	X^2 ns
7-8	32	38.	21	41.	19	35.	
9-16	16	19.	13	26.	12	22.	
$\bar{X}$ ± SEM	6.8 ±.27		7.4 ±.33		6.9 ±.34		t-test ns
Roof of house							
coconut thatch	76	89.	47	92.	48	89.	Kendall Tau
corrugated iron	9	11.	4	8.	6	11.	ns
Walls of house							
mud	53	62.	33	65.	33	61.	Kendall Tau
mud + coral stones	22	26.	14	27.	13	24.	ns
cement	10	12.	4	8.	8	15.	cement vs other ns

(continued)

Table 6 (continued)

	Households		Children				Sh pos vs neg
			Sh pos		Sh neg		
	n	%	n	%	n	%	p<
Income level (fieldworker's assessment) - see footnote							
low	60	71.	39	76.	34	63.	Kendall Tau
medium	19	22.	10	20.	14	26.	p = .054 bord
high	6	7.	2	4.	6	11.	
Latrine present?							
no	57	67.	33	65.	35	65.	Kendall Tau
use other's	6	7.	3	6.	4	7.	ns
yes	22	26.	15	29.	15	28.	
Where do preschoolers defecate?							
bush	24	29.	17	35.	12	22.	
dig hole & cover	36	43.	20	41.	25	46.	Kendall Tau
in yard then carried to latrine	14	17.	9	18.	8	15.	ns
other	6	7.	2	4.	4	7.	
in latrine	4	5.	1	2.	5	9.	
Where do school age children defecate?							
bush	34	40.	22	43.	19	35	Kendall Tau
dig hole & cover	32	38.	20	39.	21	39.	ns
latrine	19	22.	9	18.	14	26.	

Sample sizes: Households = 85, Sh pos = 51, Sh neg = 54.

Father's occupation: hotel/domestic = cook, night watchman, laundry; artisan = tailor, carpenter, barber, builder, mechanic; office/government = teacher, village official, office worker; vendor = fish, cassava, fruit, tomatoes, shells, carvings, water.

Income level ratings based on: house condition and building materials, clothing, jewelry, visible possessions (eg, radio), and personal knowledge of family.

methods is probably uncommon. The number of adults per household was 2.6-2.7 adults per group (range 1-6) and also did not vary significantly between groups (Table 6).

Most houses (89%) had a thatch roof made from makuti or coconut fronds, and only 11% had a roof made of corrugated iron. Sixty-two percent of houses had mud walls, 26% had walls made of mud and coral stones, and only 12% had cement walls. Thatch roofs and walls made of mud or mud and coral stones indicate lower socioeconomic status than do corrugated iron roofs and cement walls, because the former can be made at home without purchasing materials whereas the latter require a cash purchase. The study groups did not differ in material used for the roof of the house. A higher percentage of uninfected children came from households with the more expensive cement walls (15% vs 8%, see Table 6) but this difference was not statistically significant. See Figure 3 for illustrations of housing construction.

According to the fieldworkers' assessment of income level of the households, children in the uninfected group tended to come from wealthier families: only 63% belonged to low income families vs 76% for the infected group, and 11% came from high income families vs 4% for the infected group (Kendall's Tau p = .054 borderline).

Only 26% of households had a pit latrine, 67% had no latrine at all, and 7% had no latrine but said they used a neighbor's latrine. We doubt that all of the persons who said they used someone else's latrine actually did so, and reasons for this concern will be discussed further in section III.F. on latrines and intestinal parasites. Preschool children from most households did not defecate directly in the latrine: only 5% did so, while 29% defecated in the bush, in 43% of households the mother said they dig a small hole and cover the feces, and in 17% of households the children defecate in the yard and the feces are carried to the latrine. School children were reported to defecate in the latrine in almost all households that had a latrine (22%), 40% used the bush, and 38% said they dig a hole and cover the feces. It is not surprising that hookworm and Trichuris infections are so common in this area, given the inadequacy of feces disposal.

The presence of latrines and the reported defecation sites for preschoolers and school children did not differ significantly between the two study groups, although a higher percentage of S. haematobium infected children came from households where the respondent stated that preschoolers and school children defecated in the bush and not in the latrine (preschoolers, bush: 35% vs 22%; preschoolers, latrine: 2% vs 9%; school children, bush: 43% vs 35%; school children, latrine: 18% vs 26%). Although we could not check the truth of these answers, the implication is that more uninfected children came from better off households which either did use latrines more often or at least said they did because they knew that they were supposed to do so.

D. Schistosomiasis - Mothers' and Children's Knowledge

Regarding the reliability of the mothers' responses on schistosomiasis, Mr. Elliott notes:

Fig. 3. Local shop which illustrates different types of building materials: roof is coconut thatch (makuti), walls are mud with coral stones (left) and cement with coral blocks. Wall is cement with small coral stones.

> "The questions on the causes, symptoms, treatment and cure of schistosomiasis were difficult to ask. Since we had introduced ourselves as health workers working with the doctor, people thought that we of course knew the answers to the questions we were asking and that we were somehow testing them. This made them reluctant to respond and many took the easy way out by saying 'I don't know' (simanya)."

However the survey data show that most mothers and children either say they don't know (and are perhaps confused) about causation and prevention of schistosomiasis, or they give medically incorrect answers. In either case, the implications for control of *S. haematobium* are the same: neither mothers nor children know enough about the disease to prevent getting it through behavioral change.

1. Mothers' Knowledge of Symptoms and Treatment

The mothers were asked what the symptoms of *S. haematobium* infection were, how it could be treated, whether there were traditional medicines for bilharzia, and if there were, did they result in cure (see Table 7). Their knowledge of the symptoms was reasonably good: 47% said urinating blood was the symptom, 24% mentioned urinating blood and an itching or burning sensation with urination, and 25% replied that they didn't know. Since only 50% of the children at Mvindeni School had *S. haematobium* infection (6) and about 40% of adult male roadworkers in nearby areas were infected (23), it is conceivable that 1/4 of mothers wouldn't know the symptoms. The two study groups did not differ significantly in their responses.

When asked how bilharzia could be treated, 95% of mothers replied "in hospital by a doctor," and only 4% said they didn't know. Again responses by mothers of infected and uninfected children did not differ significantly. No mother replied that a traditional practitioner could treat bilharzia, even though traditional medicines are frequently used by people in this area of Kenya. In his ethnographic report on local medicines, Mr. Elliott writes:

> "When asked specifically about home medicines (*dawa zachikaya*) or Digo medicines (*dawa zachidigo*) for bilharzia, some said that there were some available. When asked whether or not these were effective there was a mixed response. Two interviewees told of a prominent local family who unsuccessfully tried local medicines before finally taking their child to a hospital. But when the child's mother was later interviewed, she said that these local medicines 'don't exist.' One woman told of trying local medicines unsuccessfully to treat her son before getting him successfully treated at Tiwi Health Center, but admitting to use of these medicines was rare. People seemed embarrassed about consulting local doctors, but at the same time, many wore some sort of charm on a string around their neck, leg or arm, or their

Table 7. Mothers' Opinions About Symptoms and Treatment of Urinary Schistosomiasis - for Households and Infected and Uninfected Groups

			S. haematobium				
	Households		positive		negative		p<
	n	%	n	%	n	%	
1. What are the symptoms of bilharzia?							
urinate blood	40	47.	25	49.	21	39.	Kendall Tau
itching, burning with urination	2	2.	1	2.	1	2.	ns
blood, itching, burning	20	24.	11	22.	14	26.	
don't know	21	25.	14	28.	14	26.	
other	2	2.	0	0	4	7.	
2. How can bilharzia be treated?							
in hospital by doctor	81	95.	46	90.	51	94.	Kendall Tau
don't know	3	4.	5	10.	2	4.	ns
other	1	1.	0	0	1	2.	
3. *Are there traditional medicines for bilharzia, and if so, do they cure it?*							
no	60	71.	35	69.	42	78.	Kendall Tau ns
yes - cure	16	19.	12	24.	6	11.	Yes - cure vs other:
yes - may cure	7	8.	2	4.	5	9.	X^2p=.092 bord
yes - don't cure	1	1.	1	2.	1	2.	
yes - don't know	1	1.	1	2.	0	0	

Sample sizes: Households = 85, *S. haematobium* positive = 51, negative = 54.

> children did. Small babies were often seen with a charm on a string around their waist. The household survey tabulation of people 'knowing of local medicines' and 'thinking them effective' is almost certainly an underestimation of their beliefs and practices." (For additional notes see the visit to the traditional practitioner, section III.D.2.)

As Mr. Elliott predicted, 71% of mothers interviewed for the survey denied that there are traditional medicines for bilharzia. However, 19% stated that these medicines did exist and were effective, and 8% said they existed and might be effective. A higher percentage of infected children came from households in which the mother believed that traditional medicines did cure (24% vs 11%), and a higher percentage of uninfected children were from households in which the mother denied the existence of traditional medicines (78% vs 68%). These differences were only of borderline significance ($p = .092$) but imply, as do the socioeconomic data, that more uninfected children came from households of a higher socioeconomic level which were less willing to admit to knowledge of traditional medicines.

2. A Visit to the Traditional Practitioner (Mganga) - Ethnographer's Report

Traditional medical practitioners (called mganga - singular, and waganga - plural, in both Kiswahili and Kidigo) are very important in the study area. While most people try to take advantage of Western medical treatment, many hedge their bets and visit both kinds of practitioners. In previous work in this district running a small clinic for rural access roadworkers, we found that many of the patients would arrive wearing charms from the mganga, either for the ailment they were complaining of or for an earlier problem. Many small children wear some sort of protective charm tied on a string or cord around their neck, wrist, ankle or waist.

One of the best known of the local waganga is located in Mbuani in the northwest section of the study area. He lives and practices in a large painted cement house and has open hours every day except Friday, the Moslem holy day. Patients wait to see the mganga either in the large waiting room in the front of the house or on the front porch. The mganga's examination and treatment room is a small room (3 m^2) off to the left of the waiting room. Patients remove their shoes before entering the room and sit in low wooden folding chairs on the floor with their backs to the door. The mganga sits on a mat of burlap sacks on the floor with his back to the patient; he leans on the seat of another folding chair on which sits his ndonga.

The ndonga is a vessel used for divining illnesses. It is made of gourds and stands about 25 cm high. It is shaped almost like a snowman, with a large gourd sitting on a base with a smaller gourd with a cap sitting atop the larger one. The outside of the ndonga is very dark and smooth; a string of colored beads hangs around the "snowman's" neck, and a ragged burlap shawl is draped around his "shoulders." The flat round cap is a stopper with a long pointed piece that extends about 15 cm into the *ndonga*. The base of the *ndonga* is covered with wax and ash.

The *mganga* speaks into two flat leather pouches about 4 cm^2 in size which are connected with strings and which he holds in his left hand. These charms or *hirizi* are supposed to be very powerful. With his right hand he removes the stopper from the *ndonga*; it glistens with a clear liquid that drips off the long pointed end back into the *ndonga*. The *ndonga* speaks in a soft whistling noise, like that made from a small squeeze toy, which the *mganga* alone can understand. He then translates what the *ndonga* says.

Examinations are made without physically touching the patient. In many cases illnesses are diagnosed as being the result of either taking bad medicine or a spell or curse put on the victim by someone else. The use of the *ndonga* is somewhat rare for *waganga* and few have them. The others make their diagnosis by consulting the Koran. The *mganga* we visited also had a copy of the Koran that he was reading as we entered, but he uses the *ndonga* for all his diagnoses.

The treatments offered by the *mganga* are sometimes herbal concoctions, but more often they are small charms that are worn on the body or spells that he places on the patient to undo the effects of other's spells or bad medicine. In the examining room there were bottles with different colored liquids and jar lids containing dried leaves and ash. The *mganga* has at least one assistant for making (crocheting) charms and several for collecting herbs.

When I asked if many people come to him complaining of blood in their urine, the *mganga* said that there were few. He said that there were only two recently and that he had treated and cured them. When asked how they were treated, he said with medicine (*dawa*). When pressed as to what kind of medicine, he would not be specific. When asked if he had medicine for *tego* (gonorrhea) he said yes, that there was another medicine for *tego*.

After I asked my questions he asked the *ndonga* about me. He asked where I lived and what were my real reasons for coming to see him. The *ndonga* said that I had arrived on a bicycle (parked outside the examining room window) and that I lived at the beach in a hotel. The *ndonga* confirmed that my reason for coming was only my interest in water sources and diseases. At the end of the interview the *mganga* replaced the stopper, lit a stick of incense which he placed in the *ndonga's* base and lit himself a cigarette. He thanked me for coming and noted that for some things my medicine is better and that for other things his is better.

3. Mothers' and Children's Knowledge of Cause and Prevention

a. Responses on Cause and Prevention

Both mothers and the study children were asked how *S. haematobium* infection is caused and how it can be prevented. Their responses to these questions show that most do not know how the infection is transmitted (Table 8). Over half or 55% of the parents questioned (mainly

Table 8. Mothers' and Children's Opinions About Cause and Prevention of Urinary Schistosomiasis - for Households and Infected vs Uninfected Groups

	Mother Response by Household (n=85)		Mother Response by Study Group (n=105)				Child Response by Study Group (n=99)			
			Sh pos		Sh neg		Sh pos		Sh neg	
	n	%	n	%	n	%	n	%	n	%
Question: How does a person get urinary schistosomiasis?										
Response:										
1. Don't know	47	55.	33	65.	25	46.	40	83.	42	82.
2. Eating peppers &/or sugar	2	2.	2	4.	0	0	6	12.	7	14.
3. Drinking dirty water	20	24.	9	18.	16	30.	0	0	1	2.
4. Standing in dirty water	16	19.	7	14.	13	24.	2	4.	1	2.
Kendall's Tau:			p = .057 bord 1,2 vs 3,4: X^2p = .021				ns			
Question: How can a person prevent getting urinary schistosomiasis?										
Response:										
1. Don't know	49	58.	30	59.	31	57.	40	83.	42	82.
2. Don't eat peppers &/or sugar	14	16.	9	18.	8	15.	6	12.	7	14.
3. Don't drink unboiled water	6	7.	2	4.	6	11.	0	0	1	2.
4. Don't stand in dirty water	16	19.	10	20.	9	17.	2	4.	1	2.
Kendall's Tau:			ns				ns			

mothers) stated that they did not know what caused S. haematobium infection. Only 19% knew that the people get the infection by standing in infected water, 24% thought it came from drinking "dirty" water, and 2% stated that one caught the infection by eating hot peppers or too much sugar. The misconception that unsafe drinking water commonly causes bilharzia is probably a confusion with cholera, because there have been periodic cholera epidemics at the Kenya Coast, and people have been repeatedly warned over the radio to boil all of their drinking water to prevent the spread of cholera. It is possible to contract schistosomiasis from drinking water, because the cercaricae can penetrate the oral mucosa (24) but we don't believe that the parents realize this, and this certainly is not the usual mode of transmission. The contention that eating hot peppers causes bilharzia is probably a local explanation based on the observation that eating hot peppers causes a burning sensation in the anal area during defecation, and that S. haematobium infection is associated with burning on urination. The idea that eating sugar causes bilharzia possibly resulted because the granulated sugar that is locally available is only partially refined and is light gray-brown in color; and urine which contains only minute quantities of blood is also cloudy brown, rather than yellow or red. The ethnographer felt that the belief in the etiologies based on hot peppers and sugar cane were more commonly held by parents than the survey data show, because many more children (12-14%) than mothers (2%) gave these responses, and it seems likely that the children got these ideas from their elders.

There were interesting differences in the beliefs about the etiology listed by the mothers of the infected children and the uninfected children. Higher percentages of mothers of uninfected children stated that bilharzia was caused by standing in "dirty" water (24% vs 14%), and by drinking dirty water (30% vs 18%). In addition, fewer mothers of uninfected as opposed to infected children said they didn't know how bilharzia was caused (46% vs 65%, Kendall Tau C p = .057, borderline). A significantly higher proportion of mothers of uninfected children gave an etiology related to water (either drinking or standing in it) than did mothers of infected children (54% vs 31%, X^2 p = .021) but the percent giving the correct answer (standing in water) did not differ significantly between groups.

Most study children (82-83% per group) said they did not know what caused bilharzia, and there were no significant differences between the 2 groups in responses given. The most common etiology given was "eating peppers and/or sugar" (12% of infected and 14% of uninfected groups). Only 3 children, all boys, answered that bilharzia was caused by standing in dirty water; 2 of the 3 children had S. haematobium infection.

Concerning the interpretation of the mothers' responses on how to prevent bilharzia, Mr. Elliott adds the following words of caution from his experience with the ethnography:

> "The idea of prevention was hard to put across. Many people would confuse it with 'cure.' I think that this is as much a confusion of concepts as a problem of terminology. In many cases the interviewer would

> have to explain that we meant that if a person had schistosomiasis and was treated and cured, what should she or he do to keep from getting the disease again. This problem in communication needs to be examined more closely, especially if an education program is attempted. The responses 'stop eating sugar/peppers,' 'boil water,' and 'stay out of marsh water' should appear in about the same proportion as these were given as causes."

In fact, 16 mothers (19%) reported that bilharzia was caused by standing in infected water, and 16 mothers also said that bilharzia was prevented by not standing in infected water. Very similar percentages of mothers said they didn't know how bilharzia was caused (55%) or prevented (58%). But the other two responses, related to eating peppers and sugar or to drinking water, show that the connection between cause and prevention was not well understood. Only 2% of mothers stated that eating peppers or sugar caused bilharzia, but 16% said that <u>not</u> eating them would prevent bilharzia. About 24% claimed that drinking dirty water caused bilharzia but only 7% said that one could prevent the infection by boiling drinking water or not drinking unboiled water. These conflicts are discussed further in the next section.

There were no significant differences or trends between the 2 study groups in either mothers' or children's responses on how to prevent bilharzia. The children's responses on prevention were very similar to their responses on causation: most children (82-83%) said they didn't know how to prevent bilharzia, 12-14% said to avoid eating peppers and/or sugar, 1 child said that one shouldn't drink unboiled water, and 3 children correctly advised not standing in dirty water.

b. Connections Between Cause and Prevention and Between Mothers' and Children's Responses

We further investigated the mothers' and children's abilities to connect cause and prevention of bilharzia by cross-tabulating their responses on cause with their suggestions for prevention. These results provide numerical proof of Mr. Elliott's observation that prevention is not a well understood concept. Only 10 of the 85 parents questioned stated that bilharzia could be prevented by avoiding what they had said caused the disease, and a further 33 of the 85 said they didn't know the cause or prevention (Table 9--the circled numbers indicate agreement between cause and prevention responses). Almost half (49%) of the mothers mentioned one etiology but a different prevention strategy. Further, 16 mothers had said that bilharzia was caused by standing in dirty water and 16 also said it was prevented by not standing in it, but only 7 of those 16 mentioned standing in water for <u>both</u> cause and prevention, so only 7 and not 16 parents knew how bilharzia was both caused and prevented. These results show that the mothers' conceptions of the transmission of bilharzia suffer from a) lack of knowledge and confusion with other diseases (10 mothers listed drinking water as a cause), b) partial knowledge (5 said that standing in water causes the disease but didn't know how to prevent it), c) a lack of connection between cause and prevention, and d) a

Table 9. Mothers' and Children's Responses on Cause and Prevention of Urinary Schistosomiasis: Connections Between Cause and Prevention and Between Responses of Mothers and Their Children

Question: Do mothers connect how to get schistosomiasis with how to prevent schistosomiasis? (n=85)

	Prevention response (number of cases)			
Get Response*	Don't know	Peppers/ sugar	Boil water	Don't stand in water
1. Don't know	㉝	8	2	4
2. Eat peppers/sugar	1	①	0	0
3. Drink dirty water	10	3	②	5
4. Stand in dirty water	5	2	2	⑦

Response	GET (row n)	PREVENT (column n)
Don't know	47	49
Peppers/sugar	2	14
Drink water	20	6
Stand in water	16	16

Agreement: 43/85 or 50.6% Disagreement: 42/85 or 49.4%

Question: Do children connect how to get schistosomiasis with how to prevent schistosomiasis? (n=99)

	Prevention response (number of cases)			
Get Response*	Don't know	Peppers/ sugar	Boil water	Don't stand in water
1. Don't know	(82)	0	0	0
2. Eat peppers/sugar	0	⑬	0	0
3. Drink dirty water	0	0	①	0
4. Stand in dirty water	0	0	0	③

Response	GET (row n)	PREVENT (column n)
Don't know	82	82
Peppers/sugar	13	13
Drink water	1	1
Stand in water	3	3

Agreement: 99/99 or 100%

Question: Do children and their mothers agree on how to get schistosomiasis? (n=99)

	Mother's response (number of cases)			
Child's Repsonse*	Don't know	Peppers/ sugar	Boil water	Don't stand in water
1. Don't know	㊻	1	19	16
2. Eat peppers/sugar	6	①	4	2
3. Drink dirty water	0	0	①	0
4. Stand in dirty water	1	0	1	①

Response	Child (row n)	Mother (column n)
Don't know	82	53
Peppers/sugar	13	2
Drink water	1	25
Stand in water	3	19

Agreement: 49/99 or 49.5% Disagreement: 50/99 or 50.5%

Question: Do children and their mothers agree on how to prevent schistosomiasis? (n=99)

	Mother's response (number of cases)			
Child's Response*	Don't know	Peppers/ sugar	Boil water	Don't stand in water
1. Don't know	㊽	12	7	15
2. Don't eat peppers/sugar	7	⑤	0	1
3. Don't drink unboiled H_2O	1	0	⓪	0
4. Don't stand in dirty H_2O	1	0	0	②

Response	Child (row n)	Mother (column n)
Don't know	82	57
Peppers/sugar	13	17
Boil water	1	7
Stand in water	3	18

Agreement: 55/99 or 55.6% Disagreement: 44/99 or 44.4%

* Circled numbers indicate perfect agreement.

combination of Western and Digo beliefs (2 said that one got bilharzia by standing in dirty water but that it was prevented by not eating peppers or sugar).

The children's responses to the cause and prevention of bilharzia agreed perfectly, but since the vast majority (82%) said they did not know the cause or prevention, we cannot assume that their understanding of bilharzia transmission or their ability to relate cause to prevention are superior to that of their parents (Table 9).

We also examined the possibility that the mothers' stated beliefs on cause and prevention of bilharzia had influenced their children's responses by cross tabulating the children's and their own mothers' responses to the cause and prevention questions (Table 9--the circled numbers indicate agreement between mother and child). Mothers and their children gave the same response on cause in 50% of cases and on prevention in 56% of cases, but almost all of this agreement resulted because both mother and child responded that they didn't know (46 of 49 cases of agreement for cause, 48 of 55 cases of agreement for prevention). When the mothers or children who answered "don't know" were deleted, very few cases remained: 3 of the mother-child pairs agreed on cause and 7 pairs disagreed; 7 pairs agreed on prevention (unfortunately 5 of those 7 incorrectly answered peppers or sugar) and only 1 pair disagreed.

Thus those who want the people in this community to clearly understand the transmission of bilharzia have a difficult job ahead of them. Over half of the mothers and 80% of the children either genuinely don't know how bilharzia is caused or prevented, or are confused by a combination traditional beliefs (peppers and sugar) and health education about other diseases (eg. cholera) and say they don't know when they do have incorrect etiologies in their minds. To aggravate this situation, the concept of prevention of diseases like bilharzia and its connection to cause is apparently not present in the Kidigo language nor in the minds of many mothers. On the other hand, women do buy charms from the traditional practitioner for their children to wear to prevent bad things from happening to them; this might be used as an analogy to explain prevention to them.

The misconceptions about bilharzia and other diseases are especially complicated because many of them are shared by the most highly educated and highly respected community leaders. One highly respected and well motivated primary school teacher, in an effort to encourage the school children to cooperate with our plan to treat them with metrifonate, told the girls that they must be treated for bilharzia because leaving the disease untreated would harm their bodies so that they couldn't have any children. This is one of the worst threats a person can make to girls in a traditional society which is both Bantu and Muslim and resulted because the teacher himself had confused bilharzia with gonorrhea (for further discussion of confusion between the two diseases see Appendix III). This same teacher also holds the common local misconception that uvulectomy is a suitable cure for chronic coughs in children and told us that he had taken one of his children to the traditional practitioner for this operation; he insisted that the child's cough had improved afterwards. Thus, although integration of health education into the primary school curriculum would seem to be one of the most logical ways in the long run to change behavior and decrease the transmission of schistosomiasis in this area (25,26), this education process will clearly have to begin with appropriate and tactful education of the community leaders, including the primary school teachers.

Thus, it seems very unlikely that health education alone can be effective means of controlling bilharzia in the short term in an area such as this one. We did not question enough fathers about schistosomiasis to know whether their beliefs are similar to those of the mothers and children, nor did we determine how important fathers are in deciding if, when and where medical treatment will be sought for the family. These issues also need to be explored before a successful health education program on schistosomiasis can be planned. (A summary of the health education sessions we conducted for teachers and students at two of the local primary schools is included in Appendix III section D and contains information on questions and misconceptions that arose in the general discussion period.)

E. Water

1. Results of Ethnography

a. Summary of Water Uses and Sources

The following is a very brief summary of water uses and sources in the study area which was taken from the ethnographer's report. The details of the ethnographic results on water follow in this section and in Appendix I. The results on water use from the household survey follow in section III.E.2.

Water Uses

1. Main water uses are drinking, cooking, washing dishes, washing clothes, and bathing. In addition, children play in marsh water and small amounts of water are used to make mud or cement for houses and for ritual ablution.

2. Most water is used at home; the exceptions are bathing and clothes washing, which are sometimes done at the point of collection, and playing, which is done only in the marshes.

3. Women are responsible for providing water for a household and use most of it to perform household tasks. Men are sometimes seen washing clothes but do not normally cook or wash dishes.

4. Men generally only draw and transport water when it is for sale, and the ways they draw and transport water are different from the ways women perform the same tasks.

Water Sources

1. The main water sources in the study area are deep wells, shallow water holes, marshes, water purchased from carts, and piped

water bought at public taps or kiosks. In addition a few people use spring water, and in the wet season, many use rain water.

2. There is a distinction between drinking and washing water as far as sources chosen.

3. Most households get at least some of their water from deep wells, and water from these is considered especially good for drinking.

4. Rain water is not generally considered good for drinking, but it is widely used for washing.

5. Few people have access to piped water, regardless of whether it is purchased from the local taps or delivered by the men with water carts.

6. Marsh water is used mostly for washing and is only used for drinking or cooking when other nearby sources (water holes) dry up. The marshes are a common play site for children, and many adults bathe and wash clothes there.

Notes the ethnographer made on the World Bank Safe Water Project and on the Kenyan Japanese Medical Cooperation Work on the South Coast are included in Appendix III sections E and F because these projects will affect the water sources available in the study area in the future.

b. Water Uses

1) Drinking Water (Madzi Gakunwa)

Drinking water comes from all the available sources in the area, and people even resort to using marsh water for drinking, especially during the dry season. There is a cultural distinction between water for drinking and water for washing (madzi gakuoska), a term which includes water for laundry, washing dishes, and bathing. In two places where water holes (madibwa) were used, there were separate holes for drinking and washing water even though they were only a few yards apart and the water quality was not visibly different (see Fig. 4). People seem to realize that drinking water should be boiled to make it safe, and many women assured me that they do boil all of their drinking water. Boiling of drinking water was never observed in any of the fieldwork, but this might be because most cooking is done either inside the house itself in a room or central courtyard, or in a kitchen attached to the back of the house. Drinking water is sometimes stored separately and sometimes stored with water for other purposes (see clay water vessels or mtungi under water containers, section E.1.e.3). Rain water is usually not considered suitable for drinking (see rain water or madzi gamvula under sources, section E.1.c.6).

2) Water for Cooking (Madzi Gakubiira)

Water for cooking falls into a category between that used for drinking and that used for washing. Where there are separate sources

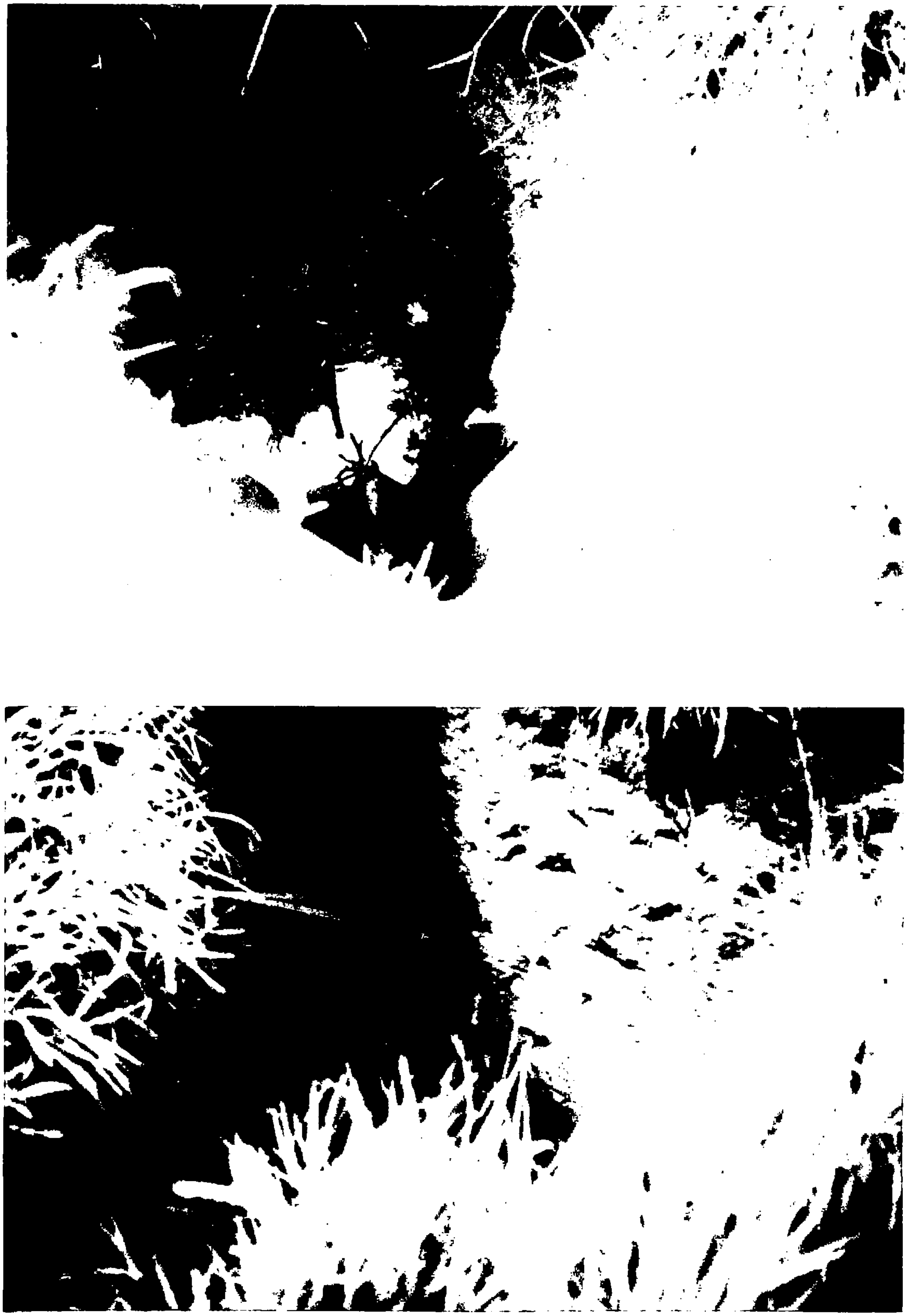


Fig. 4. Water holes designated for washing (top) and drinking water (bottom) but which do not show visible differences in water quality. (Photograph by S. Horner)

for drinking water and washing water, water for cooking would preferably be drawn from the drinking water source. More observation of cooking is needed to clarify this cultural definition. Some women considered rain water to be suitable for cooking and others did not. For many of its cooking uses (tea or chai, maize meal porridge or ugali, stew or mchuzi, and rice) the water is probably boiled long enough to kill most disease organisms.

3) Water for Dishwashing (Madzi Gakutsukutsira Vyombo)

Water for dishwashing is categorized as water for washing. Dishwashing is done outside of the house, usually some yards away from it, although in two cases women were observed washing dishes on their front porch. Dishwashing water is not heated, and sand is used more often than soap for washing. Glasses, cups and utensils are washed first in a large aluminum cooking pot (sufuria--the one the staple maize meal porridge or ugali was cooked in) and when those are clean the cooking pot itself is scrubbed out. Women perform this task while squatting or sitting on the ground. Dishes are not wiped dry but are left to drip dry either on a platform of lashed sticks built especially for this purpose or by setting them upside down on a wood pile where they await use at the next meal.

4) Water for Washing Clothes (Madzi Gakufurira)

Water for washing clothes is also categorized as washing water. Clothes are sometimes washed at the water source and sometimes washed at home. One woman explained that if there isn't a lot of laundry she does it at home, but if there is a lot, it is easier to wash the clothes at the well. At both wells and water holes people seem to be careful to draw water and then to wash the clothes several yards away from the source. At the European's well in Kibarani, where water is sold for KS-/20 ($0.0125 US) per debe or 16 liters, women reported that all laundry was done at home because the women were not allowed to do laundry at the well. On only one occasion was someone observed washing clothes directly in a water source; a teenage boy was washing a pair of pants at Shamu marsh. Most laundry is done with a minimum of water in a water bucket (ndoo, palasta) or sometimes a cooking pot (sufuria, see section on water containers, E.1.e. and Fig. 5). Most people bend over the buckets instead of squatting or sitting, and everyone seems to use some type of soap (laundry powder, laundry bar soap and bathing bar soap were all seen used). Wash water is used until it is very dirty before it is changed, rinsing is minimal, and clothes are dried by spreading them out on the grass, shrubs, or rarely, by hanging them on a line.

5) Water for Bathing (Madzi Gakuoga)

Water for bathing is categorized as a second kind of washing water. Adults were observed bathing in only two places; in the marsh areas and in "showers" or ablution enclosures at home. Home showers are generally unroofed coconut thatch (makuti) structures behind, but generally very close to the house, with a small opening for entry on the wall facing the house. They are typically about 1.5 m square. Two houses had cement showers, but both families were wealthy. The

Fig. 5. Top: Woman does laundry near water hole by washing clothes in aluminum cooking pot (*sufuria*); behind her is a plastic water bucket (*ndoo* or *palasta*). Bottom: Showers attached to houses; floor is made of coral stones (left) or coconut husks (right). (Photographs by S. Horner and T. Elliott)

shower floors are covered with crushed coral or, more often, coconut husks (see Fig. 5). People use large cups or dippers to sluice themselves with water. Very young chidren were observed being bathed while they were sitting in a plastic basin in one shower area.

Many adults who live near the marshes bathe there; most do so either early in the morning or around sunset. The Mbuani marsh area has three separate bathing areas, one each for children, men, and women. Bar soap is taken into the water and people stand in the marsh to bathe. Children bathe in the marsh areas, at home in showers, and sometimes (to save the trouble of carrying the water home) in the bush near wells.

6) Water as a Play Site (Madzi Gakuvumba)

Playing in the water is related to washing clothes and bathing since children there for the latter probably end up doing the former as well. Children have been observed and photographed playing in all of the marsh areas, even when the water level was so low that there appeared to be more mud than water. In one case young mothers were observed playing with their children in one of the marsh areas. In another, small boys were seen playing catch in the marsh with a coconut. Both girls and boys play in the marshes (See Fig. 6). No one seems to fish in the marshes, and questions about this made the parents laugh. Some parents believed that the marshes were responsible for the spread of schistosomiasis, and several said that their children were told not to bathe or play in them. One woman lamented that her son had been told not to go there "but when they go to play, you can't know where they go."

7) Ritual Bathing - Ablution (Kutawaza)

According to Moslem custom it is necessary to perform ablution before entering a mosque. The small mosque on the road west behind Mvindeni school has a water drum (pipa) to store water for this purpose (see Fig. 6). It is necessary to wash the face, hands, lower arms, mouth and feet, and sometimes people take an entire bath before entering the mosque.

8) Water for Making Mud (Udongo) or Cement (Simiti) for Building

This is one of the few uses of water for which men participate in the collection--although, according to one of the fieldworkers, they do so only to help their wives. When the floors were cemented at the primary school, water to mix the cement was purchased from the men with water carts who hauled it from Ukunda instead of drawing water from the school well, presumably because it was not the construction worker's job to draw water.

Fig. 6. Top: Children swim in S. haematobium-infected marsh near Mbuani. Bottom: Water drum (pipa) which stores water for ablution at mosque near Mvindeni School; two water dippers made from tin cans and sticks (mpoko) lean against the wall at left. (Photographs by S. Horner and T. Elliott)

c. Water Sources

1) Wells (*Chisima*)

Twelve deep water wells were visited and are marked by Ⓦ (well) or Ⓟ (well with pump) on the accompanying map (see Fig. 1). Five of the twelve wells were privately owned; two by Wadigo, two by Europeans, and one by a Kikuyu. The other seven wells were older community-owned wells to which everyone has free access. According to one of the fieldworkers, Koran forbids Moslems to sell water from home wells. The European and Kikuyu charge KS-/20 ($0.0125 US) per 16 liter container for their water, which the women draw themselves. The wells are concentrated along the main Coast highway, with a few very far inland and a few much closer to the sea.

All the wells visited were similarly constructed, with surface diameters of approximately 2.5 meters and depths of 20-25 meters. Wells with a smaller top diameter are much more difficult to dig because they get narrower at the bottom. In all cases the first 2-10 meters from the top was lined with coral blocks and cement to keep loose soil from caving in. The depth of the lining depends on the depth where solid coral is found, because the solid coral part of the well is not lined. Each well had a raised concrete lip about 20 cm wide and 20-30 cm high, and surrounding that, a sloped concrete collar 30-60 cm wide. Four of the wells had at least partial concrete covers (see the following section on pumps) and one had a hinged plywood cover that the women said was put over the well at night "to keep the rats out." Several of the wells had coconut wood poles suspended from posts on either side of the well opening. One had a pulley connected to it for raising and lowering containers for drawing water; another had a loop of bicycle chain on which a pulley could be hooked. In several cases the cross pole was deeply grooved as if worn by use with ropes, but no observations were ever made of women using them (see Fig. 7). Water containers were always lowered over the inside of the lip and pulled up against the inside walls.

Only one of the wells was reported to have gone dry in the hot season (*wakati wa dzua*) and none dried up in February 1983. Water color varied from yellow brown to clay grey and usually had suspended particulate matter. The women believe that well water is always good with one exception: some women said that someone had fallen in to the well at Mvindeni school and had died there and that the well was not properly cleaned after the body was removed (reports on this vary both in the length of time ago it happened, "just recently" to "4 years ago", and how long the body was in the well before it was found).

We did not determine how porous the coral is, but the cement linings should help prevent shallow ground water from entering the wells. Ironically the present practice of not burying feces or using pit latrines might be the best in terms of keeping fecal matter from ground water out of the wells, as the cement collars and lips prevent contamination by surface water. Encouraging people to dig pit latrines should not be done without clearly explaining the importance of siting them carefully. This is even more important where people are using shallow water holes (see water holes "*madibwa*" below).

Fig. 7. Top: Well with crosspole; woman empties container for drawing water (*ndoo*) into square tin container (*daba*). Galvanized steel buckets for carrying water (*ndoo*) rest on lip of well. Bottom: Well with pump at Mvindeni School; the pump was broken by school boys and has not been repaired. (Photographs by S. Horner)

I collected two short stories on well folklore, both from one of the Mvindeni school teachers: 1) It is believed that every well has a snake in it to keep the water fresh. One day a snake came out of the top of the well at Mvindeni Primary School, and the children tried to kill it. The snake escaped under a large coral rock near the well, but when the rock was moved, the snake was gone. It must have gone back to the well. 2) Sometimes when a deep well has been dug and still there is no water, a goat will be sacrificed and then they will get water.

2) Wells with Pumps (*Pampu*)

Four of the wells visited were fitted for pumps. These are marked Ⓟ on the map (see Fig. 1). Three of these are the ones closest to Mvindeni school and were wells that were originally dug by the European settlers to provide water for their houses and cattle. These three were capped with cement and fitted with cast iron deep water pumps in 1978 as part of an Australian Kenyan cooperative project. According to one woman, the pumps were broken by school boys a year or so after installation, and they have never been repaired. A small opening (about 50 cm^2) in the cement well cap, presumably left to allow access to the pump mechanism for repairs, is now used by the women to draw water (see Figs. 7, 8). The fourth well with a pump is one in Kibarani owned by the European. He has a diesel powered pump which draws water into a holding tank with a tap.

Late one morning at the well nearest Mwabungo (see Fig. 7 top) we met a number of women who were agitated. They said that the government people with land rovers had come that morning to tell them that there was funding to put a pump in their well. The women said that they didn't want a pump because it would break and make the water dirty. They wanted to know if I could "help them with piped water." Once the pump breaks down not only does it begin to rust into the water, but the access for drawing water with buckets is limited by the cement cap.

3) Water Holes (*Madibwa*)

Five water holes were visited and are indicated on the map with a Ⓦ (see Fig. 1). There are many more, not indicated, many of which were dry because of the hot dry season in February 1983. Most of the water holes are located in the area west of the school. None were found in Malalani or Kibarani or anywhere else on the east side of the main Coast highway. The ones visited were about 2 to 5 meters deep and were dug in sandy soil (see Fig. 4). Most had one or more logs buried in the top lip of the hole to give users safe footing while drawing water. Four of the water holes visited were used specifically either as sources of drinking water or sources of water for washing. The fifth one was said to be used for both and was said never to go dry because "the bottom is like a spring." In fact, none of the five visited had dried out in February 1983.

One of the water holes said to be for drinking water was about 20 meters from the front of a family's house. It was about 1 meter in

Fig. 8. Top: Well with pump near Mvindeni School; pump was broken and has not been repaired. Bottom: Marsh with dense vegetation near Shamu. (Photographs by S. Horner)

diameter and 2.5 meters deep. The sides sloped steeply because of the sand. Leaves and grass had been cleared away and a fence of criss-crossed palm frond stems had been erected in a circle about 1 meter from the hole on all sides. A 1 meter gap in this fence was left open for access and three loosely woven palm fronds were laid over the top of the hole, possibly to keep leaves and other debris out. Three of the five water holes visited had large populations of frogs.

4) Marshes (Mazia)

There are 3 permanent marshes within the study area, a fourth one just outside the area (the "seasonal lake" at Mwakola), and there are also 3 semi-permanent marshes (in Buga and near Mbuani). All of these are located northwest of the school. According to local residents, there are no marshes in Kibarani, Malalani, or anywhere else on the east side of the main Coast road from Diani to Mwabungo. All four sites had dense growths of reeds, water lillies and other vegetation (see Figs. 6 top and 8 bottom). The soil varied from light colored sand to dark clay-like mud. Snails were not observed at any of the sites. Residents in these areas complain about the mosquitos.

At the time of the study in the dry season in February 1983, the water in each marsh was at its lowest point, and it was necessary for people to wade in 2-3 meters from the muddy edge to bathe or draw water. Marshes are the water source of last resort for washing and drinking and are used when the water holes get low in the dry season, especially in the area around Shamu where there are no wells. Marsh wildlife include frogs, snakes and several interesting species of birds. The marshes are all marked on the map (see Fig. 1).

5) Springs (Chemi Chemi)

There are three springs in the study area; all are located near Mabokoni where the Shimba Hills start to rise out of the coastal plain. Two of these were visited. All three are located on the map, marked with an Ⓢ (see Fig. 1). The first of these, called "Dovi," is located just down hill from Mabokoni school, about .25 km to the southeast. It is an improved spring consisting of two cement pools connected with a cement trough. Water trickles out of the hillside and into the first pool which is about 1.5 meters square and 1 meter deep. From there, the spring runs down a short cement trough into a 2 by 1.5 meter pool of the same depth. Water leaves this second pool and trickles off for a few meters in a feeble stream before disappearing into the parched earth. The area around both pools was black cotton soil, and the pool bottoms were heavily silted. During one visit, a young woman drew herself a large plastic container of water, and as she walked away, the silhouette of a frog was visible through its transparent plastic side. Two teenage school boys explained that the upper cement pool is used only for drawing water, and the lower pool is used for bathing and washing clothes. When asked how long the cement work had been there they said "ever since they could remember." They said that the spring never completely dries up, and one of our indepth interviewees from the settlement scheme claimed to use the spring by Mabokoni when the local water holes were dry.

The second spring, Chibibi, located 1,000 meters northwest of Dovi, was an unimproved spring. Water trickled out of a slope into a very shallow puddle about 10-15 cm deep, 3 meters long, and 2 meters wide. Runoff at the east end disappears into the sandy soil. A woman washing clothes there used a flat bowl to scoop out water for her laundry, and said that the water never dries completely, but that it does become "very dirty" (machafu machafu). School girls from Mabokoni school were also drawing water from the puddle to fill the bottles they take to school to drink from. The spring we did not visit was along the same slope, but south of Dovi, and is called Dida.

6) Rain Water (Madzi Gamvula)

During the rainy season, almost all households interviewed used rain water for one or more of their water needs. Rain water is collected from roofs and rain gutters, in containers left outside, and as runoff from palm trees. The procedure for this last method requires taking a coconut midrib (mchinga) and lashing it to the curved trunk of a coconut palm so that it comes off of the tree like a spout. A cooking pot (sufuria) or water pail is placed under this spout and replaced when full. Rain water from puddles is also used, especially for bathing and washing clothes. These puddles become very seasonal water holes.

While carefully collected rain water is one of the safest of all sources of drinking water because of its freedom from bacteria, parasite eggs and other fecal contamination, it is not held in high esteem by the Wadigo. People almost always say that they do not use it for drinking, and several stated that they will not even use it for cooking. The local health educator suggests that this is because of the millipedes that live in the roof thatch (makuti). People don't like the reddish color of water collected off of the thatch and fear millipede excrement. Instead, these people make special trips to the flooded water holes for their drinking water. He says that they do use water collected from corrugated iron (mabati) roofs for drinking water.

The instance of the Wadigo not wanting to use rain water for drinking or cooking because the millipedes that live in the roof thatch cause the water to be red may be another example of a culture's choosing to do what is biologically best for them even though their decision cannot have had a biological basis. The common East African millipedes (Archispirostreptus gigas (27) or shungalala in Swahili) are ubiquitous at the Kenya Coast, are reddish brown in color, and are very large, with a length of at least 16 cm and a diameter of 1.5 cm or more. The local Europeans say they are "harmless," that is, they don't bite or sting like centipedes do, and children often play with them because they move slowly and roll up into a ball when touched. However, Dr. A. W. R. McCrae, an expert on millipedes, writes that "millipede repugnatorial fluids are usually rich not only in cyanide but also in benzaldehydes, which can be strongly carcinogenic. This seems a further reason why no vertebrate species specialise in making such an easy prey the main bulk of their diet!" (27) This also is a sensible reason for the Wadigo to avoid drinking water that contains millipede excrement or secretions, and one wonders how the Wadigo developed this very sensible practice.

7) Water Bought from Kiosks (Madzi ga Mfereji - Gakulunga)

There are three water kiosks which sell piped water in Ukunda: one near Ukunda stores on the east side of the main Coast road, one near the post office (posta), and a third on the south side of the road down to the beach hotels (see Fig. 1). These are marked Ⓚ on the map (see Fig. 9). There are at least two others in Diani just outside the study area to the north. Water is sold by the 16 liter container (daba or ndoo) either to individuals or to cart vendors (see water from cart vendors) at prices from KS 1/- to 1/50 ($0.06-0.09 US) per container. According to one of the field interviewers, sale of piped water by Moslems is not restricted by the Koran because it is business, and the kiosk owners themselves must purchase the water to sell.

8) Water from Cart Vendors (Madzi ga Mikokoteni)

Water delivered by the cart vendors is almost always piped water from one of the water kiosks in Ukunda or Diani. The water vendors (achina mikokoteni) push oblong wooden carts from these pick-up points to buyers as far south along the main Coast road as Mvindeni school. Each cart holds two rows of five 16 liter containers (madaba); the cart is balanced on two car wheels attached to a wooden axle near the front of the cart. The water vendor pushes the cart by grasping one or both of the mangrove pole handles that extend from behind. Bottle caps on wires are attached to the wheel hubs to create a tambourine effect as they roll. Water is sold by the 16 liter container which the water vendor transfers into one or more household storage containers. Water prices range from KS 1/50 to 2/50 ($0.09-0.16 US) per 16 liters, depending on the distance from the point of origin. Most of the vendors are concentrated in the Ukunda, Ganzioni, or Malalani sections of the study area. Ten to fifteen of these carts can be seen in these areas at a given time.

9) Water Piped to the Home (Madzi ga Mfereji Wakaya)

None of the households visited in the course of our interviews had water piped into the home. A few houses in Ukunda reportedly have piped water, but this is on the northern fringe of our study area. Piped water is not available farther south than Ukunda along the main Coast road.

d. Water Quality

We attempted to find out what women consider to be the important qualities of good water. This was only partly successful because discussion of an abstract concept like quality requires more time than we often had in an interview as well as a good grasp of the nuances of the language. From the limited interviews three attributes stand out: insects, color, and taste.

1) Insects (Dudu)

Fig. 9. Top: Water kiosk on south side of road to beach. Bottom: Metal drum (*pipa*) outside house which is used to collect rain water and store water.

The most important attribute of clean water seemed to be the absence of insects (dudu). (Note: In Swahili, dudu can mean any living creature including bacteria, helminths, insects and snails, but it is usually used for insects.) When asked how she knew her well water was good, one woman said, "One cannot know everything about it, but there are no insects." Another, showing her newly drawn bucket of water, said that there were "no big insects, but looking closer you can see tiny ones." People using water from the water holes (madibwa) seemed not to mind the frogs which were often present, but they did mention insects. The evident concern with insects might be useful in education on prevention of schistosomiasis and other water related diseases.

2) Color

The color of the water from the wells and water holes visited ranged from grey-blue to yellow-brown, and when asked, women drawing water from these sources all pronounced it "good." One woman complained that in the dry season the well water becomes the color of "milk tea" (chai ya maziwa) but that the well doesn't dry up. As mentioned earlier, one of the reasons that the rain water collected from coconut thatch (makuti) roofs is considered undesirable for drinking is its reddish color. This seemed to be the only instance where color was important.

3) Taste

Taste was the least mentioned attribute and was only suggested a few times in the context of water not tasting fresh if it was stored in the house for a long time. We asked women at the well in Kibarani, closest to the sea, if the water ever tasted salty; they said it did not. According to a local health educator, the geologist connected with the World Bank water project said that water from deep wells nearer the coast is fresh, but that shallower wells closer to the Shimba Hills are salty. This might be due to inland salt deposits left from a time when the sea was higher, or the information from the geologist may have been misunderstood.

e) Water Containers

1) Round Water Buckets (Ndoo)

The Kidigo term ndoo refers to a specific water container as well as a concept. In the specific it refers to a galvanized steel bucket that holds about 12 liters. As a concept it refers to the vessel that is lowered into a well or water hole to draw water. These vessels are usually much smaller than the bucket ndoo, and are often a plastic one gallon vegetable oil container that has had its top removed and a rope or wire handle added. Alternately, square, one gallon tin cans or round metal cans holding a half gallon are used. The ndoo, which is tethered to a rope made either of locally woven raffia or hemp, is dropped into the well until it rests on the water surface. The rope is then moved laterally until water splashes in over the edge of the container and it sinks and fills with water. The ndoo is then pulled up hand over hand and emptied into a larger bucket. See Fig. 7 top.

Each woman carries her own ndoo and rope to the well instead of using one or more communal ones left hanging in the well. This practice increases the chances for contamination of the well by ndoo that may have been left sitting in the dirt.

While the galvanized steel ndoo are not used for drawing water (presumably because they are too heavy), they are used for carrying water from the source to home, for washing clothes, and for collecting rain water. Some households also use them to store water, and they also serve as stools (along with anything else of a similar height) when there are more guests than chairs.

The galvanized steel buckets are quickly being replaced by cheaper, lighter and slightly larger plastic buckets sometimes called palasta. Larger plastic water buckets (daba) are also sometimes called palasta (see "daba" below) and this can lead to confusion for researchers. Most often, both are referred to by their shape and function and not the material of which they are made. Unless there is some special reason to call attention to the fact that it is plastic, plastic ndoo and madaba usually are called "ndoo" and "daba."

2) Square Water Containers (Daba)

This container ("debe" in Kiswahili) holds approximately 16 liters and comes in two main types: metal and plastic. The metal containers are usually resurrected vegetable oil containers with one triangular hole cut in a corner of the top (see Fig. 7 top). Older ones may have been 4 gallon petrol or kerosene cans from the days before petrol pumps were introduced in the area. The plastic variety, slightly larger, and sometimes called "palasta" (see also "ndoo") or jerrycan in English, are either purchased new in Ukunda or Mombasa, or are salvaged oil or detergent containers from the hotels. A popular representative of the latter is the recycled bright yellow 16 liter NOBLA detergent container.

Both types are used for carrying water home from water sources and for water storage. Square plastic containers are also used by the cart vendors and are the most commonly used water containers for carrying water on bicycles. Occasionally stoppers of newspaper wrapped in plastic or plugs of grass are used to keep water from spilling out when they are carried. Square containers, either full or empty, also serve as spare seating. Cut down ones are used for washing clothes.

3) Clay Water Vessels (Mtungi)

The mtungi is a clay water vessel used expressly for water storage in the home. These containers usually hold 16 liters or less (one daba) and are produced locally by a craftsman (fundi) who uses clay from somewhere in the Shimba hills. The evaporation of water that works its way through the unglazed sides cools the water inside. Some clay vessels have clay covers; others are covered with a plate (sahani) or a cooking pot (sufuria) lid. Water is drawn from the vessel either through a brass spigot at the base or more often from the top using a ladle (see mkopo, livinga). The shape of the vessel, with its small base and wide middle, allows it to sit inside a round water pail (*ndoo*), and some people store them in this manner.

4) Large Clay Water Vessels (*Simikiro*)

A *simikiro* is a second type of clay water storage container used in the home. It differs from the *mtungi* in that it never has a spigot and is usually larger, holding more than 16 liters. One of the large vessels we saw in Kibarani was a very short wide container with a small base, wide middle, and small top. It held approximately 40 liters of water and was covered with a square piece of plywood. The woman said that it had belonged to her mother. Many people use plastic and metal containers for water storage in preference to the *simikiro*, but the concept survives. When asked about water storage, people say "we use X as a *simikiro*." A health advantage of the metal or plastic containers is that they are lighter and therefore easier to rinse out and clean.

5) Metal Drums (*Pipa*)

Pipa is the Kidigo term for a metal drum. Most of these hold about 100 liters and are used either for water storage or to collect rain water (see Fig. 9 bottom). The mosque behind Mvindeni school has a permanent *pipa* to collect rain water and to act as a reservoir for water for ablution (see Fig. 6 bottom). In the dry season, many people move the drums inside to use for storage. One woman complained that water stored in this way didn't stay fresh very long and she preferred to store her water in square water containers (*madaba*). Small drums, which are sometimes recycled roof sealer containers from the hotels, are called *chipipa* ("chi" being a Kidigo diminutive).

6) Aluminum Cooking Pots (*Sufuria*)

Aluminum cooking pots of varying sizes are used for many water-related tasks. The large size ones which are used for cooking the staple maize meal porridge (*ugali*) are used also for dishwashing, and people also carry them to the well or water hole when they wash clothes (see Fig. 5 top). Cooking pots are also used for collecting rain water and occasionally for water storage.

7) Water Dippers (*Mpoko*, *Livinga*)

The *mkopo* (also *mkopo* in Kiswahili, but said with different inflection) is a dipper, and is usually made by punching two holes in opposite sides near the top of a tin can (usually from Cowboy cooking fat) and pushing a stick through. These are used to dip water from a storage container such as a clay vessel or metal drum and are often left near them. The metal drum at the Mvindeni mosque has two (see Fig. 6 bottom). The *livinga* (*kata* in Kiswahili) is a dipper made from a half coconut shell with two holes punched in it and a stick, and is used for the same purposes as the *mkopo*.

f) Water Transport

1) On the Head

Women carry both round and square water containers (ndoo and daba) balanced upright on their heads. They provide protection for their heads and support for the container by placing a rolled piece of cloth (buibui or kanga) that is coiled into a ring beneath the container. Some women use grass and rafia rings about 20 cm in diameter for this purpose. When the container is filled, a little water is splashed out of the top by hand to rub down the sides and bottom of the container before it is balanced on the head. Sometimes one woman will help lift a full daba for another woman. When it is balanced, the woman walks either with both hands at her sides or with one touching the bottom edge of the container. In her other hand she carries the container and rope used to draw the water. Women walking to get water usually carry an empty square water container balanced on its side, atop their heads. Empty round pails or plastic pails (ndoo or palasta) are carried by their handles. No observation was made of a woman carrying either a filled metal or plastic pail in her hand.

2) By Hand, Bicycle, Water Vendor Cart, or Shoulder Pole

Small children sometimes carry water by hand, but only small quantities, usually no more than a few liters. Young girls, from about age nine, carry water pails (ndoo) on their heads.

Bicycles are used to carry one or two square containers (madaba) of water at a time by strapping the containers side by side on the rear rack behind the seat. If this is regularly done, a special metal or wooden box may be affixed to the rack. The madaba are held on by pieces of innertube (mpira). This type of transport is used both for private use and by some water vendors. The weight and volume of the water limits capacity to two square pails or about 32 liters.

Water vendor carts have been described in detail already in the section on water sources.

In Tiwi (an area approximately 6 km north of the study area) a man was observed carrying two square pails of water, one connected to either end of a 2 meter pole which he had balanced on his shoulders. The weight caused the pole to bow; the water sloshed from each pail; and the man walked with concentration and difficulty.

g) Sex Roles in Water Use and Transport

In the Wadigo culture there are many tasks and roles that are sex specific, and some of these are related to water. Much more needs to be done to explore sex specific water contact and how these differences affect diseases transmitted by water contact. Examples of sex specific tasks not related to water contact include basket weaving, which is done only by men, and mat weaving and making roof thatch (makuti), which are done only by women. The impression is given that while no one would be ostracized for crossing these lines, no one would think to try. When asked if women ever make baskets, people laugh at the absurdity of the question. The roles then seem sharply defined, but it is unclear whether there are social sanctions which reinforce the distinction. The following table shows how the sexual division of labor applies to the water uses already described.

Water Use by Sex

Water Use	Sex
Drinking (kunwa)	Both
Cooking (kubira)	Women
Dish washing (kutsukutsira vyombo)	Women
Washing clothes (kufurira)	Both
Bathing (kuoga)	Both
Playing - children (kuvumba)	Both
Mud/cement (udongo-simiti)	Both*
Ritual ablution (kutazawa)	Men

* Men are allowed to "help" their wives, but it is primarily the wife's job.

The information on cooking is based on very few actual observations as stated earlier. Men were often observed washing clothes, even while sitting in front of their houses on the main Coast highway. No man was ever observed washing a dish. Ritual ablution in the study area is done only at the tiny mosque behind Mvindeni school. According to one of the fieldworkers, a larger mosque (like the one in Diani) has enough room to have a segregated section for women and they, then, are also allowed to attend the mosque.

Sex roles are even more important in drawing and transporting water. While young and adolescent boys were observed drawing water for washing clothes at wells and water holes, the only adult male who was observed drawing water was one who was drawing it to sell. The differences in how he drew the water were interesting. He carried a pulley which he attached to the crosspole suspended over the well and used a large cut down plastic daba with a wooden handle instead of an ndoo. He was drawing water from the well at Mwamuwa, where on an earlier visit we had spoken to women who were unanimous in their opposition to a proposed World Bank project to enclose their well and install a pump. When asked what he thought of the idea, he said that "a pump is needed very badly."

Water transport is also segregated along sex lines. No man was ever observed carrying a water container on his head, while women invariably carry water this way. The only man not seen using a "machine" of some kind (water cart, bicycle, or pole) to carry water was one balancing a pail (daba) on his shoulder. He was the man helping his wife carry water to make mud for the house. On the other hand, no woman was ever observed pushing a water cart (mikokoteni), carrying water on a bicycle (or riding a bicycle for that matter except side saddle, as a passenger), or carrying water with a pole. The differences observed especially in water drawing and transport could have important consequences for projects introducing pumps and other technology.

2. Results of the Household Survey

a. Time to Fetch Water, Water Use Per Person, and Distance to Marsh

The first 3 factors affecting water use that we examined in the S. haematobium-infected and uninfected study groups were time the mother reports spending each day to fetch water, liters of water available per person per day in the household in the dry season (based on the number of containers mothers reported fetching and number of family members), and distance from the household to the marsh area where S. haematobium infection is transmitted (see Table 10). The time mothers reported spending to fetch water each day did not differ significantly between the infected and uninfected groups although a higher percentage of families of uninfected as opposed to infected children reported spending over 30 minutes fetching water (24% vs 18%). A higher percentage of families with infected as compared to uninfected children reported having water delivered (16% vs 9%). This trend seems sensible since families which purchase water may be reluctant to "waste" purchased water on bathing, and might encourage their children to go to the S. haematobium infested marsh to bathe. We should note that only 20% of mothers reported spending over 30 minutes fetching water. This is almost certainly a gross underestimate; most women do not have watches and are not likely to be able to estimate amounts of time precisely. The number of containers of water used per day is more likely to be estimated precisely because women are responsible for providing the household's water and in most cases have to carry each container themselves.

A significantly higher percentage of households of infected children reported having small amounts of water per person per day (5.0-9.9 liters/person) than did households of uninfected children (35% vs 20%), while 22% of both groups of households reported a high daily water use (16.0-37.9 liters/person; Kendall Tau C p = .044, see Table 10). This difference implies that S. haematobium-infected children from the households with low water availability may go to the marsh area to bathe either because there is little water available at home or because they want to spare the mother the effort of fetching additional water and can enjoy playing in the marsh at the same time. The mean quantity of water available per person per day for all 85 households was 13.1 liters.

The ethnography revealed that the marsh area in Mvindeni appeared to be the only local water source within the study area which meets the criteria necessary to support the snail hosts for S. haematobium and can transmit the infection to humans. We therefore wanted to determine whether children who were S. haematobium infected were more likely to live closer to the marsh area than those who were uninfected. To examine this possibility, we plotted the locations of the infected and uninfected children's households on a map which included the locations of the marsh area as well as other water sources (see Fig. 10). We first tested the hypothesis that infected children were more likely to live within 2,000 meters of the Shamu marsh area than were uninfected children. However there was no significant difference:

Table 10. Time Spent Fetching Water, Amount of Water Used, and Distance from Household to Marsh by Households and by Infected vs Uninfected Groups

	Households		*S. haematobium*				Sh pos vs neg
			positive		negative		
	n	%	n	%	n	%	p<
Time spent per day to fetch water (dry season)							
none-delivered	13	15.	8	16.	5	9.	X^2 ns
<15 min	41	48.	23	45.	26	48.	
15-30 min	14	16.	11	22.	10	18.	
>30 min	17	20.	9	18.	13	24.	
Number of containers[1] of water used per day by household (dry season)							
2-3	15	18.	11	22.	9	17.	Kendall Tau
4-5	58	68.	35	69.	36	67.	ns
6-7	9	11.	3	6.	8	15.	
>7	3	4.	2	4.	1	2.	
Liters of water used per person per day in household (dry season)[2]							
low 5.0-9.9	20	24.	18	35.	12	20.	X^2 ns
med 10.0-15.9	43	51.	22	43.	31	57.	low vs med-high:
high 16.0-37.9	22	26.	11	22.	12	22.	Kendall Tau p=.044
$\bar{X} \pm$ SEM	13.1±.67		12.1±.94		12.8±.71		Mann Whitney 1 tail p=.086 bord
Distance from household to marsh[3]							
<2000 meters	25	30.5	16	31.	19	37.	X^2 ns
≥2000 meters	57	69.5	35	69.	32	63.	

Sample sizes: Households = 85, Sh pos = 51, Sh neg = 54.

[1] One container holds approx. 16 liters.

[2] Calculated from number of containers used per day and household size.

[3] Household n = 82, Total children = 102.

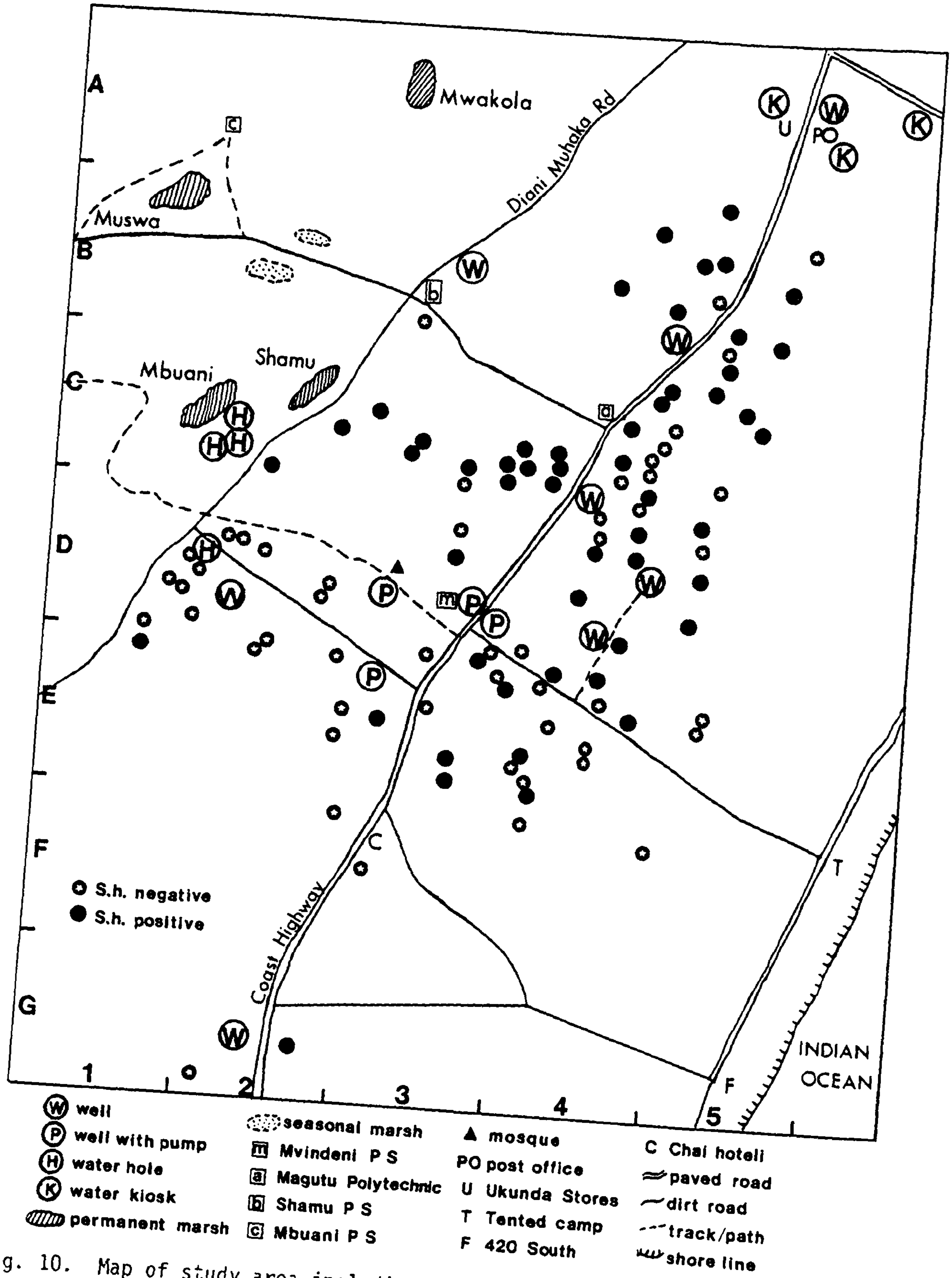


Fig. 10. Map of study area including locations of water sources and of homes of *S. haematobium* infected (●) and uninfected study children

31% of infected children and 37% of uninfected children lived within 2,000 meters of the marsh (see Fig. 10 and Table 10).

We next tested the hypothesis that the main road (Coast Highway indicated on map with a double solid line) would act as a barrier to marsh use, so that children who lived west of the highway, where the marsh is located, would more often be infected than those who lived east of the highway and who had to cross the highway to reach the marsh. This also was not the case: of the study children living west of the highway (near the marsh), 49% were infected and 51% were uninfected; of those living east of the highway, 52% were infected and 48% were uninfected.

Mr. Elliott, using his detailed knowledge of the study area, then considered both proximity to the marsh and availability of alternative bathing areas and further subdivided the area west of the highway into the northwest quadrant (where wells and pumps and dense vegetation for private bathing are all relatively scarce) and the southwest quadrant (where wells, pumps and cover for bathing are abundant). See the dashed line representing a foot path on Fig. 10 which divides northwest and southwest quadrants. Of the 24 study children living in the northwest where alternative bathing sites are scarce, 83% of children had S. haematobium infection and only 17% were uninfected; of the 21 children living in the southwest where alternative bathing sites are plentiful, only 10% were infected and 90% were uninfected ($X^2 p<.0005$). These results emphasize the value of the ethnography and detailed knowledge of the study area in interpretation of results and also show that people in this area do choose safer water sources for bathing when they are readily available. Whether they choose safer bathing areas because of convenience or desire to avoid bilharzia is unclear.

Mr. Elliott's detailed description of the bathing areas available in the east, northwest, and southwest sections of the study area follows:

> East section: The entire area east of the highway is mostly coral underneath a thin layer of sandy soil. Water does not accumulate here for long even in the rainy season. There are few wells because the water is brakish, and chiselling through the coral to dig a well is difficult. The wells that do exist are either inappropriate for bathing because they are out in the open or close to homes (the 2 in area D-4 and the water pump in D-3), or in the case of the well in C-4, privately owned and there is a charge for water. In the northern part of this area, water is usually purchased from vendors. Water for bathing and bathing spots (so that water need not be hauled home to bathe with) are relatively few. The marsh is far away.
>
> Southwest section: This section has both an abundance of handy pumps and wells and good cover for bathing near them. The soil in this area is deeper than in the east section and there are water holes and seasonal catchments for rain water. The undergrowth is dense

and provides screening for bathing near wells and pumps. The well near Govi's shop (D-2) and the pump near the Mosque (▲in D-3) both are used for on-site bathing. The homes are almost all quite near to a well or pump and this area has more outdoor thatch showers. Children in the southwest section are near to the marsh areas but also have easy access to other sources of bathing water and bathing places.

Northwest section: While the soil makeup here is very similar to that in the southwest section, there is a marked absence of wells or pumps in this area. The well in B-3 is very distant. The well in C-4 as mentioned above is open to the highway and the water is charged for. The well in B-4 is in a densely populated area. Many of the people in this area draw their water for most purposes from the marsh. The children in this area have almost no access to safe bathing water or bathing places and are relatively close to the marshes.

b. Water Use Per Person, Income Level, and House Characteristics

Because water use per person differed in the infected and uninfected groups and because we felt that determinants of water use and income level in the community were important, we further examined the relationships of water use per person and income level to other household characteristics in the 85 households studied. Water use per person per day was highly significantly and inversely correlated with number of children, adults, and total persons in the household, both when the variables were grouped by category (Table 11) and when they were analyzed as continuous variables (Table 12). Families with less water available per person also reported spending more time fetching water, and those with more water spent less time, but this relationship was only of borderline significance (Table 11 and 12). Water use per person was not significantly related to distance from the household to the marsh, presence or absence of a latrine, or income level.

Since families which were larger and took more time to fetch water tended to have less water available per person, we then asked whether this was because larger families were poorer and perhaps took more time to fetch water because they could not afford to buy it. On the contrary, income level was positively correlated with number of children and number of household members (Table 12); this was primarily because the medium income families were larger than the low and high income families ($p = .076$ borderline, Table 13). Income level estimated by the fieldworkers was highly correlated with housing construction, including presence of a latrine, roofing material (thatch or corrugated iron) and construction of walls (mud, mud and coral stones, or cement). See Tables 12 and 13.

c. Water Sources and Uses in Dry and Wet Seasons

We asked mothers in the household survey to name the water sources they used in both the dry and wet seasons for each of the 5 main water uses identified in the ethnography (drinking, cooking, dish washing,

Table 11. Relationships Between Amount of Water Per Person Per Household and Other Household Characteristics

	Liters of water per person per day (dry season)						
	low		medium		high		p<
	4.8-9.9		10.0-15.9		16.0-37.9		
	n	%	n	%	n	%	
Time spent per day to fetch water (dry season)							
none-delivered	3	15.	6	14.	4	18.	Kendall Tau
<15 min	9	45.	19	44.	13	59.	ns
15-30 min	2	10.	10	23.	2	9.	low+med vs high:
>30 min	6	30.	8	19.	3	14.	Kendall Tau p=.095 bord
Distance from household to marsh							
<2000 meters	6	30.	15	36.	4	20.	X^2 ns
≥2000 meters	14	70.	27	64.	16	80.	
No. children per household							
1-4	6	30.	25	58.	21	96.	X^2 p = .0001
5-14	14	70.	18	42.	1	4.	
No. adults per household							
1-2	10	50.	23	54.	21	96.	X^2 p = .0014
3-6	10	50.	20	46.	1	4.	
No. household members							
3-6	4	20.	12	28.	21	96.	Kendall Tau
7-8	4	20.	27	63.	1	4.	p = .0001
9-16	12	60.	4	9.	0	0	
Latrine present?							
no	14	70.	33	77.	16	73.	X^2 ns
yes	6	30.	10	23.	6	27.	
Income level (field worker's assessment)							
low	13	65.	30	70.	17	77.	Kendall Tau
medium	6	30.	10	23.	3	14.	ns
high	1	5.	3	7.	2	9.	

No. households = 85, except for distance to marsh (n = 82).

Table 12. Pearson Correlation Matrix of Household Size, Income Level, Water Use, and House Construction

	Income level	No. children	No. adults	No. members	Amt. water	Water/ person	Time water	Marsh dis- tance	Latrine	House roof	House walls
Income level[1]	-	.21**	.14	.24**	.36*^{4}	.00	-.09	.10	.53*^{4}	.67*^{4}	.71*^{4}
No. children[2]	.21**	-	.09	.92*^{4}	.29*^{3}	-.60*^{4}	.10	.01	.15*	.07	.07
No. adults[2]	.14	.09	-	.48*^{4}	.08	-.34*^{4}	-.14*	.16*	.11	.00	.18*
No. members[2]	.24**	.92*^{4}	.48*^{4}	-	.29*^{3}	-.67*^{4}	.03	.07	.18*	.07	.13
Amt. water[2]	.36*^{4}	.29*^{3}	.08	.29*^{3}	-	.41*^{4}	-.13	.25**	.16*	.24**	.28*^{3}
Water/person[2]	.00	-.60*^{4}	-.34*^{4}	-.67*^{4}	.41*^{4}	-	-.14*	.12	-.04	.08	.13
Time water[1]	-.09	.10	-.14*	.03	-.13	-.14*	-	-.44*^{4}	-.19**	-.11	-.05
Marsh distance[1]	.10	.01	.16*	.07	.25**	.12	-.44*^{4}	-	-.02	.06	-.00
Latrine[3]	.53*^{4}	.15*	.11	.18*	.16*	-.04	-.19**	-.02	-	.41*^{4}	.54*^{4}
House roof[1]	.67*^{4}	.07	.00	.07	.24**	.08	-.11	.06	.41*^{4}	-	.61*^{4}
House walls[1]	.71*^{4}	.07	.18*	.13	.28*^{3}	.13	-.05	-.00	.54*^{4}	.61*^{4}	-

No. households = 85, except for marsh distance (n=82).

1 Coded from lowest to highest, see Table 6 for categories used.

2 Coded as continuous variables 3 coded 0 = no latrine, 1 = have latrine.

* = $p < .10$ one tail

** = $p < .05$ one tail

*^{3} = $p < .01$ one tail

*^{4} = $p < .001$ one tail

Table 13. Relationships Between Income Level of Household and Household Size and Construction

	Income Level of Household (fieldworker's rating)						
	low		medium		high		p<
	n	%	n	%	n	%	
No. children per household							
1-4	38	63.	9	47.	5	83.	Kendall Tau
5-14	22	37.	10	53.	1	17.	ns
No. adults per household							
1-2	41	68.	9	47.	4	67.	Kendall Tau
3-6	19	32.	10	53.	2	33.	p = .101
No. household members							
3-6	29	48.	5	26.	3	50.	Kendall Tau
7-8	22	37.	8	42.	2	33.	p=.076 bord
9-16	9	15.	6	32.	1	17.	
Latrine present?							
No	52	87.	11	58.	0	0	Kendall Tau
Yes	8	13.	8	42.	6	100.	p = .0001
Roof of house							
coconut thatch	60	100.	15	79.	1	17.	Kendall Tau
corrugated iron	0	0	4	21.	5	83.	p = .0001
Walls of house							
mud	49	82.	4	21.	0	0	Kendall Tau
mud + coral stones	10	17.	11	58.	1	17.	p = .0001
cement	1	2.	4	21.	5	83.	

No. households = 85

clothes washing, and bathing). Their responses were tabulated for all 85 households, to provide a general picture of community behavior and resources, and for both the S. haematobium infected and uninfected groups, to determine whether there were differences in water use which might have encouraged transmission of S. haematobium infection.

The number of water sources used in the dry and wet seasons is shown in Table 14. In the dry season, 91% of households reported using only one water source for all purposes, and 9% reported using two sources. In the wet season, however, when rain water becomes available, only 41% used one source, 56% used two sources, and 2% reported using three different water sources. The number of water sources used in the dry season was almost identical for the infected and uninfected groups. In the wet season, a higher percentage of households with uninfected as compared to infected children used two water sources (59% vs 49%), and a lower percentage of the uninfected group used only one source (39% vs 49%), but this difference was not statistically significant.

The specific water sources mothers reported using in both the dry and wet seasons for each of the five major water purposes (drinking, cooking, dish washing, clothes washing, and bathing) are listed for all 85 households and for the infected and uninfected groups in Appendix VI. The water sources used were identified in the ethnography (see section III.E.1.c.) and included wells, wells with pumps, water holes, marshes, springs, rain water, and water bought from kiosks (taps) and water cart vendors. Only 4 households in the dry season and 1 household in the wet season reported using more than one water source for a given purpose, so the water sources were recoded according to primary water source for each purpose (see Appendix VI for definitions of collapsed categories), in order to provide a simpler picture of water source by purpose and to make statistical analysis feasible.

The primary water sources used by purpose in the dry and wet seasons for all 85 households are shown in Table 15. In the dry season, wells were by far the most common water source used and were used by 75-78% of households depending on the purpose. The second most common source was water purchased from taps or from water cart vendors (15-18% of households), and water holes or springs were the third most common source (7-8% of households). No one reported using either rain water or water from the marsh area in the dry season.

In the wet season, more water sources were reported, and, unlike the dry season, the percentage of households using a given source varied markedly between purposes. The most common water sources reported were either well water or rain water. Rain water became the most common source reported for dish washing (41% of households), clothes washing (58%), and bathing (53%), and well water was the second most common source reported for these purposes (26-38%). Well water remained the most commonly reported source for drinking (65%) and cooking (53%), but 12% of households also reported switching to rain water for drinking water and 27% used rain water for cooking in the wet season.

Table 14. Total Number of Water Sources Used for All Purposes by Season for Households and for *S. haematobium* Infected vs Uninfected Groups

					Children							
	Households				DRY				WET			
	DRY		WET		Sh pos		Sh neg		Sh pos		Sh neg	
No. of sources	n	%	n	%	n	%	n	%	n	%	n	%
1	77	91.	35	41.	47	92.	50	93.	25	49.	21	39.
2	8	9.	48	56.	4	8.	4	7.	25	49.	32	59.
3	0		2	2.					1	2.	1	2.
χ^2						ns				ns		

Sample sizes: households = 85, Sh pos = 51, Sh neg = 54.
See Appendix VI for primary and secondary water sources used.

Table 15. Primary Water Source Used in Dry and Wet Seasons by Purpose
Number and Percent of Households

	DRY SEASON - % of Households					WET SEASON - % of Households				
Source	Drink	Cook	Dishes	Clothes	Bathe	Drink	Cook	Dishes	Clothes	Bathe
Well	75.	76.	76.	76.	78.	65.	53.	38.	26.	29.
Tap/carts	18.	16.	16.	15.	15.	14.	9.	9.	6.	6.
Water hole/spring	7.	7.	7.	8.	7.	8.	8.	8.	7.	8.
Rain	0	0	0	0	0	12.	27.	41.	58.	53.
Marsh	0	0	0	0	0	1.	2.	4.	4.	4.

	DRY SEASON - n of Households					WET SEASON - n of Households				
Source	Drink	Cook	Dishes	Clothes	Bathe	Drink	Cook	Dishes	Clothes	Bathe
Well	64	65	65	65	66	55	45	32	22	25
Tap/carts	15	14	14	13	13	12	8	8	5	5
Water hole/spring	6	6	6	7	6	7	7	7	6	7
Rain	0	0	0	0	0	10	23	37	49	45
Marsh	0	0	0	0	0	1	2	3	3	3

n of households = 85

The changes in water sources used between seasons seem very sensible indeed, given water scarcity, because the mothers said that they switched from well water (which they have to fetch) to rain water (which they can collect in their yards), and the largest percentages of mothers changed to using rain water for washing dishes, clothes, and bathing. These are tasks which generally require more water than is needed for drinking and cooking, and also the cleanliness of the water is less important than it is for drinking water.

Only one to four percent of households per purpose reported using water from the marsh area in the wet season. This is a very small percentage in an area where S. haematobium is unquestionably endemic. It is possible however that most S. haematobium infection is contracted by children who use the marsh and that most adults do not use the marsh as a water source. Another explanation is that the adults are reluctant to admit to using marsh water for bathing regardless of season. We have observed adults bathing and washing clothes in the marsh area, and we have been told that the marsh has separate bathing areas designated for adult males, adult females, and for children, but we cannot say what proportion of adults regularly use the marsh. We also cannot be certain that other sources of S. haematobium infection do not exist in or near the study area. Both adults and children could contract the infection while traveling elsewhere in the district eg from the streams north and south of Ukunda. It is also possible that seasonal pools created by rain water are a source of transmission, as has been documented in the Gambia (28). However the ethnographer felt that these seasonal pools were so small and temporary that they were unlikely to be a major source of infection for adults in this area.

The primary water sources used by purpose in the dry and wet seasons for the infected and uninfected groups are shown in Table 16. In the dry season, fewer families of infected compared with uninfected children reported using well water, and more families of infected children purchased water from taps or water carts, perhaps because more families of infected children may have been located closer to the water taps and kiosks. These differences were of borderline significance for water for cooking and for washing dishes ($X^2p = .064$) and were not statistically significant for the other three purposes. In the wet season, fewer mothers of the infected children again used well water and more purchased water from taps and carts for drinking and cooking than did mothers of uninfected children, but these differences were not statistically significant. For dish washing and clothes washing, more mothers of uninfected children used rain water and fewer used well water than mothers of infected children; the differences in the use of rain water between groups were of borderline significance for both purposes. There were no differences between study groups in reported use of water from the marsh area for any of the five water purposes, and only 4% of mothers reported using marsh water for any purpose.

We tabulated the changes in primary water source used in dry and wet seasons by purposes for all of the combinations of water sources used by the mothers, because the data presented for each season separately implied that the mothers of uninfected children purchase water

Table 16. Primary Water Source Used in Dry and Wet Seasons by Purpose - Percent of *S. haematobium* Infected and Uninfected Groups

					DRY SEASON - % of Group					
	Drink		Cook		Dishes		Clothes		Bathe	
Source	pos	neg	pos	neg	pos	neg	pos	neg	pos	neg
Well	76.	83.	74.	87.	74.	87.	76.	85.	76.	87.
Tap/carts	18.	11.	20.	7.	20.	7.	18.	7.	18.	7.
Water hole/spring	6.	6.	6.	6.	6.	6.	6.	7.	6.	6.
Well vs tap/carts	X^2 ns		X^2p=.064 bord		X^2p=.064 bord		X^2 ns		X^2 ns	

					WET SEASON - % of Group					
Source	Drink		Cook		Dishes		Clothes		Bathe	
	pos	neg	pos	neg	pos	neg	pos	neg	pos	neg
Well	67.	72.	53.	61.	45.	37.	35.	28.	33.	33.
Tap/carts	14.	9.	10.	6.	10.	6.	6.	4.	6.	4.
Water hole/spring	8.	6.	8.	6.	8.	6.	8.	4.	8.	6.
Rainwater	12.	11.	26.	26.	33.	48.	47.	61.	49.	54.
Marsh	0	2.	4.	2.	4.	4.	4.	4.	4.	4.
Rainwater vs other	ns		ns		Kendall Tau p=.062 bord		Kendall Tau p=.075 bord		ns	

Sample sizes: *S. haematobium* pos = 51, neg = 54.

less often and use rain water more often than the mothers of infected children. These trends could mean that mothers of uninfected children make better use of scarce resources including water, money, and time. The changes between seasons for all 85 households are shown in Table 17. A comparison of the percentage of households which changed water sources between seasons for each purpose shows that mothers were most conservative and the fewest (14%) changed their water source for drinking water (where a clean dependable water supply is most important), and the highest percentage of mothers (65%) changed their water source for the purpose where cleanliness is least important (clothes washing). Thirty-two percent changed water sources for cooking, 46% did so for dish washing, and 59% changed sources for bathing.

The changes in primary water source between seasons for the S. haematobium infected and uninfected groups are shown in Table 18. There were no differences between groups in the percent of mothers who changed water sources for drinking, cooking, or bathing. A higher percent of mothers of uninfected compared with infected children reported changing their water source for dish washing (52% vs 39%) and clothes washing (67% vs 55%) but these differences were not statistically significant with Chi-square tests.

d. Parents' Report of Child's Contact with Marsh by Sex, Age Group, Purpose, Distance to Marsh, Water Use, and Income Level

We asked the mothers who participated in the household survey whether or not their study child used the marsh area where S. haematobium infection is transmitted for any of five purposes: bathing, washing clothes, drawing water, playing, or any other purpose. Their responses were analyzed between and within study groups for differences in reported marsh contact by sex, age group, distance from households to the marsh area, household water use, and income level. Mothers of 44 S. haematobium-infected children and 45 uninfected children answered the questions on their child's use of the marsh. The differences in reported marsh use between the infected and uninfected groups by sex, age group, and purpose are shown in Table 19. There were no differences between the study groups in sex ratio or age. A significantly higher proportion of mothers of infected as compared with uninfected children reported that their child used the marsh for at least one purpose (57% vs 33%, $\chi^2 p = .026$), and higher proportions of infected children reportedly used the marsh for each of the five purposes mentioned, including bathing (43% vs 18%, p = .009), washing clothes (41% vs 27%, ns), drawing water (30% vs 16%, ns), playing (36% vs 24%, ns), and other purposes (20% vs 10%, ns). Infected children reportedly used the marsh for a mean of 1.7 activities per child, while the mean for uninfected children was only 0.9 activities per child (p = .014); 27% of infected children were reported to use the marsh for 4-5 activities, compared with only 9% of uninfected children (p = .036).

These findings are important because they show that many mothers knew that their children had contact with the marsh, and the children who were infected were also reported to use the marsh more than uninfected ones. Nevertheless, 33% of the uninfected children reportedly

Table 17. Changes in Primary Water Source Used Between Dry and Wet Seasons by Purpose - Number and Percent of Households

			% of Households (n=85)			
DRY	WET	Drink	Cook	Dishes	Clothes	Bathe
Well	Well	65.	53.	38.	26.	29.
Tap/cart	Tap/cart	14.	8.	9.	4.	5.
Water hole/ spring	Water hole/ spring	7.	7.	7.	6.	7.
well	rain	8.	19.	34.	44.	42.
well	tap/carts	0	1.	0	2.	1.
well	water hole/ spring	1.	1.	1.	1.	1.
well	marsh	1.	2.	4.	4.	4.
tap/carts	rain	4.	8.	7.	12.	11.
water hole/ spring	rain	0	0	0	2.	0
% no change in sources:		86.	68.	54.	35.	41.
% change in sources:		14.	32.	46.	65.	59.

			n of Households			
DRY	WET	Drink	Cook	Dishes	Clothes	Bathe
Well	Well	55	45	32	22	25
Tap/carts	Tap/carts	12	7	8	3	4
Water hole/ spring	Water hole/ spring	6	6	6	5	6
well	rain	7	16	29	37	36
well	tap/carts	0	1	0	2	1
well	water hole/ spring	1	1	1	1	1
well	marsh	1	2	3	3	3
tap/carts	rain	3	7	6	10	9
water hole/ spring	rain	0	0	0	2	0
n no change in sources:		73	58	46	30	35
n change in sources:		12	27	39	55	50

Table 18. Changes in Primary Water Source Used Between Dry and Wet Seasons by Purpose - Percent of *S. haematobium* Infected and Uninfected Groups

Season/Source		% of Group									
		Drink		Cook		Dishes		Clothes		Bathe	
Dry	Wet	pos	neg	pos	neg	pos	neg	pos	neg	pos	neg
Well	Well	67.	72.	53.	61.	45.	37.	35.	28.	33.	33.
Tap/carts	Tap/carts	14.	9.	8.	6.	10.	6.	4.	2.	4.	4.
Water hole/ spring	Water hole/ spring	6.	6.	6.	6.	6.	6.	6.	4.	6.	6.
well	rain	8.	9.	14.	24.	24.	46.	33.	52.	35.	50.
well	tap/carts	0	0	2.	0	0	0	2.	2.	2.	0
well	water hole/ spring	2.	0	2.	0	2.	0	2.	0	2.	0
well	marsh	0	2.	4.	2.	4.	4.	4.	4.	4.	4.
tap/carts	rain	4.	2.	12.	2.	10.	2.	14.	6.	14.	4.
water hole/ spring	rain	0	0	0	0	0	0	0	4.	0	0
no change in sources (%):		86.	87.	67.	72.	61.	48.	45.	33.	43.	43.
change in sources (%):		14.	13.	33.	28.	39.	52	55.	67.	57.	57.
X^2 (change vs none)		ns		ns		ns		ns		ns	

Sample sizes: Sh pos = 51, Sh neg = 54.

Table 19. Mothers' Report of Children's Contact with Marsh by Sex, Age Group, and Purpose - *S. haematobium* Infected vs Uninfected Groups

	S. haematobium positive %	(n)	negative %	(n)	pos vs neg p<
Sex					
male	59.	(26)	49.	(22)	X^2 ns
female	41.	(18)	51.	(23)	
Age group					
6-9 yr	41.	(18)	51.	(23)	X^2 ns
10-15 yr	59.	(26)	49.	(22)	
Mother's report that child does use marsh for:					
bathing	43.	(19)	18.	(8)	$X^2 p = .009$
washing clothes	41.	(18)	27.	(12)	X^2 ns
drawing water	30.	(13)	16.	(7)	X^2 ns
playing	36.	(16)	24.	(10)	X^2 ns
other	20.	(9)	10.	(4)	X^2 ns
Does child use marsh for any purpose?					
no	43.	(19)	67.	(30)	X^2 $p = .026$
yes	57.	(25)	33.	(15)	
Number of purposes child uses marsh for					
0	43.	(19)	67.	(30)	
1	11.	(5)	4.	(2)	Kendall Tau
2	14.	(6)	11.	(5)	$p = .011$
3	4.	(2)	9.	(4)	
4	18.	(8)	7.	(3)	
5	9.	(4)	2.	(1)	
X ± SEM	1.7 ± .28		0.9 ± .22		t-test p=.014 one tail
Number of purposes child uses marsh for (collapsed):					
0	43.	(19)	67.	(30)	$X^2 p = .036$
1-3	29.	(13)	24.	(11)	
4-5	27.	(12)	9.	(4)	

Sample sizes: *S. haematobium* pos = 44, neg = 45.

used the marsh but did not have patent S. haematobium infections in two urine examinations done 6 months apart. We next examined the relationships of reported marsh contact to sex, age group, and distance from the household to the marsh within the two study groups; this was an attempt to elucidate further why some children were infected and others weren't (see Table 20). Children's sex was not significantly related to either use or lack of use of the marsh or to number of purposes within either study group, although a trend in the infected group indicated that a higher percentage of girls as opposed to boys tended to use the marsh for 4-5 activities (33% vs 23%, ns). We should point out here that the girls both in the sample and at Mvindeni School as a whole were one year younger on the average than the boys were. Given the differences in water use for adult males and females in this community (see section III.E.1.g.) we might predict that, controlling for age, girls would use the marsh more often for household tasks (fetching water and washing clothes), boys would more often play in the marsh, and both sexes would bathe there. These possibilities are examined in the following paragraphs and in Table 21. Our data on S. haematobium egg counts by sex do not show a major difference between boys and girls in prevalence or intensity of infection, but the possibility of sex differences in intensity and transmission of infection and water contact patterns deserves further study.

The analysis of marsh use by age group and by distance to the marsh within the study groups provided interesting and significant results. Within the infected group, a higher proportion of older as opposed to younger children used the marsh for some purpose (62% vs 50%, ns) and used the marsh for 4-5 activities (38% vs 11%, borderline p = .076). Within the uninfected group, the opposite pattern emerged: a higher proportion of the younger rather than older children used the marsh (48% vs 18%, p = .035) and used it for 1-3 activities (39% vs 9%, p = .031). Thus the children in the infected group whose mothers knew they used the marsh tended to use the marsh for more activities and tended to be older (and therefore probably had had more years of contact with the marsh) than was true in the uninfected group.

Regarding distance of the child's house to the marsh, a much higher proportion of infected children who lived close to as opposed to far from the marsh used the marsh (91% vs 46%, p = .005) and used it for both 1-3 and 4-5 activities (p = .018). Within the uninfected group, however, children closer to the marsh tended to use it and to use it for more purposes but these relationships were only of borderline significance.

In a further attempt to determine which children use the marsh most often, we examined the relationships of each of the children's specific uses of the marsh (bathing, washing clothes, drawing water, and playing) to sex, age group and distance of households to the marsh within each study group (see Table 21). As we predicted, within both study groups, a higher proportion of female as opposed to male children reportedly used the marsh for washing clothes (50% vs 35%) and drawing water (30% vs 23%). These trends however were not statistically significant. In the uninfected group, a higher proportion of males reportedly used the marsh for bathing (23% vs 13%) and playing

Table 20. Relationships of Mother's Report of Children's Contact with Marsh to Sex, Age Group, and Distance to Marsh Within *S. haematobium* Infected and Uninfected Groups

	S. haematobium							
	positive				negative			
	%	(n)	%	(n)	%	(n)	%	(n)
Marsh use by sex	male		female		male		female	
doesn't use marsh	46.	(12)	39.	(7)	68.	(15)	65.	(15)
does use marsh	54.	(14)	61.	(11)	32.	(7)	35.	(8)
χ^2	ns				ns			
No. purposes by sex	male		female		male		female	
0	46.	(12)	39.	(7)	68.	(15)	65.	(15)
1-3	31.	(8)	28.	(5)	23.	(5)	26.	(6)
4-5	23.	(6)	33.	(6)	9.	(2)	9.	(2)
Kendall Tau	ns				ns			
Marsh use by age group	6-9 yr		10-15 yr		6-9 yr		10-15 yr	
doesn't use marsh	50.	(9)	38.	(10)	52.	(12)	82.	(18)
does use marsh	50.	(9)	62.	(16)	48.	(11)	18.	(4)
χ^2	ns				p = .035			
No. purposes by age group	6-9 yr		10-15 yr		6-9 yr		10-15 yr	
0	50.	(9)	38.	(10)	52.	(12)	82.	(18)
1-3	39.	(7)	23.	(6)	39.	(9)	9.	(2)
4-5	11.	(2)	38.	(10)	9.	(2)	9.	(2)
Kendall Tau	p=.076 bord				p = .031			
Marsh use by distance to marsh	<2000 m		≥2000 m		<2000 m		≥2000 m	
doesn't use marsh	9.	(1)	54.	(18)	50.	(7)	75.	(21)
does use marsh	91.	(10)	46.	(15)	50.	(7)	25.	(7)
Kendall Tau	p = .005				p=.055 bord			
No. purposes by distance to marsh	<2000 m		≥2000m		<2000 m		≥2000 m	
0	9.	(1)	54.	(18)	50.	(7)	75.	(21)
1-3	54.	(6)	21.	(7)	43.	(6)	14.	(4)
4-5	36.	(4)	24.	(8)	7.	(1)	11.	(3)
Kendall Tau	p = .018				p=.089 bord			

Sample sizes: *S. haematobium* pos = 44, neg = 45 except for distance to marsh (pos = 44, neg = 42).

Table 21. Relationships of Report of Children's Bathing, Washing Clothes, Drawing Water and Playing in Marsh to Sex, Age Group, and Distance to Marsh Within S. haematobium Infected and Uninfected Groups

	S. haematobium							
	positive				negative			
	%	(n)	%	(n)	%	(n)	%	(n)
Bathes in marsh by sex	male		female		male		female	
doesn't bathe	58.	(15)	56.	(10)	77.	(17)	87.	(20)
does bathe	42.	(11)	44.	(8)	23.	(5)	13.	(3)
χ^2	ns				ns			
Washes clothes in marsh by sex	male		female		male		female	
doesn't wash clothes	65.	(17)	50.	(9)	77.	(17)	70.	(16)
does wash clothes	35.	(9)	50.	(9)	23.	(5)	30.	(7)
χ^2	ns				ns			
Draws water from marsh by sex	male		female		male		female	
doesn't draw water	77.	(20)	61.	(11)	91.	(20)	78.	(18)
does draw water	23.	(6)	39.	(7)	9.	(2)	22.	(5)
χ^2	ns				ns			
Plays in marsh by sex	male		female		male		female	
doesn't play	65.	(17)	61.	(11)	70.	(14)	82.	(18)
does play	35.	(9)	39.	(7)	30.	(6)	18.	(4)
χ^2	ns				ns			
Bathes in marsh by age group	6-9 yr		10-15 yr		6-9 yr		10-15 yr	
doesn't bathe	72.	(13)	46.	(12)	74.	(17)	91.	(20)
does bathe	28.	(5)	54.	(14)	26.	(6)	9.	(2)
χ^2	p=.086 bord				p=.070 bord			
Washes clothes in marsh by age group	6-9 yr		10-15 yr		6-9 yr		10-15 yr	
doesn't wash clothes	72.	(13)	50.	(13)	61.	(14)	86.	(19)
does wash clothes	28.	(5)	50.	(13)	39.	(9)	14.	(3)
χ^2	ns				p=.053 bord			
Draws water from marsh by age group	6-9 yr		10-15 yr		6-9 yr		10-15 yr	
doesn't draw water	78.	(14)	65.	(17)	78.	(18)	91.	(20)
does draw water	22.	(4)	35.	(9)	22.	(5)	9.	(2)
χ^2	ns				ns			
Plays in marsh by age group	6-9 yr		10-15 yr		6-9 yr		10-15 yr	
doesn't play	72.	(13)	58.	(15)	73.	(16)	80.	(16)
does play	28.	(5)	42.	(11)	27.	(6)	20.	(4)
χ^2	ns				ns			

Table 21 (continued)

	positive				negative			
	%	(n)	%	(n)	%	(n)	%	(n)
Bathes in marsh by distance to marsh	<2000 m		≥2000 m		<2000 m		≥2000 m	
doesn't bathe	45.	(5)	61.	(20)	93.	(13)	75.	(21)
does bathe	54.	(6)	39.	(13)	7.	(1)	25.	(7)
Kendall Tau	ns				p=.085 bord			
Washes clothes in marsh by distance to marsh	<2000 m		≥2000 m		<2000 m		≥2000 m	
doesn't wash clothes	18.	(2)	73.	(24)	57.	(8)	82.	(23)
does wash clothes	82.	(9)	27.	(9)	43.	(6)	18.	(5)
χ^2	p = .001				p = .043			
Draws water from marsh by distance to marsh	<2000 m		≥2000 m		<2000 m		≥2000 m	
doesn't draw water	46.	(5)	79.	(26)	64.	(9)	93.	(26)
does draw water	54.	(6)	21.	(7)	36.	(5)	7.	(2)
Kendall Tau	p = .019				p = .010			
Plays in marsh by distance to marsh	<2000 m		≥2000 m		<2000 m		≥2000 m	
doesn't play	54.	(6)	67.	(22)	69.	(9)	78.	(21)
does play	46.	(5)	33.	(11)	31.	(4)	22.	(6)
Kendall Tau	ns				ns			

Sample sizes: Sh pos = 44, Sh neg = 45 except for distance to marsh (pos = 44, neg = 42) and distance to marsh by play in marsh (pos = 44, neg = 40).

(30% vs 18%); these trends by sex were not present in the infected group, and none of the differences were statistically significant.

Older children in the infected group were more likely to use the marsh for all 4 purposes than were younger children, and this difference was of borderline significance for bathing (54% vs 28%, p = .086). In contrast, the younger children in the uninfected group were more likely to use the marsh for all 4 activities than were older children, and these differences reached borderline significance for bathing (26% vs 9%, p = .070) and for washing clothes (39% vs 14%, p = .053). These findings further substantiate the impression that the infected group has relatively heavy S. haematobium infections because they have had more contact with the marsh for a longer period of time than have the children in the uninfected group.

Distance from the child's household to the marsh was associated, as expected, with marsh use in both groups. Within the infected group, children living closer to the marsh were more likely to use it for all 4 purposes, and these differences were statistically significant for washing clothes (82% vs 27%, p = .001) and for drawing water (54% vs 22%, p = .019). In the uninfected group, children who lived closer to the marsh were also more likely to wash clothes there (43% vs 18%, p = .043), draw water (36% vs 7%, p = .010) and play in the marsh (31% vs 22%, ns) but the children who lived farther from the marsh were more likely to bathe there (25% vs 7%, p = .085). This last unexpected finding was probably due to the availability of alternative water sources for bathing for the uninfected children who lived close to the marsh (see section E.2.a.).

Finally, we examined the possibilities that the children's use of the marsh was related to the amount of water use per person per day at the households and to household income level (Table 22). In the infected group, as the water use per person per day in the dry season increased, so did the proportion of children using the marsh (borderline, p = .10). In the uninfected group, water use and marsh use were not related. This finding seems to reject the notion that a scarcity of water in the household is a major reason for children to use the marsh. Rather it implies that households whose infected children use the marsh are households which both want and obtain more water per person than those whose children do not use the marsh. As the income level of the households increased in both study groups, the proportion of children that used the marsh decreased in a linear fashion, but these trends were not statistically significant.

F. Latrines

1. Ethnographer's Summary of Latrines

The following 5 point summary on latrines in the study area was taken from the ethnographer's report:

1. Very few households have latrines.
2. The main obstacles to building them are rocky soil or coral that is hard to dig or sandy soil which collapses.

Table 22. Relationships of Mothers' Reports of Children's Contact with Marsh to Household Water Use and Income Level Within *S. haematobium* Infected and Uninfected Groups

	S. haematobium positive						S. haematobium negative					
	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)
Marsh use by liters water/person/day/household in dry season												
	4.8-9.9		10.0-15.9		16.0-37.9		4.8-9.9		10.0-15.9		16.0-37.9	
doesn't use marsh	54.	(7)	45.	(4)	27.	(3)	60.	(6)	71.	(17)	64.	(7)
does use marsh	46.	(6)	55.	(11)	73.	(8)	40.	(4)	29.	(7)	36.	(4)
Kendall Tau	p = .10 bord						ns					
Marsh use by income level of household												
	low		medium		high		low		medium		high	
doesn't use marsh	42.	(14)	44.	(4)	50.	(1)	63.	(19)	73.	(8)	75.	(3)
does use marsh	58.	(19)	56.	(5)	50.	(1)	37.	(11)	27.	(3)	25.	(1)
Kendall Tau	ns						ns					

Sample sizes: *S. haematobium* positive = 44, negative = 45.

3. There is a wide understanding that people should have and use latrines.
4. This understanding is not firmly enough held to overcome the obstacles of sandy and rocky soil.
5. People do not like to talk about latrines.

2. Ethnographer's Report on Latrines

About 75% of the households interviewed for the household survey did not have a latrine. People seemed aware of the need for latrines (choo) and almost all were apologetic about not having one, offering excuses, or often answering that they don't have one "yet." One family said that the hole was dug, but the latrine was not yet built. Others claimed to use a neighbor's latrine. This latter explanation was more common in Ganzoni nearer Ukunda where the population is denser and there is less bush available for defecation.

The latrines that were seen were small structures (1.5 meter sq.) usually constructed of mud and coral stones (gavipande vipande) with coconut thatch (makuti) roofs, and sometimes with makuti walls as well (see Fig. 11). The latrines with thatch walls are distinguishable from showers because the latrines have roofs and the showers do not. One house had a cement walled latrine with a corrugated iron roof. In households where there was a latrine it was not possible to determine if it was actually being used.

Alternatives to using the latrine are defecating in the bush (porini or vueni) or in the woods (tsaka). We were told that people often go into the bush and dig a small hole in which to defecate. In houses with latrines, preschool children (anache adide) are not allowed to use them for fear they would fall in. Parents of these children said that they have the child defecate on a piece of paper or a large leaf which is then carried to the latrine or thrown in a garbage pit. This was never observed. The difficulties of building a latrine in the study area center around two geological features: sand and rocks. Sand (mchanga) is the main soil constituent west of the Coast highway, and people in this area showed me the remains of latrine pits that collapsed either while being dug or after being flooded during the rainy season. East of the Coast highway, in Kibarani and Malalani, the soil is a fine dusting of sand atop solid coral. While the coral provides good support for pit walls, it needs to be chiseled away with a crowbar.

The digging of latrines is a task that is often hired out to men who make their living at digging holes through coral for latrines or wells. These men are called mtsimba choo or mtsimba chisima depending on which they are digging. The same men often dig both. The charge for digging a hole 2 meters in diameter is KS 90/- or more per foot of depth ($5.60 U.S.). This is much more money than most people in the area can afford. A latrine 20 feet deep would cost close to KS 2,000/- ($125 US) to dig, a sum which would be earned only in 6-9 months by an unskilled laborer. The people interviewed were divided on whether or not the work of the mtsimba choo could be successfully done by otherwise unemployed family members. Some said that "the mtsimba choo must be hired, there is no other way." Others, notably

Fig. 11. Latrines at primary school near Mvindeni; roof is coconut thatch and walls are made of mud. Note school boys urinate outside the latrine.

two households which had latrines, argued that anyone could dig a latrine, but that people who did not have them, or who thought it necessary to hire someone to dig one, were not motivated enough to do so. One woman complained that even though some of the people in the area work in the hotels and have some money, they want to spend it on "luxury things" and "drinking" instead of on the mtsimba choo.

In general, people were uncomfortable talking about latrines, and after our initial indepth interviews, we moved the topic to the last section of the survey forms. Most people have heard that they are supposed to have latrines. They don't have them in part because there appears to be too little motivation to overcome the technological and financial difficulties of digging in coral or sand. Any attempt to increase the number of pit latrines in the area should address motivation and financial and technical problems.

3. Household Survey

a. Mothers' Reports of Children's Use of Latrines

Of the 85 households visited for the household survey, only 26% (22/85) had a latrine, and only 5% of mothers stated that their preschool age children defecated in the latrine (see Table 6). As the ethnographer reported, people who did not have latrines were uncomfortable talking about them because they have been told repeatedly that they should build latrines and use them, most recently as part of anti-cholera campaigns on the radio. Mothers frequently reported that even though their children did not defecate in a latrine, they disposed of the feces in some other "sanitary" way, eg in 17% of households mothers said that they had the preschool children defecate in the yard, then carried the feces to the latrine; 43% of households stated that they dug a hole for the preschool child to defecate in, then covered the hole, and this explanation was also given for school children in 38% of households.

We suspected that these other sanitary means were not likely to be used and crosstabulated the presence of a latrine in the house with the place the preschool and school age children were said to defecate, in order to get some idea of the reliability of the mothers' responses on defecation sites (Table 23). The tabulations show in general that most mothers' responses were consistent and appeared honest. In 13 households where the preschool children were said to use the latrine or have their feces taken to a latrine, the house actually did possess a latrine (11 of 13 cases) or the adults said they had access to a neighbor's latrine (2/13). In 5 additional cases, the feces supposedly were taken to a latrine but the house had none. All 19 households in which school children were said to use a latrine either did have one (16/19) or said they used a neighbor's latrine (3/19). In 16 additional households for preschoolers and 9 households for school children, children reportedly defecated in the bush or in a hole when the household either had a latrine or said it used a neighbor's latrine, showing that people were willing to give unfavorable and probably truthful answers.

Table 23. Presence and Reported Use of Latrines by Preschool and School Children - Number of Households

	Where do preschoolers defecate?				
Does house have latrine?	latrine	bush	dig hole	yard to latrine	other
no	0	20	26	$\boxed{5}$	5
use other's	0	⓵	⓷	②	0
yes	④	⓷	⓻	⑦	1

	Where do school children defecate?		
Does house have latrine?	latrine	bush	dig hole
no	0	29	28
use other's	③	⓵	⓶
yes	⑯	⓸	⓶

Sample sizes: preschoolers, 84 households; school children, 85 households.

○ = consistent (say use latrine and also have latrine)

□ = inconsistent (say use latrine but say don't have latrine)

◎ = say have latrine or have access to one but also admit that children don't use latrine.

These results have important implications for health education on feces disposal because they show that the degree of fecal pollution in this community is even higher than one would expect based on the percentage of households which do not have latrines. Even in the few households that have latrines, most preschoolers do not use them, and nearly a third of the school children are said not to use them either. Safer mechanisms for feces disposal in this area clearly need to be found. For adults and school children, convincing all families to build and use pit latrines regularly is a monumental task, but would allow for safe and practical disposal of their feces. The preschoolers however present special problems. As was pointed out in the ethnography, some mothers don't want their younger preschool children to use pit latrines because they are afraid the children will fall in. The senior author was also told this by mothers in another part of Kenya (Machakos District (29)), and believes this is a genuine problem and not merely an excuse. In addition, a poorly maintained pit latrine can transmit infections very efficiently to children who still put their unwashed fingers and other objects in their mouths and who enter latrines with bare feet. In this situation, it may actually be best to train the preschoolers to defecate in a small hole or particular corner of the yard, rather than telling mothers that all of their children must use latrines. An effective solution for the disposal of feces of preschool children in this area needs to be realistic and physically appropriate; pit latrines are clearly not providing this solution now. A recent review shows that intestinal helminth infections in Kenya are generally as prevalent as they were 60 years ago (30). The inappropriateness of pit latrines for preschool children may in part explain this unfortunate phenomenon.

b. Latrine Presence and Hookworm and *Trichuris* Infections

Since latrine use was uncommon in this area (Table 6) and the prevalences and intensities of hookworm and *Trichuris* infections in the school children were quite high (Table 5), we examined the data to determine whether children living in households with latrines had lower worm burdens than those living in households without latrines (Table 24). The 75 children from households without latrines did not differ in sex or age from the 30 children from households with latrines. The prevalences of hookworm and *Trichuris* infection were higher in children without a latrine than in those with one (hookworm: 85% vs 77%, *Trichuris*: 80% vs 73%) but these differences were not statistically significant. More children from houses without latrines had heavy hookworm infections ($\geq$5,000 epg) than did children from houses with latrines (12% vs 3%, borderline p = .061), but the geometric mean egg counts (380 vs 191 epg) did not differ significantly. *Trichuris* egg counts did not differ significantly between groups. Interestingly, *Trichuris* egg count group was positively correlated with income level of the family (p = .017); this was probably because better off families tended to have more children present to transmit the infection.

These data show that possession of a latrine and family wealth in this area do little if anything to protect children from acquiring hookworm and *Trichuris* infections. These findings are not surprising, given the life cycles of the parasites, the constant fecal pollution of the environment, the high prevalences and intensities of the infec-

Table 24. Prevalence and Intensity of Hookworm and *Trichuris* Infections in Children by Presence of Latrine and Income Level of Household

		No latrine %	No latrine (n)	Has latrine %	Has latrine (n)	p<
hookworm	neg	15.	(11)	23.	(7)	X^2 ns
	pos	85.	(64)	77.	(23)	
hookworm neg		15.	(11)	23.	(7)	Kendall Tau
1-4999 epg		73.	(55)	73.	(22)	p=.061 bord
≥5000		12.	(9)	3.	(1)	
arithmetic $\bar{X}$		2,459		1,251		
geometric $\bar{X}$		380		191		t-test ns
Trichuris	neg	20.	(15)	27.	(8)	X^2 ns
	pos	80.	(60)	73.	(22)	
Trichuris neg		20.	(15)	27.	(8)	X^2 ns
1-999 epg		16.	(12)	10.	(3)	
1,000-4,999		43.	(32)	43.	(13)	
≥5,000		20.	(15)	20.	(6)	
arithmetic $\bar{X}$		3,140		3,630		
geometric $\bar{X}$		478		324		t-test ns

	Income level: low %	low (n)	medium %	medium (n)	high %	high (n)
hookworm neg	19.	(14)	12.	(3)	12.	(1)
1-4,999	71.	(52)	79.	(19)	75.	(6)
≥5,000	10.	(7)	8.	(2)	12.	(1)
Kendall Tau			ns			

	Income level: low %	low (n)	medium %	medium (n)	high %	high (n)
Trichuris neg	26.	(19)	12.	(3)	12.	(1)
1-999 epg	17.	(12)	8.	(2)	12.	(1)
1,000-4,999	40.	(29)	54.	(13)	38.	(3)
≥5,000	17.	(12)	25.	(6)	38.	(3)
Kendall Tau			p = .017			

Sample sizes: no latrine = 75, house has latrine = 30.

tions, and the fact that most children and some adults are barefoot most of the time, but they may be used to help convince people in the community to use latrines and encourage all of their neighbors to do so regularly. The relatively few people who do have latrines and who are relatively wealthy are not managing to protect their children from intestinal helminths any more than are the rest of the community. This point can hopefully be used by health educators to illustrate that sanitation is a community affair that must be dealt with by active participation of all and not just a few members of that community.

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APPENDIX I. IN-DEPTH HOUSEHOLD INTERVIEW NOTES

HOME VISIT NO. 1 Feb. 21, 1983, 9:30 AM

INCOME LEVEL

MEDIUM-based on housing materials, clothes, jewelry, and fact that husband works in Mombasa.

HOUSE DESCRIPTION

The house is fairly large and is located not far off the main road, across from and about 1/4 mile south of the school. The house is built of coral and cement, has a coconut thatch (makuti) roof, a large porch (baraza) with coral cement pillars, and a low coral cement wall at each end for sitting. It has a carpentered wooden door and shuttered windows, the latter having bars and wide gauge mesh as protection. A glimpse inside showed smooth plastered (cemented?) walls and floor, with painted walls. General layout is one central hall with rooms off to each side. Seven people live there - 2 adults (atu azima) and 5 children. There is no rain barrel or gutter. There is a shower area (cement and stone) and a latrine (choo), but no private well.

INTERVIEWEE

The mother is a tall self assured woman wearing a new kanga, rings and a wrist watch. Throughout the interview she holds/entertains a small child around 1 year of age. She speaks with conviction and seems animated and at ease.

KNOWLEDGE AND ATTITUDES ABOUT SCHISTOSOMIASIS

Cause: When asked the cause of schistosomiasis she first says "I don't know" ("simanya") and then adds "I think it's water" ("ninafikiri ni madzi"). She says some people think that it is from eating too much hot pepper (pili pili) or sugar (sukari).

Symptoms: She says she does not know the symptoms.

Cure: To cure it, it is necessary "to be taken to the hospital" ("pelekwa sipitali"). There is a specialist in Mombasa who treats people for schistosomiasis and it was necessary to go there before our project began treating children at the school.

Prevention: She is not sure how to keep from getting bilharzia but "probably it is good not to use hot pepper or a lot of sugar" ("si humire pilipili ama sukari nyingi").

WATER

Uses/Sources: She gets water for all purposes from a well (kutoka chisima). Sometimes she buys water from a man who delivers water on a bicycle, but he charges KS 2/50 per 16 liter container (debe), and it is also well water. She sometimes used to get water from the well at the primary school, but she doesn't any more because "a person fell in the well and was killed" ("chisima chagwa mtu"). The water was not cleaned up properly ("tachiya safishwa"), and she will not use it, although others still do. This happened "recently" ("dzuzi dzuzi").

Seasonal availability: "In the hot season, water is a problem" ("siku za nduza madzi ni shida") because "the well becomes dry" ("chisima nkukauka"). But "in the rainy season, water is plentiful" ("wakati wa mvula, madzi nmanji").

Water quality: She thinks that the well water is "dirty" ("machafu") and "it has insects" ("gana adudu"). She says she always boils the water they use for drinking.

Who fetches: Her daughter (in Standard 3) collects the water, or sometimes she herself does.

Where used: Sometimes she washes her clothes at home, "other times" ("wakati wanjina") she does it at the well. Adults bathe at home, children bathe with well water in the bush (porini) near the well, or sometimes at home.

Amount: In a day, their household uses "3 metal buckets" ("ndoo tatu") or "approximately 2 of the larger plastic buckets" ("kama palasta mbiri") of water.

Storage: Before, she used to store water in a drum (pipa) but after about 3 days the water would become bad. Now she prefers to store it in plastic buckets, or in a clay water container used for household water storage (mtungi). Water needs to be used or changed "around every 3 days" ("kama mara tahu").

Description of water source: see home visit #2.

LATRINE

Presence and feces disposal: The family does have a latrine. The adults use it, but the children defecate at the house and then the mother takes the feces and throws them in the latrine.

General comments: She says that most people in this area don't have latrines. "The latrine diggers want a lot of money" ("Mtsimba choo anataka pesa mingi") and "the prices of other things are high" ("matumizi ya vitu vyengine ni juu"). She also says that the people who work at the tourist hotels nearby like to spend their money on luxury or "prestigious things" ("vitu vya starehe", literally "things of comfort") or on drinking.

HOME VISIT NO. 2 Feb. 21, 1983, 11:30 AM

INCOME LEVEL

Low-based on housing materials, clothing, jewelry

HOUSE DESCRIPTION

Medium sized mud house with small verandah held up by mangrove poles and occupied by 2 adults and 6 children. There are rough windows and a corrugated iron door, dirt floors; yard and area under porch roof has wilting blossoms and stray leaves. A coconut grater/seat (mbuzi) sits by the door. House is located one house south of Home Visit #1 site. There are 6-8 chickens roaming about. There is a shower area (coconut thatch), but there is no latrine, no private well, and no metal drum for water storage.

INTERVIEWEE

The mother is a plump soft-spoken woman with braided hair; she is sitting on a coconut thatch shingle deftly weaving strips of rafia for a mat as she talks. She is wearing a worn kanga and part of an old bui bui and has bracelets on one wrist.

KNOWLEDGE AND ATTITUDES ABOUT SCHISTOSOMIASIS

Cause: She does not know the cause.

Symptoms: The symptom is "urinating blood" ("kukodzola damu").

Cure: To cure it, it is necessary to go to the hospital at Msambweni. "There is no other way" ("hakuna njia"). When asked if there is any "medicine from traditional practitioners for schisto" ("dawa ya mganga kwa kichocho"), she replies that there are, but that they aren't any good.

Prevention: When asked how one can keep from getting schisto she answers, "I am not able to know" ("siwezi kujua"). She does say that it is a parent's responsibility to keep children from getting schisto. (contradiction?).

WATER

Uses/sources: Most of their water is from the well (chisima) in the settlement scheme. She doesn't use water from the well at the primary school because "it's far away" ("ni mbali"). Sometimes they get water from a European who lives behind their house and has a tap (mfereji). This water is from a deep well and is pumped into a tank which has a tap.

Seasonal availability/quality: She says that the well water is good quality and that it is available all year (cf. home visit #1).

Who fetches: Water is carried from the well in buckets (na ndoo) and "we usually draw it ourselves," referring to herself and her daughter ("sisi enye uchaheke").

Where used: She uses water only "here at home" ("hapa hapa nyumbani"), including water for bathing. She washes all clothes at home.

Amount: They use "around 5 large plastic pails full each day" ("kama palasta tsano kila siku"). When I commented that this was a lot, she said that with many children you need a lot.

Storage: Water is stored either in "plastic buckets or a clay pot" ("palasta ama mtungi"). Water is used up or replaced with fresh water every 5-7 days.

Description of water source: The well is located about 1/4 mile from houses for home visits 1 and 2 and is an "improved" well with a cement lip and cover inscribed "Australia Kenya Co-operation 1978." The pump on top is broken (the pump handle has snapped off), and next to it there is a square hole approximately 1 ft by 2 ft from which women draw water. Water appears to be approximately 60 ft down from the top and has visible floating debris. While observing, an older woman came with 3 metal buckets and a Mazola oil container on a hemp rope. She said that the pump had been broken for about 2 years and that the school boys break it. (Local directions: Go in on road to Mzee's house, past Mwanamisi's shamba, and take first path off to left.)

LATRINE

Presence and feces disposal: The family does not have a latrine; they use the bush (porini).

General comments: They don't have a latrine because it is too expensive. When I remarked that I heard that latrine diggers charge a lot of money, the woman agreed, "It is true, but it is necessary for us to find the latrine digger the money he wants" ("Sindivyo, lakini ni lazima umuenzere mtsimba choo pesa hizo atakeza").

HOME VISIT NO.3 Feb. 23, 1983, 9:30 AM

INCOME LEVEL

Low

HOUSE DESCRIPTION

The house is a small, cement plastered house painted white with a coconut thatch (*makuti*) roof and is very near the main road south of and across from the primary school - about 1/2 way between school and *hoteli*. The house is "L" shaped with 2 doors from the inside apex each leading into 1 room. A single window onto the porch was shuttered with bars and wire. The letters "IЯAMO" were scratched into the wall of the front of the house (dyslexia?). Firewood (*kuni*) is piled in one corner of the porch. Three people live there - 2 adults and 1 child. There is a coconut thatch (*makuti*) shower area attached at the back, there is no private well, and the household uses the latrine from the house behind. There is no outside metal drum (*pipa*) or rain spout.

INTERVIEWEE

The mother is a plump young woman with plaited hair who sits on a #20 tin can (open end up) and leans against the mangrove porch post as she talks. She laughs seemingly out of nervousness, wears two worn *kangas*, and no jewelry. An older woman with 2 new *kangas* appears soon after the interview begins, claims the third available chair (relegating Mariam to the tin can) and carefully watches the whole interview process.

KNOWLEDGE AND ATTITUDES ABOUT SCHISTOSOMIASIS

Cause: She says she "doesn't know" (*"simanya sababu"*).

Symptoms: The symptoms are "blood in the urine" (*"mikodze na damu"*) and the urine gets "very hot"(burns? - *"imoho sara"*). The older lady (*bimkubwa*) watching the interview adds that the urine itches or stings (*washa washa* in Kiswahili).

Cure: To treat it "we go to the hospital" (*"ukuphiya sipitali"*). When asked if there are any home medicines (*"kuna madawa gachikaya"*) for schisto, she says yes, but that the ones from the hospital are preferred.

Prevention: She doesn't know how to prevent schisto.

WATER

Uses/sources: She gets most of her water from the well (*"chisimani"*) or if it drys up (*ama gachigoma*) "we buy from the men with carts from Ukunda" (*"unagula na achina mikokoteni kula Likunda"*). This water in Ukunda is piped (*"gafereji"*) and costs Ks 2/- per 16 liter container. While we wait she returns from the well (see description of interview 2, the well by Mwanamisi's house) with a bucket of water. She takes one small (Cowboy) tin of this water to wash out an *ndoo*-sized roof sealer pail which she then fills with water from a plastic *debe* from the "water cart man" (*"achina mikokoteni"*). He pours 4/5 of the plastic *debe* into the pail and she takes the rest inside - presumably to put in the clay water storage pot (*mtungi*). She then returns the yellow *debe* and offers the man a 5 shilling note asking if he has change. He has none; and she puts the note inside her bra and he leaves. Apparently she buys water often enough so that he is willing to wait for payment in spite of what she says about using well water except when the well is dry.

Seasonal availability: In the rainy season, they use rain water for bathing and washing clothes, but not for drinking. She claims that the only water sources she uses at any time of year are the well, rainwater, and the men with carts.

Who fetches: She collects the water herself with the children ("Ukuphiya sisi enye na anache") or buys it from the water cart man.

Where used: Water is used either at home or at the well, depending... ("kaya ama kukoviko chisimani").

Amount: Sometimes she uses up to 8 buckets (ndoo) of water in a day; "it depends on the use of the water" ("inategemea matumizi gamadzi"). If she uses 8 buckets she "makes 8 trips" to the well ("ata mara nane").

Storage: "We put/store it in a drum and in a clay water pot" ("Ukugatia pipani na mutungi"). "Other water is kept in its carrying bucket" ("gangina gakasimkwa na ndoo oye") and the water is changed "around every 3 days" ("kama siku tahu").

Description of water source: See home visit #2, less than 1/4 mile away.

LATRINE

Presence and feces disposal: They do not have a latrine; the adults use the latrine of the house behind theirs, and the children defecate in the "bush" ("porini").

General comments: She says that in order to have a latrine, one must hire a latrine digger. Her husband is not ambitious enough to dig a latrine himself, because there are "many stones" in the soil ("mawe manji"). (For "not ambitious" she uses "anaona uvivu" which the local field worker does not like translated as "lazy"). When asked how much it would cost to have a latrine dug, she answers "it depends" ("inategemea"), but that "it is expensive, much money" ("ni ghali, pesa nyingi").

HOME VISIT NO. 4 — Feb. 23, 1983, 11:30 AM

INCOME LEVEL

Medium

HOUSE DESCRIPTION

The house is a large cement house with a coconut thatch (makuti) roof located not far from where they are digging the new well. The house is painted red and white, and the front porch (which has mangrove posts) has a cement seat at each end. Doors and window shutters are carpenter-built. The porch has an earth floor. There is a coconut thatch shower area and cement kitchen area attached to the back. The occupants are 5 adults ("tsano atu azima") and 1 child ("anache mwenga"). There is no private well, and no visible rain barrel or gutter (but claims to use in rains). There is a latrine.

INTERVIEWEE

The mother is a friendly, smiling woman in her late 30's or early 40's who speaks with enthusiasm and confidence. She has just returned from the well and is carrying a debe on her head and a Wesson oil container with hemp rope in her hand. She is in a hurry to fix lunch so that she can go to her 2 PM adult education class. She speaks and understands Kiswahili quite well and agrees to answer our questions if we will hurry. She is wearing a cotton dress covered with 2 new kangas and wears gold earrings and no other jewelry.

KNOWLEDGE AND ATTITUDES ABOUT SCHISTOSOMIASIS

Cause: She says the cause is "water from the marsh areas" ("madzi gaziani").

Symptoms: The symptoms are "urinating blood" ("kukodzola damu") and "itching" ("kuawiwa").

Cure: To cure it "there is no way except the hospital" ("takuna njira yenjina isiphokala sipitali"). She knows of no local or traditional medicines for schisto.

Prevention: To prevent it one must boil water for drinking and bathing.

WATER

Uses/sources: Most of their water comes from the well of a neighbor however if it is dry ("chikama gakunywa") "we go to the Mwamuwa well" (this is the stone and cement well the government wants to put a pump in).

Seasonal availability: When the hot days come, the neighbor's well becomes dry, but in the rainy season, "there is no problem with water" ("takuna shida ya madzi"). In the rainy season, they collect rain water from the coconut trees ("kutoka minazini gamvula"). The local field worker explains this procedure. One or two pieces of coconut midrib (mchinga) are tied to the trunk of a coconut tree with string or rope (kamba) or rafia (mlala) so that they come off the tree like spouts. A bucket, metal cooking pot (sufuria) or other container is placed below the spouts and is replaced when filled.

Who fetches: "We collect the water ourselves" ("nisisi enye"), even "small children" ("anache adide") like this one (she points to a 5 year old). Even "small boys" ("watoto wadogo wakiume") can carry the small buckets used for drawing water.

Where used: Water for bathing is sometimes used at the well and sometimes at home. If the woman has a lot of clothes to wash, she takes them to the well.

Amount: She goes for water usually 3 times each day, but "it depends on the use of water at home" ("inategemea matumizi gamadzi gakaya").

Storage: "Drinking water is stored in a clay water pot" ("ukugaika mtungini gakunwa"). Drinking water is always boiled. Water for cooking is stored "in a drum" ("pipani"). The water is changed about every 2 days, when it runs out completely ("mpaka kusira" - until it is finished).

Description of water source: The neighbor's well, which is located about 1/2 mile from the house of the interview - towards the school (north). The well is an improved well with a concrete lip (1 1/2 ft. wide, 1 ft. high) surrounded by a 2 ft. wide sloping collar. Tethered goats are grazing nearby. Water is down about 20-25 meters. Coral blocks built down about 8 meters. Relatively small diameter at top, approximately 8 ft. across. The well has two coconut poles (minazi) across the top, both with deeply worn grooves from ndoo ropes. There is a full bucket of water sitting on the collar. Water is greyish, with fine particulate matter suspended in it. Bags are floating on water surface of well.

LATRINE

Presence and feces disposal: The house does have a latrine. The adults use it, but for small children a hole is made ("anache adide anaenderwa dibwa").

General comments: When I say that some people say it is too expensive to hire someone to dig a latrine, she answers that they have dug their own and that "it is lazy people who must hire" ("niavivu lazima kuajiri"). (Again the field worker doesn't like translation of avivu as lazy people, better as "people who do not want to do it" or something along those lines). It is expensive to hire.

HOME VISIT NO. 5 (done by Mohammed Ali) Feb. 23, 1983 - 2:30 PM

INCOME LEVEL

Low

HOUSE DESCRIPTION

The house is a mud house with a coconut thatch (makuti) roof; there is a small porch (baraza) with no benches at ends. The windows and doors are home made, and the porch has an earth floor. Four adults and 6 children share the space. There is no rain barrel, no latrine, no private well, but there is a coconut thatch (makuti) shower.

INTERVIEWEES

The father, who is home for the afternoon from work at one of the hotels, and the mother, who is simply dressed in kangas and wearing no jewelry.

KNOWLEDGE AND ATTITUDES ABOUT SCHISTOSOMIASIS

Cause: "It is affected by standing in places which have been urinated in many times or by bathing in the water areas" ("China ambukizwa nikuima phahali ambavo phaka kotsolive mara nyingi ama kuoga maziani").

Symptoms: The symptoms are blood in the urine and "itching" ("nakuawiwe").

Cure: To cure it you must go to the hospital. "There is no other way" ("Takuna njira yanjina").

Prevention: To keep from getting schisto you need to "bathe in clean places" ("kuoga phahali safi") and "not bathe in the marsh areas" ("usioge ziani").

WATER

Uses/sources: They get their water from 2 adjacent water holes ("the well of the holes" or "chisima cha dibwa") or, when they are dry, "we go to draw water from the spring" (this refers to a fresh water spring somewhere near Mabokoni.

Seasonal availability/quality: In the dry season they more often use the spring, which is sometimes clean and sometimes dirty. They say that water for drinking and bathing is boiled.

Who fetches: Water is drawn by the mother and the small girls and boys.

Where used: The water for bathing and washing clothes is sometimes used at the well or spring and sometimes at home.

Amount: Water is drawn "6 or 7 times, until the needs of the house are satisfied" ("mara sita ama mara saba mpaka gatosha matumizi gehu ga kaya").

Storage: Water is stored "in a large clay vessel or a small one" ("simikironi ama mtungini"). [A simikiro is a large clay container which holds 2-4 debes (32-64 liters) of water. It usually tapers near the top and is covered with a plate or lid from a cooking pot (sufuria). Simikiro do not have spigots, but mtungi may. Water is always scooped out from simikiro.] Water is replaced and the containers rinsed about every 4 days.

Description of water source: The two water holes (*chisima cha dibwa*): the one closer to the primary school is used for drinking water; the second one, 5 yards behind and to the right is used for washing. Water in both is greyish and there are insects, debris and frogs. The holes are about 3-4 ft. across the top and roughly triangular in shape with wooden poles buried across the corners for people to stand on. The water is 5-6 ft. below ground level. There is a large depression to the left of the two holes which fills up in the rainy season. Behind the water holes is a football field. The field worker (Mohammed Ali) says that no one owns the water holes.

LATRINE

Presence and feces disposal: "There is none, we dug it but it is not yet built" ("*tauna, watsimba, lakini taubado kuchitengeza*"). "We go to the forest [to defecate], everyone, even the adults ("*aphiya misitumi atu usi mpaka atu azima*").

General comments: Sometimes they have dug a latrine, but it collapses ("*chinamomonyoka*") because the sand is loose ("*manage msanga unamwagika*").

HOME VISIT NO. 6

Feb. 24, 1983 - 10:00 AM

INCOME LEVEL

Low

HOUSE DESCRIPTION

The house is a large square house with walls made of mud and coral stones, a coconut thatch (makuti) roof, a front porch halfway across the front wall, and roughly made windows high up on the front wall. There is an outside shower made of makuti, and a latrine made of mud and coral stones with a makuti roof. The house has no private well. One to two adults and 3 children live there.

INTERVIEWEES

The father is there by chance that day. He works as a fireman at the Mombasa airport, but lives in Msambweni and only visits here (Mvindeni) occasionally. He appears to be in his late 40's with graying hair; he is dressed in pants and a shirt and wears a wrist watch (that works!). The mother is a thin, quiet woman who looks too old to be breast feeding the 1 1/2 year old child who clings to her. She is washing maize meal porridge (ugali) out of a pot (sufuria) when we arrive and joins us to answer questions about water. She wears 3 kangas, bracelets and a traditional medicine charm (dawa) around her neck.

KNOWLEDGE AND ATTITUDES ABOUT SCHISTOSOMIASIS

Cause: The father says that schisto comes from dirty water.

Symptoms: Father: blood in the urine.

Cure: Father: To cure it, it is necessary to go to the hospital at Msambweni. He does not know of any home cures. "It is always best to go to the hospital." It only costs 4 Kenya shillings. He goes to the hospital when he is sick and tells his wife to send the children there for any illness.

Prevention: Father: You prevent schisto by boiling drinking water.

WATER

Uses/sources/quality: They get all of their water from the well at Mvindeni school. Sometimes the water has "dust or little bugs" in it ("vumbi ama adudu adide").

Seasonal availability: In the dry season the well does not go dry ("tachikauka"), and "there is no other place to get water" ("takuna phahali phangina phamadzi").

Who fetches: The mother collects the water herself or the female children ("anache achichetu") do so, using either a bucket or a 16 liter container (debe).

Where used: The water is only used at home (kaya bahi) for bathing (kuoga), for washing dishes (kutsukutsira vyombo) and for washing clothes (kufurira).

Amount: They fetch water about 4 times in a day "if the opportunity permits" ("*kama nafasiyo inakuruhusa*").

Storage: Water is stored "only in a drum" ("*pipani tu*"), and it is cleaned out every day.

Description of water source: Well at Mvindeni school, 1/4 mile from the house.

LATRINE

Presence and feces disposal: The house has a latrine (mud/coral walls, *makuti* roof) located about 6 yards from the house. It is used by the adults; they "dig a hole for the small children" ("*unasibimira dibwa anache adide*").

General comments: When I ask if it was difficult to dig a latrine, because of the rocks, the father answers, "it is easy, you can dig 10-15 feet without finding a rock." He dug his own latrine in 3-4 days. "It is not necessary to hire a latrine digger." ("*Si lazima kuajiri mtsimba choo*").

HOME VISIT NO. 7 — Feb. 24, 1983 - 11:45 AM

INCOME LEVEL

Low

HOUSE DESCRIPTION

The house has mud and coral walls with coconut thatch (*makuti*) roof. It is situated on the left as one passes back down the dirt road from the primary school to the beach, near the European's house and near some mango trees. The house has a mud front porch with mangrove poles, carpenter built door and a window on the front. The structure is divided into 3 parts, the main body of the house with 4 small rooms, 2 off each side of a central hall and then a roofless tiny courtyard, followed by a low, roughly made kitchen. The yard is cluttered. Six children and 2 adults live there. There is no latrine; there is a shower made of *makuti*.

INTERVIEWEE

The mother is off collecting water when we arrive and returns carrying a yellow plastic NOBLA *debe*, which at one time held 16 liters of detergent, on her head. In her hand is a square 2 liter Mazola oil tin used to dip in the well. She wears the remains of a black *bui bui* and a *kanga* as a dress and a single black wire bracelet. She laughs pleasantly and breastfeeds her youngest (about 18 months old), as two other children, a boy approximately 3 years of age and a girl about 5 play nearby.

KNOWLEDGE AND ATTITUDES ABOUT SCHISTOSOMIASIS

Cause: She doesn't know.

Symptoms: The symptoms are "blood in the urine and a burning sensation upon urinating" ("*Kukodzola damu na kuawiwa*").

Cure: She says that it is necessary to go to the hospital; there are no local medicines.

Prevention: She doesn't know how to keep from getting schisto.

WATER

Uses/sources/quality: She gets her water from the European's well ("*chisimani cha mzungu*"), where the water is good, or other times at the well of Bwana Iddi. When asked how one could tell if the water is good, she says that you can't know everyting ("*chochote*") about it, but you can look for things inside. They pay the European KS -/20 per *debe* and draw their own water.

Seasonal availability: During the hot season ("*wakati wa dzua*") the water becomes low (*nikupungua*). In the rainy season, rain water is used for cooking, bathing and washing clothes, but drinking water is still taken from the well.

Who fetches: The woman herself draws the water and gets help from the female children.

Where used: Water for bathing, washing clothes and even for bathing the children is used at home because the people using the well do not allow people to do these things by the well.

Amount: They use around 4 *debes* of water (about 64 liters) a day or even 6 *debes* (about 96 liters) on days when she washes clothes. This is because there are so many children.

Storage: Water "is stored in a large clay pot, a smaller one, and in a small drum" ("*Kugaika simikironi, mtungi na chippa*") and is changed completely every 2 days or so. Since I have never seen a *simikiro* she says that I can see hers. It is a *low*, very wide vessel, roughly made, which looks something like this . It holds about 2 *debes* (32 liters) of water and is covered by a square piece of plywood. She says that it is very old and belonged to her mother.

Description of water source: The well is about 5 minutes walk from this household and is near a European's house. The well is 20-25 meters deep and is very narrow, the top being oval, approximately 4' by 5', with a cement lip and collar. The inside has coral block down about 1 meter. There is a heavy pole suspended across the top of the well with an attached pulley that none of the women there is using. A signpost reads "*Tafadhali lipa kabla ya kuchota maji*", Kiswahili for "please pay before drawing water." The cost is KS -/20 per *debe*, payable at the house. The women say that the well doesn't dry up and that the water is good. The color of the water is yellow-brown but it has little sediment. There is a hinged plywood cover for the well which folds back. One woman explains that the cover is put over the opening at night to keep rats from falling in.

LATRINE

Presence and feces disposal: The household has no latrine and all the family defecates in the bush (*ukuphiya mavueni*).

General comments: It is difficult to dig a latrine because of the stones in the soil (*Ninqumu kwa ajili gamawe*), and it is necessary to hire someone to dig one. She claims that it costs KS 100-120/- per foot to have one dug through the rocks.

HOME VISIT NO. 8 Feb. 25, 1983 - 9:00 AM

INCOME LEVEL

Low

HOUSE DESCRIPTION

A mud and coral house with a coconut thatch (makuti) roof in Ganzoni, just south of Ukunda and a little east of the old Coast road past the small mosque. The house has carpentered windows and doors, a connected coconut thatch shower, and no rain barrel, gutter, or latrine. Two adults and one child live there. The yard is neat, and the area is densely populated.

INTERVIEWEE

The mother is a slight woman in her late 30's with short hair. She has 2 sets of large earring holes and wears wire bracelets and a blue stone ring. She is wearing 2 kangas, and has a packet of traditional medicine (dawa) on a cord around her left ankle. She is very quiet and seems ill at ease and suspicious at first. She talks into her hand.

KNOWLEDGE AND ATTITUDES ABOUT SCHISTOSOMIASIS

Cause: She does not know the cause.

Symptoms: She also does not know any of the symptoms.

Cure: For treatment it is necessary to go to the hospital.

Prevention: She does not know how schisto can be prevented.

WATER

Uses/sources: Water is either purchased from the men with the water carts (for KS 2/= per debe or 16 liters) or from the tap by the post office.

Seasonal availability: During the rains, rain water is used but only for washing clothes.

Who fetches: The mother herself fetches the water from the tap by the post office.

Where used: Water for bathing and washing clothes is used at home.

Amount: Four or 5 debes (approximately 64-80 liters) are used each day.

Storage: Water is stored in the house in a water drum; the drum is washed out about every 5 days.

LATRINE

Presence and feces disposal: The household does not have its own latrine. The adults use the neighbor's latrine; for the small children they dig a small hole to bury the feces.

General comments: It is very difficult to dig a latrine because the soil has so many rocks. "It is necessary to hire a latrine digger."

HOME VISIT NO. 9 — Feb. 25, 1983 - 11:00 AM

INCOME LEVEL

Low

HOUSE DESCRIPTION

The house is a large square house built of mud and coral with cement framing the doors and windows. It is located in Ganzoni, near to home visit #8, but a little farther north. The house has a central hall with doorways off to each side, a porch (*baraza*), a coconut thatch (*makuti*) roof, and carpenter-built doors and windows. The house has a *makuti* shower, no rain barrel or gutters, and no latrine nor private well. It is again in a densely populated area, but people do not gather around during the interview.

INTERVIEWEES

The mother is a slender woman in her 40's wearing the remains of a *buibui* and an old *kanga*. She is shy at first but grows animated, especially when telling of the troubles they have had getting treatment for their son for schisto. Her husband is about the same age, greying, and wears a plaid *kikoi*. They seem polite, serious, and surprised and pleased with my attempts at Kidigo.

KNOWLEDGE AND ATTITUDES ABOUT SCHISTOSOMIASIS

Cause: Neither mother nor father knows the cause of schisto.

Symptoms: The mother knows her son had the disease because she could see blood in his urine (*"Ninamanya manu choche ukuchiona inchibaya kukutsola damu"* - literally "I know because you could see his urine is bad. There is blood in the urine.").

Cure: She knows it is necessary to go to the hospital for treatment. When her son had the disease, they first used local medicine (*dawa za chidigo*) "but it failed to cure" (*"lakini kaphorere"*). They then took him to the health dispensary at Diani which gave him a letter to the Tiwi Health Training Centre where he got treatment and was cured.

Prevention: She doesn't know how to prevent schisto.

WATER

Uses/sources: They get water either from the well behind the post office or from the men with water carts. This is piped water either from near the post office or from Diani. Water from the well behind the post office costs KS 1/50 per *debe* (16 liters); water from Diani costs more.

Seasonal availability: Even in the hot seasons, the well does not dry up (*"chisima tauchikauka"*). In the rainy season, rain water is used for bathing and cooking but not for drinking.

Who fetches: Either the mother herself or the girls in the family fetch the water from the well.

Where used: The adults and children bathe at home, and clothes are washed at home.

Amount: They use about 5 buckets or 4 debes in a day.

Storage: Water is stored in a small drum that they use as a water storage pot (simikironi). It is washed out every day.

Description of water source: The well behind the post office is about 1/4 mile from this house (almost directly diagonal at 10 o'clock from the front door and across the road). The well has a concrete lip and collar and has coral blocks down about 15 ft. to the solid coral level. The water is about 20 meters down and appears clean (free of insects and debris) except for one Wesson oil jug (a well bucket) floating on the surface. Women drawing water there say that nobody owns it and that it never goes dry. Many people use it. The water itself looks slightly yellowish upon close examination and has fine particulate matter suspended in it.

LATRINE

Presence and feces disposal: They don't have one, not yet (Tauno, tachibadosina). The adults use one of the neighbor's latrines and "the small children defecate in a hole" ("anache adide ananya kaya dibwani").

General comments: They say that people can either dig a latrine themselves or hire someone, but that there are many rocks in the soil.

APPENDIX II

T. Elliott's Notes on Interviewing and Collecting Income and SES Data

No one whom we wished to interview refused to cooperate. We chose women as respondents because they were likely to know more about water sources, use and storage than were men. Women were also almost always at home during the morning hours when most of the interviewing was done, and men were seldom present. It was rarely necessary to return because a mother was absent, although it was necessary on several occasions to wait while one returned from drawing water.

The choice of women as respondents may not have been the best in terms of questions asked about schistosomiasis. The role of men in deciding if, when, and where medical treatment would be sought for family members was not sufficiently examined and needs to be explored further. If the husband was home, it was necessary to inform him that we wanted to ask his wife some questions as well as asking her permission. When men sat in on the interviews the women were more reticent. This was also true when neighbors of either sex listened in. In Ganzoni, where the houses are close together, this was a particular problem, and in one interview it was necessary to politely ask the onlookers to leave. The women we interviewed all had some understanding of Kiswahili, but much preferred to speak and be addressed in Kidigo, their tribal language.

The use of interviewers from the community was a mixed blessing. On the plus side, they knew their way around the area, and because they knew many of the people, we may have gotten more cooperation than we would have otherwise. They also had insights into family income that were helpful (see discussion which follows on income and income proxies). On the other hand, it was sometimes hard for the interviewers to interview close friends and neighbors and be taken seriously. We got around this problem to some extent by having a second interviewer interview some of the households around the main interviewer's home.

The presence of a European was also helpful and problematic. My presence, while lending the "authority" of an outsider, also probably intimidated some of the respondents. On the other hand, when I was along the interviewers found that people were more willing to answer what, from the interviewers, would seem to be obvious questions. If the interviewer alone asked someone he knew well "where do you get your water," the respondent would think it a joke. If I were along it appeared that the question was being asked for my benefit, and the respondent could then be engaged in often profitable conversation. This might be avoided in the future by the interviewers explaining that the "doctors had asked him to ask these questions."

Asking questions about schistosomiasis presented special problems. Because we introduced ourselves as working with the doctors who examined the school children and identified ourselves as health workers and not doctors to escape an onslaught of symptoms and requests for treatment, people assumed that we knew what the "real" cause, symptoms, treatment, and prevention of schistosomiasis were and that we were somehow testing them. Also, because they thought of us as health workers and representatives of Western medicine, their responses were probably colored by what they thought we wanted to hear.

The order of the interview topics was also important. Because we initially asked the women easy questions, such as the names and standards (grade levels) of other children from that household who attended Mvindeni School, they became less shy and more confident. Next, we asked the questions on knowledge and attitudes about schistosomiasis to avoid prejudicing their answers on cause and prevention by our barrage of later questions on water sources and marsh contact. We left the unpopular topic of latrines until last, when the respondents would be most comfortable with our questioning and when their possible alienation would do least harm to their willingness to continue, or to the quality of their other answers.

We used a form translated into Kidigo and asked the interviewers to read the questions exactly as they were written; this had the advantages of consistency between interviewers and ensured that the questions were not translated in a way that prejudiced the responses. This is especially important when the interviewers are not experienced.

Accurate income data is difficult to collect in the study area for a number of reasons. First, people are reluctant to say how much money they make or have. A more important problem in collecting income data is the variety of cash and non-cash sources of income and the variety of non-cash reserves. Bartering, crops produced for home consumption, and investments like livestock all add to the difficulty in determining either income or net worth. A third problem is determining what constitutes a household. Polygamy and extended families affect not only from where resources are available, but also how they are distributed. The following is a brief description of some of the pros and cons of various types of income estimation or income proxies.

(1) Direct questions on sources of income

Direct questions on sources of income are met with suspicion. People have difficulty seeing the relationship of their income to health work and are reluctant to discuss their worth with a stranger. This may make them less cooperative on other matters. As mentioned above, there are also the difficulties of quantifying goods or services bartered, food grown for home consumption, and income from the sale of crops which needs to be averaged over the whole year.

(2) Expenditure

This indicator has the advantage of arousing less suspicion than questions on income. People seldom realize that income can be calculated from expenses and many people are happy to talk about how costly things are. Disadvantages are the possible tendency to exaggerate and inflate expenses and the great number of questions necessary to cover food, fuel, transport, school fees, etc. Again the problems of quantifying bartered goods and services or food produced for home consumption arise.

(3) Father's occupation

The reliability of this indicator depends on being able to estimate income from occupation and to determine how the income is spent. The main advantage is that people are willing to say what the household head does. Problems arise when other household members work outside the home or when the household head's income is divided between two or more households. At one household we visited the father worked at the Mombasa airport and earned a regular cash salary. The household however appeared to be quite poor. This, we found, was because he had another wife and household in Msambweni where he spent most of his time (and presumably resources). Another problem is that it is difficult to estimate the income of someone like a traditional doctor's (mganga's) assistant without actually asking how much money he makes.

(4) Ownership of household items

Possession of a bicycle, radio, parafin lamp with a glass or mantel or a pressure lamp are all possible proxy indicators. This assumes that people all value these items and will purchase them if possible. While less difficult to ask than direct questions on income, people still have trouble seeing how these questions have bearing on your stated interest in their health problems, or in looking for ways to prevent diseases in children. Questions about radios might be made to sound reasonable if it were explained that the government was interested in starting health education broadcasts.

(5) Dress, shoes and jewelry of the mother

The advantage to these indicators is that the information is available through observation. There are unfortunately many disadvantages as well. Observation and conversations with the fieldworkers suggest that younger women regardless of income are more likely to wear new kangas and jewelry than are older women. The dress at the time of the interview may also reflect the woman's activity at that moment more than anything else. At one interview we found the mother who was preparing to leave for her adult education class dressed in new kangas and wearing bracelets and earrings. At a subsequent visit we found her chopping coconut midribs for roof thatch wearing a worn black wraparound that was once a bui bui.

(6) Housing materials

This proxy indicator again has the advantage of being collectable through observation. There is a hierarchy of building materials from mud (udongo) or mud and coral stones (gavipande vipande) to coral block or cement. Coconut thatch (makuti) is the roofing material of choice for low and middle income housing, and corrugated iron (mabati) and tiles (vigae) are more often seen in high income households. Information on housing materials was collected on the household survey forms and a composite indicator could be created using a scoring system as follows:

walls: mud or mud with coral stones = 1
walls: coral blocks or cement = 2
roof: thatch (*makuti*) = 0
roof: corrugated iron (*mabati*) or tiles = 1

This would give the following breakdown of income level by housing material:

Income Level	Score	Description
High	3	coral blocks or cement and *mabati* or tile
Medium	2	mud or mud with coral stones and *mabati* or tile
	2	coral blocks or cement and *makuti*
Low	1	mud or mud with coral stones and *makuti*

The scoring system might have to be changed if too many of the households fall into one of the categories to allow for analysis. One disadvantage of using housing materials as an indicator in this study area is that some of the households in the Mvindeni resettlement scheme have other homes in Ukunda. The Mvindeni homes, as farm or *shamba* houses, may not accurately reflect the family's overall wealth.

(7) Subjective Evaluation

We chose to use subjective evaluation of the households by the fieldworkers as high, medium or low income for the household survey. These judgements were based on housing materials and condition; the mother's dress; household items that were visible - or sometimes, in the case of radios, audible; and information available to the fieldworker as a member of the community on occupation, cash crops, other holdings etc. The advantage of this system is that it includes many inputs, some hard to otherwise quantify, and weighs them together without endless formulas or scoring systems. The obvious disadvantages are the subjectivity of the final ranking and the problems of inter and intra fieldworker variation.

In order to come up with better approximations of income it would be necessary either to spend a lot of time with each household collecting a vast amount of information on sources of income and expenditure, or to study enough households in depth to determine which of the above mentioned or other proxy indicators are most reliable.

APPENDIX III

Notes on Kidigo and Glossary of Terms in Kidigo and Kiswahili Relating to Water, Sanitation, and Schistosomiasis

A. Notes on Kidigo for Kiswahili Speakers

While it has been impossible to do more than scratch the surface of an analysis of Kidigo in two months, the following may give a Kiswahili speaker some insights into some of the ways Kidigo differs from Kiswahili.

In general, the Kidigo language is even more melodic and softer than Kiswahili. The consonant sounds "ts," "z", "ph" and "ch" are more common than in Kiswahili and the overall effect is to give the language a soft, buzzing sound. Many of the nouns in Kidigo are the same as in Kiswahili and thus cause no problem. Some words are similar but with slight consonant changes, and others are completely different. Verb structure is like that of Kiswahili in that the subject pronoun and tense marker precede the verb stem, but the subject pronouns and tense markers themselves are different. Mixing Kidigo nouns into a sentence spoken in Kiswahili has a jarring effect on the listener. I'm not sure whether this is because the Wadigo are so surprised to hear an outsider speaking in their dialect, or because the two languages are just not mixed. The result is usually either laughter or a look of total bewilderment and communication is disrupted.

Unless someone intends to work in the area for a long time and has a great facility for languages it might be best to learn enough nouns to understand Kidigo when it is spoken and use Kiswahili when speaking. It is worthwhile to learn the Kidigo greetings which are very important culturally and very much appreciated when used. These are often specific for sex, number, age, status (amount of respect to be shown), and sometimes time of day. The pecking order for status by sex and age is roughly: old men, old women, adult males, adult females, children. A very short list of greetings follows:

1. Salamaliku - Most common greeting, used for greeting usually more than one person of equal status. (Usually man to man). Response is "salama, manyauwe" (fine, and you?).

2. Shikamo - also used in Kiswahili. This is a greeting of respect used for an mzee (old man), bimkubwa (old woman), teacher, or anyone whose status is high. Children use this greeting with all adults, but especially with men. Response is "marahaba". This response is very important and must be used in reply to avoid offending the person greeting you with "shikamo." More than one mzee or bimkubwa can be greeted with the plural greeting "shikamoni."

3. Usikiradze (plural msikiradze) or uonadze (plural monadze) - greetings used with women or children (same or lower status) casually. Response is "salama manyauwe" or just "salama".

4. Uviphi (plural mviphi) - greeting for men, women or children. This greeting is very difficult to pronounce because of the "ph" sound which is different from any found in English. The best approximation is a breathy "pth" sound. Response is "salama."

5. Sibankheri - used to greet men or a single man. Response is "salama."

6. Ukalamukadze (plural mkalamukadze) - "good morning". Greeting used for equals and people of lower status--or even people of higher status after "shikamo" has been used. Response again is "salama."

7. Usindaze (plural msindaze) - "Good afternoon" used as ukalamukadze (above).

Examples of Changes from Kiswahili to Kidigo

Change	English	Kiswahili	Kidigo
1. Emphasis put on different syllable	ladle	mkópo	mpokó
2. Change "k" to "ch"	well	kisima	chisima
	schistosomiasis	kisonono	chisonono
3. Dropping a "w"	a few people	watu wachache	atu achache
	marsh	ziwa	zia
4. Add an "r" or "l"	path	njia	njira
	rain	mvua	mvula
5. Change "l" to "r"	two	mbili	mbiri
	monkey	tumbili	tumbiri
6. Change "j" to "dz"	the other day	juzi juzi	dzuzi dzuzi
	urine	mikojo	mikodzo
7. Change another consonant for "ph"	place	mahali	phahali
	to cure	kuponya	kuphoza

These are not all the common changes and they are not consistently made. The word for symptom for example is dalili in both Kiswahili and Kidigo and doesn't make the expected change in Kidigo to daliri. Because of these irregularities, Kidigo might be easier to learn if one didn't already have a grounding in Kiswahili.

As noted earlier, while the general design for forming verbs is basically the same in Kiswahili and Kidigo (subject pronoun, tense marker, object pronoun, verb stem) the constituents themselves are often different in the two languages. In the past tense there is also a shift in the order of subject pronoun and tense marker in Kidigo. The 1st-3rd person singular and plural of the regular Kidigo verb *kumanya* (to know) are given below for the present tense:

nnamanya	1st person singular	unamanya	1st person plural
unamanya	2nd person singular	unamanya	2nd person plural
anamanya	3rd person singular	anamanya	3rd person plural

The future and past tenses have not only different tense markers, but also change irregularly in the negative. For example, *nndamanya* (I will know) changes to *sinndamanya* (I will not know), while *mndamanya* (you, plural, will know) goes to *tamndamanya* (you, plural, will not know). As a result Kidigo seems much more complex than standard Swahili.

B. Terminology for Urinary Schistosomiasis in the Study Area

There is some confusion in the terms used in Kidigo for schistosomiasis. Part of this problem stems from the confusion of the disease with gonorrhea, with which it shares the symptom of painful urination. In some parts of coastal Kenya and Tanzania, *kisonono* is used for gonorrhea and *kichocho* is used for schistosomiasis (still called bilharzia locally in English). In the study area people used either term for urinary schistosomiasis, but they changed the "k" sound in Swahili word *kisonono* to a "ch" in Kidigo (*chisonono*). *Chisonono* was more commonly used than *kichocho*. Some people said that when the symptoms are more severe, the term *chisonono* is used rather than *kichocho*, but this was not widely agreed upon.

The term gonorrhea locally is *tego* and is supposedly derived from the verb *kutega*, "to trap." Before gonorrhea was known to be sexually transmitted, it was believed to be caused (as many diseases still are) by someone having successfully put a spell on a person, thus trapping them. The term *chisonono* was used in the survey interviews and seemed not to be confused with gonorrhea, as most people gave the main symptom as blood in the urine, and no one mentioned discharge of pus or sexual transmission. Care should be taken to make sure the correct term is found as there seems to be great variation in use over a relatively small geographic area. According to a local health educator, the Duruma, a tribe which lives inland from the Wadigo, use the word *chapicho* for urinary schistosomiasis.

C. Glossary - Water, Sanitation, and Schistosomiasis

The following is a short glossary of some useful terms in Kidigo and Kiswahili relating to water, sanitation, and schistosomiasis.

English	Kiswahili	Kidigo
Water Source	Mwnamopatikana Maji	Mnamopatikana Madzi
well	kisima	chisima
piped home	mfereji wa nyumbani	mfereji wa kaya
piped kiosk	mfereji wa kibandani	mfereji chibandani
cart	mkokoteni	mkokoteni
hole	shimo	dibwa
marsh	ziwa	zia
rain water	maji ya mvua	madzi gamvula
spring	chemichemi	chemichemi
pump	pampu	pampu
Water Uses	Matumizi ya Maji	Matumizi Gamadzi
drinking	ya kunywa	gakunwa
cooking	ya kupikia	gakubiira
washing dishes	ya kuosha vyombo	gakutsukutsira vyombo
washing clothes	ya kufua	gakufurira
bathing	ya kuoga	gakuoga
playing	ya kucheza	gakuvumba
ablution	ya kutawadha	gakutawaza
to draw	kuvuta	kunweka
to carry	kuchukua	kutsukula
to use	kutumia	kutumia
Schistosomiasis	Kichocho	Chisonono
to cause	kutenda	kuhenda
symptoms	dalili	dalili

English	Kiswahili	Kidigo
to treat	kutibu	kulagula
to cure	kuponya	kuphoza
local doctor	mganga	mganga
local medicine	dawa za kienyeji	dawa za kaya
to prevent	kukinga	kudzikinga
urine	mikojo	mikodzo
to urinate blood	kukojoa damu	kukodzola damu
to burn or itch	kuwashwa au kuteketea	kuawiwa ama kuphia
sugar cane	muwa	mua
sugar	sukari	sukari
pepper	pili pili	mwatsaka
Latrines	Vyoo (singular choo)	Vyoo
to urinate	kukojoa	kukodzola
to defecate	kunya	kunya
to dig	kuchimba	kutsimba
sand	mchanga	mtsanga
rocks	mawe	mawe
preschool children	watoto wadogo	anache adide
school children	watoto wa shule	anache askuli
adults	watu wazima	atu azima
to dig small hole	kuchimba shimo dogo	tsimba dibwa dide
the bush	pori	vue
the forest	msitu	tsaka

D. Notes on the Health Education Sessions

Two health education sessions were held, one at Galu School for teachers and students on the afternoon of 29 March and a second at Mvindeni School for students, teachers and parents on the morning of March 30.

The basic program for both sessions was as follows:

(1) Introduction of speakers by school officials.

(2) Summary of what the project had accomplished by Dr. Stephenson.

(3) Life cycle of schistosomiasis by T. Elliott.

(4) Questions on life cycle and discussion of How to Prevent Schistosomiasis led by T. Elliott.

(5) Life Cycle of Hookworm by Dr. S. Kinoti.

(6) Questions on Life Cycle and Discussion on How to Prevent Hookworm led by Dr. S. Kinoti.

(7) Summary of Prevention Ideas and Demonstration of Blood Loss - Dr. M. C. Latham.

(8) Closing by school officials.

In the Mvindeni session a health educator from the area presented the schistosomiasis life cycle.

Questions asked about schistosomiasis were:

(1) If people wear shoes in the water can they still get it?

(2) Can the parasites enter skin of the arms or upper body as well as the feet and legs?

(3) Can you get it by drinking water with the parasites?

(4) Can cows get it from marsh water?

(5) Can people get it from the puddles that form in the long rains?

(6) Can people get it from standing in urine of someone who has the disease?

(7) Can people get it from water holes?

A common misconception is that schistosomiasis is caused by eating peppers, sugar cane or too much sugar.

The ways the audience suggested to prevent getting schistosomiasis were:

(1) Don't go in the marshes.

(2) Don't urinate in the marshes.

To these the health educator added that people with blood in their urine should go to the hospital for early treatment to avoid spreading the disease.

Questions asked about hookworm were:

(1) Can you keep from getting it by wearing shoes?

(2) When you talk of blood loss is it volume or quality?

A common misconception was that hookworm can be gotten from eating coconuts. There was also confusion about the different types of worms that people get.

The ways to prevent getting hookworm suggested by the audience were:

(1) Use latrines.

(2) Wear shoes.

Additional comments:

(1) The children seemed fascinated by visual aids, either drawings to explain points or the color stick chart pictures used by the health educator.

(2) The demonstration of the amount of blood lost over a year which was done using red dyed water was very well received.

(3) Kiswahili for the presentations seemed to be fairly easily understood.

(4) It is important to keep the messages to a minimum. At the second session, explanations of the different kinds of other worms and unplanned information by the health educator diluted the main messages on hookworm and schistosomiasis.

(5) The issue of partial measures to prevent the diseases arose but was not satisfactorily resolved. Technically, it is probably better for people using marsh water for bathing to do so standing outside of the marsh. Should this be mentioned or is it better to only say that marsh water shouldn't be used for bathing? Localizing the area used for excreta disposal or telling people to bury stools in small holes would probably reduce the spread of hookworm. Should this half measure be mentioned or is it better to insist on use of pit latrines?

E. Notes on the World Bank Safe Water Project (from a conversation with a local health educator)

The World Bank Safe Water Project was developed in response to the 1981 cholera outbreak in the South Coast area. It has KS 3 million from the Swedish government and an additional KS 1 million from the Ministry of Water Development. The area to be covered is part of Msambweni Division - from Ukunda south to the Ramisi River and from the sea inland to where the power line posts were constructed to go to Tanzania. Funzi Island is also included. The project has three components: water supply, sanitation, and health education. The water supply component will protect existing sources (mainly deep water wells), expand existing piped water systems (Ukunda and Msambweni), and drill new bore holes in the area. The sanitation component will encourage the local inhabitants to build ventilated pit latrines, and the health education component will educate people on water related disease and the needs for protected water supplies and pit latrines.

The protecting of deep water wells was started with a survey of the area which located 106 wells. It was then decided only to cover and install pumps in those with a top diameter of two meters or less. The number of wells meeting this criterion is 53, including the well at Mwamuwa in the southern part of the study area. Two hundred pumps are to be supplied by a Mombasa firm. At each pump site a local committee of two men and two women is chosen to learn how to maintain and repair the well. There is no other provision for maintenance. Twenty wells will be covered initially with the remaining 33 to follow. All work has been stopped at the time of this writing (April 1983) by the government order to suspend all development projects pending a budget review.

The expansion of existing piped water supply will be done in Ukunda and in Msambweni, which presently has a piped water system run from a bore hole pump. In Ukunda the piped water will be extended as far south as the Youth Center. The remaining 147 pumps will be used with bore holes which are mainly to be drilled based both on where people already go to get their water and on the work of a World Bank geologist who has surveyed parts of the area. The bore holes will be about 30 meters deep. Every school in the project area will get a bore hole pump. This work was originally scheduled to begin in March 1983.

The sanitation component's main thrust is ventilated pit latrines which have a long pipe from the pit to the roof to draw off odors. The problems of digging pits in solid coral and pits dug in sand collapsing have not been given primary consideration. The health educator suggests the use of old oildrums (mapipa) to keep latrines dug in sand from collapsing and hard work to dig the ones in coral. Oildrums cost KS 25-30/- each and about 20 would be used for one latrine at a cost of KS 500-600/-.

The third component, health education, is being done first through the local health technician. The World Bank has supplied Collier MacMillan stick board sets with stick-on pictures depicting symptoms and life cycles of water related diseases. The set currently being used is from Egypt but plans are underway to make another set that will more closely resemble coastal Kenyan people.

F. Notes on the Kenyan Japanese Medical Cooperation Work on the South Coast (from a conversation with a local health educator)

The Kenyan Japanese Medical Cooperation Project was started in 1980, with staff working out of the Tiwi health training center. Their main interests are cholera, dysentery, schistosomiasis and Shigella. They do not work on any other parasitic diseases. Their work has included water testing of deep water wells (only one of these has been found to have cholera, and that in Ramisi) and they have a project to drill bore holes and supply pumps for four housing camps on the Ramisi estate. Another project they are planning is to provide piped water to an area with schistosomiasis near Kinonyo called Muachinga. The water will come from the main pipeline that brings water to Mombasa from Marere.

APPENDIX IV

SCHISTOSOMIASIS-NUTRITION STUDY
HOUSEHOLD SURVEY FORM
(ENGLISH TRNASLATION)

Date____________ Time______

Interviewer________________

I. Identification Information

1. Child's name
2. Father's name
3. Mother's name
4. Children from this home in school______________________Std___

______________________Std___

______________________Std___

______________________Std___

5. Person interviewed____

II. Knowledge and Attitudes - Schisto

1. How does a person get schisto?
   - 1) by eating peppers
   - 2) by eating sugar or cane
   - 3) drinking dirty water
   - 4) walking in, standing in dirty water
   - 7) doesn't know
   - 8) other
2. What are the symptoms of schisto?
   - 1) urinating blood
   - 2) itching/burning sensation
   - 3) urinating blood and itching/burning
   - 4) urinating pus
   - 7) doesn't know
   - 8) other
3. How can schisto be treated?
   - 1) hospital or doctor
   - 2) home medicine
   - 3) stop eating sugar or pepper
   - 4) local doctor
   - 7) doesn't know
   - 8) other
4. Are there home medicines for schisto? 0) there aren't 1) there are
5. Do these medicines cure?
   - 0) they don't cure
   - 1) they do cure
   - 2) sometimes they cure, sometimes not

Child's ID

6. How are you able to prevent schisto?
    1) don't eat a lot of pepper
    2) don't eat a lot of sugar
    3) stop eating lots of pepper and sugar
    4) boil water
    5) don't stand or walk in dirty water
    6) there is no way to prevent it
    7) doesn't know
    8) other
7. How many people live in this house?

Adults ______

Children ______

III. Water Sources

1. Source codes
    1) well
    2) water hole
    3) spring
    4) marsh
    5) pump
    6) purchased at tap
    7) tap in home
    8) other
    9) men with carts
    10) rain water

	Dry season		Wet season	
	place			
Use	1	2	1	2
drinking				
cooking				
washing dishes				
washing clothes				
bathing				

2. How long does it take you to get water?
    1) no time, it is delivered
    2) <15 min.
    3) 15 min. but <1/2 hour
    4) 1/2 hr. or more
3. What quantity of water do you use each day at this home?
    1) one container or less
    2) 2 or 3
    3) 4 or 5
    4) 6 or 7
    5) >7

IV. Water Contact

1. Does this child bathe in the marsh? ______

Wash clothes? ______

0) No

Draw water? ______

1) Yes

Play? ______

Do anything else? ______

V. Choo (latrine)

1. Does this house have a latrine?
   1) Yes, their own
   2) No, there is none
   3) they use someone elses
   8) other
2. What do preschool children use?
3. What do school children use?
   1) latrine
   2) the bush
   3) they dig a small hole
   4) they go here--someone takes it to the latrine
   5) other

VI. Housing/Income

1. What material was used to make the walls of this house?
   1) mud
   2) small stones w/ mud
   3) coral blocks
   4) cement
   8) other
2. Roofing material?
   1) thatch
   2) galvanized steel
   3) tile
   8) other
3. Income level?
   1) low
   2) medium
   3) high

Comments ____

____

____

APPENDIX IV, cont.

SCHISTOSOMIASIS-NUTRITION STUDY
HOUSEHOLD SURVEY FORM
(KIDIGO VERSION)

Date____________ Time______

Interviewer_________________

I. Identification Information

1. Dzina ra mwanache______________________ Std___ ID#___
2. Dzina ra baba____
3. Dzina ra mayo____
4. Anache akaya hiyo arioskula______________________ Std___
   ______________________ Std___
   ______________________ Std___
   ______________________ Std___
5. Mtu achiyehojiwa_______________________________________

II. Knowledge and Attitudes - Schisto

1. Atu apatadze chisonono?
   1) kwa kurya mwatsaka
   2) kwa kurya sukari ama miwa
   3) kunwa madzi machafu
   4) kunyendeka, kuima kwenye madzi machafu
   7) kamanya
   8) njira zanjina__________________
2. Dalali za chisonono nziphi?
   1) kukodzola damu
   2) kuawiwa
   3) kukodzola damu na kuawiwa
   4) kukodzola usaa
   7) kamanya
   8) njira zanjina__________________
3. Chisonono chinaweza kulagulwa viphi?
   1) sipitali ama dakitari
   2) dawa zachikaya
   3) kusitorya sukari ama mwatsaka
   4) mganga
   7) kamanya
   8) njira zanjina______________
4. Kuna dawa zachikaya zachisonono?
   0) takuna
   1) zikuko
5. Dawazino zinaphoza?
   0) taziphoza
   1) zinaphoza
   2) saa zinaphoza, saa taziphoza

ID ra mwanache

6. Dze, unaweza kudziepusha viphi na chisonono?
   1) kusirya mwatsaka munji
   2) kusirya sukari nyinji
   3) kusitorya sukari nyinji na mwatsaka munji
   4) chemsha madzi
   5) kusima ama kusinyendeka kwenye madzi machafu
   6) takuna njira kudziepusha
   7) kamanya
   8) njira zanjina________________________________

7. Atu angaphi anasagala nyumba hino? Atu azima_____

Anache _____

III. Water Source

1. Source codes
   1) chisima
   2) madibwa
   3) chemichemi
   4) mazia
   5) pampu
   6) kulunga mfereji
   7) mfereji wakaya
   8) njira zanjina
   ____
   9) achina mikokoteni
   10) madzi ya mvula

	wakati wa dzuwa		wakati wa mvula	
	phahali			
	1	2	1	2
kunwa				
kubiira				
kutsukutsira vyombo				
kufurira				
kuoga				

2. Inatsukula mudagani kulunga madzi?
   1) tahihala muda manamtu nkugareha
   2) kabla dakika kumi na tsano
   3) zaidi ya dakika kumi na tsano lakini tafika nusu saa
   4) nusu saa ama zaidi

3. Kiasi gani cha madzi mnahumira kila siku hiva kaya?
   1) chia cha kuhekera madzi chimwenga ama kupungua
   2) via viiri ama vihahu
   3) via vinne ama vitsano
   4) via sita ama saba
   5) zaidi ya via saba

IV. Water Contact

1. Mwanache hiyu n'kuoga maziani? _____

kufula nguo _____

kuheka madzi _____

kuvumba madzi _____

au kuphiya kwa mambo ganjina? _____

0) taphiya

1) nkuphiya

V. Choo

1. Kaya phana choo?
   1) ndiyo, choo enye
   2) Hata taana choo
   3) anahumira chaphamwenga na atu anjina
   8) phahali phanjina ______________________________
2. Anache adide anahumirani?
3. Anache ya skuli anahumirani?
   1) choo
   2) vue
   3) n'kutsimba dibwa dide
   4) hiphahipha, mtu wanjina n'kugatia chooni
   8) phahali phanjina ______________________________

VI. Housing, Income

1. Vitu virivyohumirwa kudzengerwa makuta ganyumba?
   1) udongo
   2) mawe gavipandevipande
   3) mawe ga kutsonga
   4) simiti
   8) vitu vyanjina ______________________________
2. Vitu vyakuezekera?
   1) makuti
   2) mabamba
   3) vigae
   8) vitu vyanjina ______________________________
3. Chipato chakukisiya?
   1) tsini
   2) kanhikanhi
   3) dzulu

COMMENTS ______________________________________

____

____

APPENDIX V

SCHISTOSOMIASIS NUTRITION PROJECT

Tribe ____________________

Primary school ____________________

Child's ID ____________________

Father's name ____________________

Child's names ____________________

Mother's name ____________________

Child's birthdate (mo,yr) ____________________

Siblings' names, sex, stds ____________________

Clinical and anthro exam date	Pre-exam	Exam 1	Exam 2	Exam 3
date (decimal)				
standard,teacher				
STOOL collected, date, initials				

ANTHROPOMETRY

Arm circumference, cm.			
Height, cm.			
Weight, Kg.			
Subscapular, mm.			
Triceps skinfold, mm.			

How do people get bilharzia? ____________________

Is there any way to keep from getting bilharzia? How? ____________________

COMPLAINTS

Dysuria now:
ever:

Hematuria now:
ever:

MEDICATIONS NOW?			
Ever treated for bilharzia? (details)			
CLINICAL EXAM: PUBERTY SIGNS (specify)			

EYES	1. xerosis conjunctivae	- +	- +	- +
	2. Bitots spots	- +	- +	- +
	3. corneal xerosis or scarring (state)	- +	- +	- +
	4. conjunctivitis	- +	- +	- +
	5. other (specify)			
	6. EARS (specify)			
MOUTH	7. angular stomatitis	- +	- +	- +
	8. angular scars	- +	- +	- +
	9. cheilosis of lips	- +	- +	- +
	10. no. decayed teeth			
	11. no. missing teeth			
	12. no. filled teeth			
	13. mottling of teeth	0 1 2 3	0 1 2 3	0 1 2 3
	14. other (specify)			
	15. GLANDS (specify)			
SKIN	16. follicular hyperkeratosis	- +	- +	- +
	17. scabies/fungal infections	- +	- +	- +
	18. other (specify)			
INTERNAL	19. hepatomegaly (F.B.)			
	20. splenomegaly-Hackett			
	21. other (specify)			

OTHER CONDITIONS (specify)

APPENDIX VI.

Water Sources Used in Dry and Wet Seasons by Purpose - Number of Households (n = 85)

	DRY SEASON					WET SEASON				
	Drink	Cook	Dishes	Clothes	Bathe	Drink	Cook	Dishes	Clothes	Bathe
Well	63	64	64	64	65	55	45	32	22	25
Tap	7	8	8	8	8	6	3	3	2	2
Carts	6	4	4	3	3	5	5	4	2	3
Water hole	4	4	4	5	4	7	7	7	6	7
Spring	1	1	1	1	1	0	0	0	0	0
Rain	0	0	0	0	0	10	22	35	49	44
Marsh	0	0	0	0	0	1	2	3	3	3
Carts & tap	1	1	1	1	1	0	0	0	0	0
Carts & well	1	1	1	1	1	1	0	1	1	0
Rain & well	0	0	0	0	0	0	1	0	0	1
Water hole & spring	1	1	1	1	1	0	0	0	0	0
Well & carts	1	1	1	1	1	0	0	0	0	0

Collapsing of categories:

uncollapsed	collapsed to:	uncollapsed	collapsed to:
well well & carts	well	rainwater rainwater & well	rainwater
water hole spring water hole & spring	water hole/spring	marsh	marsh
tap carts carts & tap carts & well	tap/carts		

APPENDIX VI Water Sources Used in Dry and Wet Seasons by Purpose - *S. haematobium* Infected and Uninfected Groups (n = 105)

DRY SEASON	Number of Children									
	Drink		Cook		Dishes		Clothes		Bathe	
	pos	neg	pos	neg	pos	neg	pos	neg	pos	neg
well	39	44	38	46	38	46	39	45	39	46
tap	4	3	5	3	5	3	5	3	5	3
carts	3	3	3	1	3	1	2	1	2	1
water hole	2	2	2	2	2	2	2	3	2	2
spring	1	0	1	0	1	0	1	0	1	0
rain	0	0	0	0	0	0	0	0	0	0
marsh	0	0	0	0	0	0	0	0	0	0
carts & tap	1	0	1	0	1	0	1	0	1	0
carts & well	1	0	1	0	1	0	1	0	1	0
rain & well	0	0	0	0	0	0	0	0	0	0
water hole & spring	0	1	0	1	0	1	0	1	0	1
well & carts	0	1	0	1	0	1	0	1	0	1

WET SEASON	Drink		Cook		Dishes		Clothes		Bathe	
	pos	neg	pos	neg	pos	neg	pos	neg	pos	neg
well	34	39	27	33	23	20	18	15	17	18
tap	3	3	0	3	0	3	0	2	0	2
carts	3	2	5	0	4	0	2	0	3	0
water hole	4	3	4	3	4	3	4	2	4	3
spring	0	0	0	0	0	0	0	0	0	0
rain	6	6	12	14	17	26	24	33	24	29
marsh	0	1	2	1	2	2	2	2	2	2
carts & tap	0	0	0	0	0	0	0	0	0	0
carts & well	1	0	0	0	1	0	1	0	0	0
rain & well	0	0	1	0	0	0	0	0	1	0
water hole & spring	0	0	0	0	0	0	0	0	0	0
well & carts	0	0	0	0	0	0	0	0	0	0

Sample sizes: Sh pos = 51, Sh neg = 54