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Piped water supply and intestinal parasitism in Zimbabwean schoolchildren

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Abstract

The prevalence of intestinal parasitism in primary schoolchildren in three areas, communal (peasant farm) lands, commercial farms and urban townships, was assessed by examination of concentrated and stained stool specimens to determine the effect of water supply on intestinal parasitism. Piped water in communal lands was associated with decreased frequency of schistosomiasis and hymenolepiasis, but not with decreased frequency of protozoa. Schistosomiasis was very common in commercial farm labour communities, particularly on farms adjoining the local river, despite the availability of stored borehole water supplied through communal taps. The prevalence of intestinal parasitism in children from urban areas with municipal water supplied to taps in each household was similar to that of children in communal areas who obtained water from surface streams. The frequency of *Giardia lamblia* infection was higher in urban than in rural schoolchildren, and within communal areas was higher in children with access to protected borehole water. The provision of piped water was, therefore, not found to be associated with reduced prevalence of intestinal parasitism, though additional factors such as frequency of contact with infected water, the provision of ancillary improvements and the actual usage of available water supplies would need to be more closely assessed.

Introduction

Provision of a piped water supply and improved sanitation facilities are regarded as an essential part of primary healthcare programmes in developing countries. While many studies have claimed to show improved health status resulting from such provisions a recent review (BLUM & FEACHEM, 1983) has cast doubt on the validity of their conclusions. FEACHEM, *et al.* (1983a) have suggested that helminth infections are more sensitive to improvements in sanitation facilities than are other intestinal organisms, and comparisons of helminth prevalence may therefore be a reliable indicator of the impact of these improvements on the health status of a community. In a recent study in urban centres in Africa improved excreta disposal facilities were not found to have a marked impact on intestinal parasitism (FEACHEM *et al.*, 1983b).

Although other factors may be of importance, the provision of piped water would also be expected to be associated with reduction of parasite prevalence, particularly where transmission is influenced by contact with infected water or poor hygiene or where the parasite is water-borne.

For some parasitic infections, local environmental modifications which may accompany the provision of piped water can have a greater impact than piped water itself. The prevalence of schistosomiasis, for example, is influenced by the degree of contact with infected surface water, and control of this disease was more effective in St. Lucia (JORDAN *et al.*, 1978) where safe swimming pools were provided in addition to piped water, than in South Africa (WALKER *et al.*, 1970) where piped water was available, but children still used local rivers for recreation. Nevertheless, for most faecally-transmitted parasites, the provision of piped water, with increased opportunities for hand washing and decreased opportunities for contamination of water supply, would be expected to result in a reduced prevalence of these organisms in a community.

This study was undertaken to provide information on three questions of importance in Zimbabwe as a developing African country with an active water-development programme: (i) is the provision of piped water in rural areas associated with a decrease in intestinal parasitism? (ii) to what extent does proximity to sources of infected water influence intestinal parasitism, even when piped water is supplied? (iii) is the provision of water via individual household taps rather than communal taps associated with a significant decrease in intestinal parasitism?

Materials and Methods

Study area and population

Because of the relative ease of collecting specimens, the study was restricted to children, aged 6 to 18 years, all attending primary schools in the study areas. The children were asked about the source of water in their home where this was at all doubtful, but they were not asked about the usage made of the facilities that were available. Wherever possible, reports of water supplies were verified by observation in home areas. No specific questions were asked about sanitation facilities or socio-economic status, but as far as possible comparisons were made between children from villages geographically close to each other and with similar facilities. Data on the nutritional status of the children was also obtained and will be presented in a separate paper. The age and sex of each child was recorded from school records, where these were available.

For information on the effect of piped water in rural areas, two schools in villages in Chiweshe communal land, a peasant farming area north of Harare, was surveyed. The villages were about 20 km apart, and while one (253 children) had for a number of years been supplied with borehole water distributed via communal taps, the other (413 children) had no piped water supply, all water being obtained from a surface stream or shallow unprotected wells.

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In order to determine the effect of proximity to an infected water source, schoolchildren on four commercial farms in the Mazoe valley north-east of Harare were included. Two of the farms (169 children) were bounded by the Mazoe river, while two adjacent farms (90 children) were separated from the river by a main road and farmland. On all four farms borehole water was available from communal taps, with about one tap for 50 people.

The influence of individual taps were made by examining specimens from children in the small urban centres of Bindura and Chinhoyi (total 480 children), each of which have municipal water supplied to indoor taps in each house. Bindura lies to the east and Chinhoyi to the west of the rural study areas.

Specimens

After explaining the nature of the study, all children in the classes visited were asked to provide a small sample of faeces in a plastic pot. Over 90% compliance with this request was achieved during the course of the visit, though no attempt was made to authenticate the origin of the samples.

All specimens were transported to the laboratory for processing on the day of collection. Thin smears of each sample were fixed overnight in Schaudinn's solution and stained using trichrome stain (WHEATLEY, 1951). A sample of each specimen was concentrated by the formol-ether technique (ALLEN & RIDLEY, 1970) and examined microscopically.

As a reliability check a random sample of 161 specimens (11·4% of total) was examined independently by two microscopists and the results compared. Further comparisons were made between concentrated and stained-smear examinations.

Statistics

Comparisons of the prevalence of parasites in the various communities were made using chi-squared test.

Results

Reliability and Validity of Recorded Data

In schools in communal farm lands and urban areas there were reasonably well documented records of the ages of children. On commercial farms, however, such records were not always available, and the age was recorded only when the stated age could be corroborated by other family members, the teacher or the farm owner. The validity of the stated ages is, nevertheless, open to doubt.

Where possible, the availability of piped water to the community where the children were living was confirmed by personal observations. Piped water in the communal areas was obtained from deep boreholes and stored in enclosed galvanized iron tanks before distribution via taps. The supply had been available for over six years before the study, and there were 12 taps serving a population of about 500 villagers. On the commercial farms piped water was obtained and stored as in communal areas, with about one tap for 50 people. In the urban areas river-water was sand-filtered and chlorinated before distribution to taps in each household.

Age and Sex

The two groups in the communal lands, those with and without piped water, were comparable with regard to both the sex and ages of the children. There were slightly more girls than boys (male: female ratio 1:1·2 and 1:1·4 in communities with and without piped water respectively) as was also the case in the urban schools (male: female ratio 1:1·3). Commercial farm schools, however, were very different with some having mainly boys and some mainly girls. In schools adjacent to the river the male:female ratio was 1:2·1, while in those away from the river it was 1:0·5.

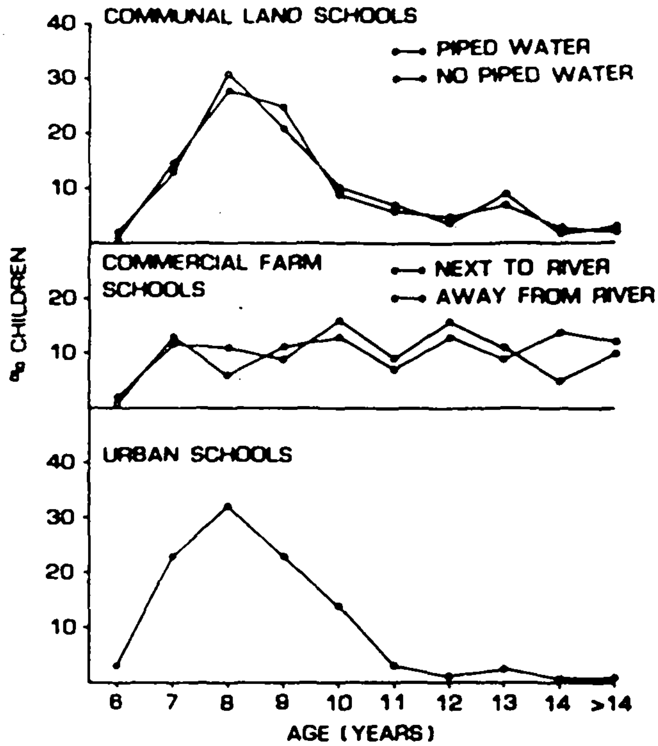

Fig. 1. Age distribution of children in schools in communal lands, commercial farms and urban areas.

Although the age range was very wide (6 to 18 years), over 60% of all the children sampled were aged seven to nine (Fig. 1). The over-all pattern of age distribution in communal land and urban schools was very similar. On commercial farms, however, the pattern was different, with no marked peak age in the group sampled, and with older children forming a higher percentage of the sample population. Reference has already been made to the questionable reliability of age data from these farms.

Reliability of Laboratory Data

Agreement between the two microscopists on the 161 specimens examined independently was achieved in 93% of cases. Discrepancies occurred in most instances when one microscopist but not the other observed a single helminth egg in a specimen. More serious discrepancies were noted between the results of concentrated and stained smear examinations. *Entamoeba coli* was found in concentrates but not in stained smears in 28·5% of cases where these cysts were found by either examination, usually because only a few cysts were present. *Giardia lamblia* cysts were identified in stained smears, but not concentrates in 26·1% of positive specimens. Mis-identification of other protozoan cysts in concentrates occurred frequently.

The results presented here are therefore from concentrates for helminth eggs and *E. coli* cysts, and from stained smears for other protozoa. It should be noted that the results are from single stool specimens only, and may therefore underestimate the true parasite burden of the communities surveyed.

Parasite prevalence

Apart from schistosomiasis and *Hymenolepis nana*, specific helminth infections occurred in less than 1% of children (Table I), in some cases (for example *Strongyloides*) being found in children from only one school. Thus, comparisons of helminth prevalence were only made with *Schistosoma* sp. and *H. nana*.

Protozoan infections occurred more frequently (Table II), with 70% of the children harbouring at least one such parasite. Because of their pathogenic importance, particular note was taken of *G. lamblia* and *E. histolytica* which occurred in 17·7% and 5·7% of children respectively.

Schoolchildren living on commercial farms had a significantly higher prevalence of intestinal parasites than children from communal or urban areas ($p < 0{\cdot}01$). Although this was true for both helminths and protozoa, in the case of *G. lamblia* the prevalence in urban areas was significantly higher than in rural areas whether communal or commercial ($p < 0{\cdot}01$).

Parasite prevalence in relation to sex and age

The only parasite showing a higher prevalence in relation to the sex of the host was *E. histolytica* which was found in 54/648 (8·3%) males and 26/757 (3·4%) of females ($p < 0{\cdot}001$).

Schistosome infections were found most commonly in the 10 to 12 year age groups, while dwarf tapeworm infections were found with more or less equal frequency whatever the age (Fig. 2.). Amongst the protozoa there was no marked relationship between age and prevalence of infection over the age range studied. An apparently high prevalence of giardiasis in very young children was probably a result of the small sample size, only 16 children being recorded as six years old in the school records.

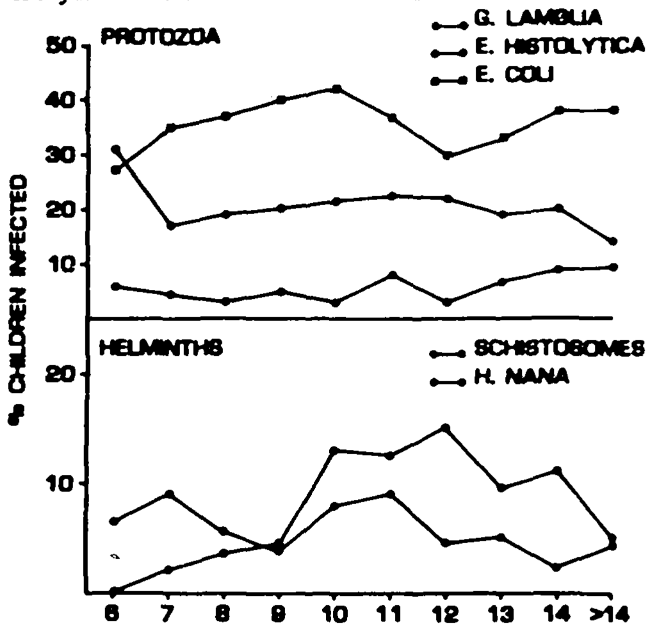

Fig. 2. Incidence of helminth and protozoan infections in schoolchildren from all areas. Helminth data shows schistosome and *H. nana* infections only as other helminths were rarely found. Protozoa data shows *E coli*, *E. histolytica* and *G. lamblia* only. Other protozoa, omitted for clarity, showed no peak age incidence.

Table I—Prevalence of intestinal helminths (%) in schoolchildren from the three study areas.

	Communal lands	Commercial farms	Urban areas	Total
S. mansoni	3·3	15·4	4·8	5·9
S. haematobium	2·9	1·5	0·2	1·7
H. nana	4·4	8·5	8·8	6·6
Hookworm	0·2	0·8	1·7	0·8
Taenia sp.	0·3	0	0·8	0·4
Strongyloides sp.	0	0	0·4	0·1
No helminths	90·9	74·9	85·2	85·3
N	666	259	480	1405

Table II—Prevalence of intestinal protozoa (%) in schoolchildren from the three study areas

	Communal lands	Commercial farms	Urban areas	Total
G. lamblia	14·9	16·6	22·1	17·7
E. histolytica	4·1	10·8	6·1	5·7
E. coli	36·2	46·7	34·8	37·7
E. hartmanni	1·1	1·5	1·5	1·3
I. buetschlii	4·8	14·7	4·4	6·5
E. nana	15·3	18·9	12·9	15·2
C. mesnili	4·1	10·8	5·4	5·8
No protozoa	33·8	10·4	35·2	30·0
N	666	259	480	1405

Table III—Intestinal parasite prevalence (%) in children from communal lands

	No piped water supply	Piped water supply
S. mansoni	4·8	0·8
S. haematobium	4·4	0·4
H. nana	6·0	3·2
No helminths	87·4	96·8
G. lamblia	11·6	20·2
E. histolytica	3·6	4·8
E. coli	36·1	36·3
E. hartmanni	1·7	0
I. buetschlii	4·6	5·2
E. nana	15·5	15·1
C. mesnili	2·7	6·4
No protozoa	35·1	31·6
N	413	253

Table IV—Intestinal parasite prevalence (%) in children from commercial farms

	Farms bordered by Mazoe River	Farms not bordered by Mazoe River
S. mansoni	20·7	5·6
S. haematobium	2·4	0
H. nana	7·7	10·0
No helminths	68·6	86·7
G. lamblia	18·3	13·3
E. histolytica	5·3	21·1
E. coli	49·7	46·7
E. hartmanni	2·4	0
I. buetschlii	15·4	13·3
E. nana	23·1	11·1
C. mesnili	10·1	12·2
No protozoa	10·7	10·0
N	169	90

Communal areas

Comparisons between the prevalence of intestinal parasites between the two Chiweshe schools with and without piped water (Table III) showed marked reduction in helminth infections where piped water was available ($p < 0·001$). This was not however the case with protozoan parasites, particularly with the pathogen, *G. lamblia*, which was more common in children with access to piped water ($p < 0·01$).

Commercial farms

In children from the labour communities on commercial farms, there were quite notable differences in the prevalence of *S. mansoni* between farms adjacent to and separate from the Mazoe river (Table IV; $p<0·01$), though *H. nana* infections were common in both groups. Protozoan parasites were identified much more frequently in these children than in children from other areas, nearly 90% harbouring at least one species. On one farm, not adjacent to the river, *E. histolytica* was found in 26·8% of 56 children, but the prevalences of other protozoa were very similar on all four farms.

Urban centres

The parasite prevalence in the two urban centres were similar to each other (Table V) with *S. mansoni* being found as commonly in children from these centres as in children from communal areas with no access to piped water. *H. nana* infections, found in 8·8% of urban children, were more common than in other areas, despite the ready access to tap-water. The same was true for *G. lamblia* which showed a prevalence nearly twice that of children in rural areas with no access to piped water ($p<0·001$).

Discussion

It has been suggested on theoretical grounds that intestinal helminth infections may be a sensitive indicator of the effectiveness of improved sanitation facilities (FEACHEM *et al.*, 1983a). Although other factors are of importance, the provision of piped water to a community may also result in reduction of

Table V—Intestinal parasite prevalence (%) in schoolchildren from urban areas

	Bindura	Chinhoyi	Total
S. mansoni	3·9	5·8	4·8
S. haematobium	0	0·4	0·2
H. nana	6·3	11·6	8·8
No helminths	85·5	84·8	85·2
G. lamblia	19·5	25·0	22·1
E. histolytica	6·3	4·0	6·1
E. coli	32·8	37·1	34·8
E. hartmanni	1·3	1·8	1·5
I. buetschlii	3·5	5·4	4·4
E. nana	12·9	12·9	12·9
C. mesnili	4·7	6·3	5·4
No protozoa	34·7	35·7	35·2
N	256	224	480

parasite prevalence since some parasites may be water-borne, access to piped water may decrease the frequency of contact with surface water and the opportunity for improved hygiene is increased. Infections transmitted through water contact such as schistosomiasis or by direct faecal contamination such as hymenolepiasis or by consumption of contaminated water such as giardiasis would therefore be expected to occur less frequently if clean water was readily available. The prevalence of soil-transmitted helminths such as *Ascaris*, *Trichuris* and hookworm, would be influenced less by water supply than by improvements in sanitation (FEACHEM *et al.*, 1983a). The almost complete absence of such helminths in the communities studied in this survey accords with previous findings (e.g., GOLDSMID, 1976) and remains an unexplained phenomenon.

Infection with *S. haematobium* is extremely common in Zimbabwe and although most eggs are excreted in the urine, the presence of eggs in stool specimens reflects the high prevalence and heavy worm loads of many children in this area (MASON & TSWANA, 1984). The intermediate snail host of this parasite, *Bulinus* (*Physopsis*) *globosus*, may be readily found in most water bodies and differences in the prevalence of *S. haematobium* may thus indicate the frequency of water contact, being highest in communal areas with no piped water and lowest in urban area. The snail host for *S. mansoni* (*Biomphalaria pfeifferi*) is more focally distributed, and comparisons between communities widely separated geographically are less valid. The snails are most frequently found in large permanent rivers, and the high prevalence of *S. mansoni* in children from farms in the Mazoe valley was therefore not unexpected. The importance of frequency of water contact was demonstrated by the significant differences in the prevalence of this parasite on farms adjacent to and separate from the river. Even in urban areas, however, some children harboured this infection, indicating that they also occasionally had contact with rivers, probably for recreation. WALKER *et cl.* (1970) found that even deterrents such as wire fences and heavy fines were inadequate in preventing children from using such rivers where no alterntive recreation was provided. In the communal areas, *S. mansoni* was more common in the village with no piped water, and although no snail surveys were carried out the villages were close together, with similar geographical features, i.e., no main rivers, but small streams within 1·0 km of each village. We therefore have no reason to believe the differences were due to different snail populations, but again probably reflect the frequency of water contact in the two villages.

The epidemiology of *H. nana* infection is not well understood, but the ability of these, unlike most other, tapeworms to complete their development to an adult from an ingested egg, suggests that infection is associated with faecal contamination of fingers or food. In communities with ready access to water, with increased opportunity for hand washing, infections were as common as in communities reliant on surface water, though it should be noted that no attempt was made in this study to monitor hygiene practices in the study population.

Protozoan parasites were found more frequently in this study than in previous surveys (GOLDSMID *et al.*, 1976) though this may be partially explained by the increased sensitivity of stained smears in identifying such infections. Again the provision of piped water was not associated with a reduction in the prevalence of infection in schoolchildren, and in fact the most common pathogen, *G. lamblia*, was more prevalent in communities with "safe" water.

The transmission of *Giardia* cysts via piped water has been recorded in both developing (KHAIREY *et al.*, 1982) and developed (DYKES *et al.*, 1980) countries, and via municipal water in both Europe (BRODSKY *et al.*, 1974) and America (HOROWITZ *et al.*, 1976), presumably as a result of contamination of the water supply. Direct spread of cysts from person-to-person for example through the use of communal toilets is also possible, and the high rates of giardial infection in urban children may be related to overcrowding rather than water supply. If such were the case, however, we would have expected high rates of infection with other faecally-transmitted protozoa in these children, and this was not the case. It is known that the infective dose of *Giardia* cysts is very low, as few as 10 to 100 cysts being recorded as sufficient to cause an infection (RENDTORFF & HOLT, 1954), but even so the evidence for direct spread is far from convincing as this would not explain the significant difference in *Giardia* prevalence in the two schools in the communal areas.

In some outbreaks of giardiasis, animals have been implicated as a source of infection (DYKES *et al.*, 1980), and *Giardia* of human origin is transmissable to rodents (HAIBA, 1956). *Giardia* cysts have been identified frequently in stool specimens from dogs in Harare (Fleming, personal communication). More detailed investigation of the water supply, toilet facilities, and animals would be needed to identify the origin of the infections diagnosed in this study.

It should be noted that many of the criticisms raised by BLUM & FEACHEM (1983) in relation to other studies on the impact of water and sanitation could be applied to this study. Our comparisons, while based on reasonably large sample sizes, were made between only a few representative communities, and this may lead to erroneous conclusions. *Ascaris* and *Trichuris*, for example, though not found in any of the children included in this report, are not completely absent from this area. *Strongyloides* larvae were found in samples from only one school, indicating a particular focus of infection. Thus local factors, other than water supply, may be important in parasite transmission. The stability and mobility of the children was not determined, nor were the authenticity of the origin of the samples or the use made of available water supplies. Nevertheless, in the communal farming lands comparisons between groups with and without piped water were valid in terms of the sex and age distribution of the children, and we would not expect differences in other factors, e.g. mobility, to be significant.

While the sex and age distributions of the urban samples were also similar to the communal land samples, comparisons between the two are more tentative, in that socio-economic factors, overcrowding and mobility of families may well differ markedly. The urban children were included, however, as a group with ready access to adequate supplies of filtered and chlorinated (and therefore presumably "safest") water.

The age distribution of children on commercial farms was different from that of other communities, with a higher proportion of the children being aged 10 years and over, and the high prevalence of schistosomiasis may be a reflection of this. Again, however, the ages of children in the two groups we compared, adjacent to and away from the river, were similar. The sex differences in the two groups may account for apparent differences in the prevalence of *E. histolytica*, which was more common in boys than girls in all areas, but other parasites were equally common in boys and girls and the prevalences of, e.g. schistosomiasis could not be accounted for on this basis.

We conclude that while the provision of piped water may contribute towards a reduction in the prevalence of some parasites, e.g. schistosomiasis, local factors particularly the proximity to infected water bodies may override any benefit. Faecally transmitted parasites such as *H. nana* and protozoal infections were equally or more common in communities with and without a piped water supply. Thus while other benefits may accrue, significant reduction in parasite prevalence may not be realized unless the provision of piped water is accompanied by concomitant interventions in other sources of infection.

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