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The use of morbidity questionnaires to identify communities with high prevalences of schistosome or geohelminth infections in Tanzania

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Abstract

Parasitic infections were investigated in Morogoro Rural District, Tanzania, between October 1992 and June 1993. A total of 4589 schoolchildren (aged 7–17 years) from 30 primary schools was screened for infection with *Ascaris lumbricoides, Trichuris trichiura*, hookworms (3456 children only), *Schistosoma mansoni* and *S. haematobium*. The children were also asked about their recent experiences of the following: diarrhoea, abdominal pain, blood in stool, perception of suffering from schistosomiasis, and worm infection and examined for spleen and liver enlargement. Among schools, there were correlations between the prevalence of *S. mansoni* infection and bloody stools, spleen enlargement and liver enlargement, and between *S. haematobium* infection and the presence of blood in urine. To exclude ecological explanations for the correlations, logistic regression was used to estimate the adjusted odds ratio (OR) for each infection and each sign or symptom. No sign or symptom was significantly associated with any geohelminth infection. Reported blood in stool was significantly associated with *S. mansoni* infection (OR=1·62, P=0·045). Reported blood in urine was significantly associated with *S. haematobium* infection (OR=7·71, P<0·001), as was reported blood in stool (OR=11·52, P<0·001), indicating that presence of blood in either form of excreta was related to the local term for schistosomiasis. These results support the possibility of using reported blood in stool as a means of rapid assessment for identifying communities with a high prevalence of *S. mansoni* infection.

Keywords: geohelminthiasis, schistosomiasis, *Ascaris lumbricoides, Trichuris trichiura*, hookworms, *Schistosoma haematobium, Schistosoma mansoni*, prevalence assessment, morbidity, questionnaire, children, Tanzania

Introduction

Conventional approaches to identifying communities with high prevalence of parasitic infection are usually too expensive and time-consuming for countries such as Tanzania. Some workers have therefore investigated alternative approaches using questionnaires. A series of studies in a rural Tanzanian district identified villages with high prevalences of *Schistosoma haematobium* infection using a simple questionnaire, a cost-effective screening technique (LENGELER *et al.*, 1991a, 1991b, 1991c). The approach was validated in 7 other African countries (RUSG, 1995) before being recommended by the World Health Organization (WHO) as a method of screening communities for *S. haematobium* infection by District health management teams (CHITSULO *et al.*, 1995).

The morbidity questionnaire approach has also been applied to *S. mansoni* infection, but primarily to aid diagnosis at the individual level. Together with clinical studies, various morbidity indicators have been significantly associated with infection, including diarrhoea, hepatomegaly, splenomegaly, and reported blood in stool (ONGOM & BRADLEY, 1972; SUKWA *et al.*, 1985; GRYSEELS & POLDERMAN, 1987; GRYSEELS, 1988; PROIETTI & ANTUNES, 1989; LIMA E COSTA *et al.*, 1991). More recently, attributable risk analysis has been applied to data from Burundi and China, where a high fraction of bloody stool episodes could be attributed to *S. mansoni* and *S. japonicum* infection (GUYATT *et al.*, 1995; BOOTH *et al.*, 1996). Together, these observations suggest that development of rapid assessment indicators for intestinal schistosomiasis is feasible.

In the present paper we describe the results of the first large scale investigation of this method of assessing infections with *S. mansoni, S. haematobium, Ascaris lumbricoides, Trichuris trichiura* and hookworms. We describe the age-related distribution of helminth infections and several signs and symptoms among children in Morogoro Rural District, Tanzania and report on the potential of the questionnaire-based approach in the identification of communities with high prevalence of each helminth infection, using logistic regression methods to ensure that any observed geographical correlations were not ecological.

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Materials and Methods

Study area

The study was conducted in 30 villages of Morogoro Rural District between October and December 1992. The district is one of the 5 that form Morogoro Region and lies 500–1000 m above sea level, covers an area of 19250 km^2, and contains the Uluguru mountains. To the north, the average rainfall is approximately 1500 mm per annum. In the south of the district, which includes the mountainous area, annual rainfall ranges from 2000 mm to 2500 mm. The short rainy season occurs between late October and mid January, and the long rainy season between March and May. Minimum and maximum daily temperatures in the study area are 10–21°C and 26–34°C respectively.

Sampling schools

A list of all the schools in the district was obtained from the district education officer. A second list was prepared, excluding schools in the mountains and those which were remote and inaccessible. From this list, 30 schools were selected at random. Meetings at schools and in the adjacent communities were organized before the study, in order to inform parents about the aims of the project and to seek consent. In each school, 160–180 children aged 7–17 years were randomly selected for parasitological and clinical examination. A morbidity questionnaire was also administered, focusing on symptoms commonly associated with intestinal helminths and schistosomiasis with a recall period of 2 months.

Stool examination

All selected children were given stool containers one night before the survey and asked to collect stool at home the next morning and to bring the filled container to school. At school, the specimens were macroscopically examined for consistency, mucus and overt blood before using the Kato–Katz technique (KATZ *et al.*, 1972). The slides were examined the next day for the presence of *S. mansoni. A. lumbricoides* or *T. trichiura*

eggs. Approximately 75% of all supplied stools were examined using the saline flotation method (YANG & SCHOLTEN, 1977) for hookworm eggs. Each stool sample was examined only once.

Urine examination

Urine specimens were collected between 10:00 and 13:00. They were first examined macroscopically for macrohaematuria. With specimens without macrohaematuria, a reagent strip test to identify microhaematuria was performed, followed by filtration of 10 mL of urine using a Nuclepore™ membrane as described by ZUMSTEIN (1983). The filter was examined under the microscope and any eggs of *S. haematobium* were counted.

Morbidity questionnaire

A questionnaire was first tested and then administered in the common language (Kiswahili) by 2 clinical officers, who were not aware of the parasitological and clinical findings. Children were asked to recall episodes of bloody diarrhoea, bloody urine, diarrhoea, bloody stools and abdominal pain in the 2 months before the survey. They were also asked if they thought they currently had worms or schistosomiasis (*minyoo* and *kichocho*, respectively, in Kiswahili).

Clinical examination

Schoolchildren were examined for liver and spleen enlargement by 2 clinical workers who were unaware of the findings of the other surveys. When the liver was palpable, the maximum size was measured in centimetres from the right costal margin in the mid-clavicular line whilst the child was supine. Children were palpated while standing for spleen enlargement and the size was measured using the classification of HACKETT (1944).

Data analysis

Prevalences of each infection, sign and symptom were estimated for each age group and each school population. Confidence limits (95%) for the morbidity indicators were estimated as described by FLEISS (1981). For each infection, the prevalence and arithmetic mean intensity (number of eggs per gram of faeces or 10 mL of urine) were estimated for each age group and sex. The relationship between the prevalence of morbidity and the prevalence of infection was also assessed for each sign, symptom and parasite species, using the rank correlation test of KENDALL (1938) to test for any geographical correlation between each infection and morbidity indicator.

Logistic regression was used to identify which of the significant rank correlations were least likely to be ecological, by testing for associations between individual signs and the presence of particular infections having adjusted for sampling in different schools. This analysis was conducted using the Egret™ computer program (SERC, 1991). Models were constructed with a single sign or symptom as the dependent variable, and terms for one or more infections, sex and age (Table 3). The school of each child was added as a random effect, in order to adjust for random variation in the prevalence of each sign or symptom among the schools. Since hookworm data were available for only 75% of the children, each model was fitted on a reduced dataset with a term for hookworm infection, and then on the whole dataset without the term for hookworm infection. From the output of each model, the adjusted odds ratio (OR) for each infection and associated value of P (null hypothesis: OR=1) were recorded.

Results

A total of 4589 children from 30 schools entered the surveys, although not all children provided information for all surveys; only 3456 could be examined for hookworm infection. The most common infection was *S. haematobium*, with an overall infection prevalence of

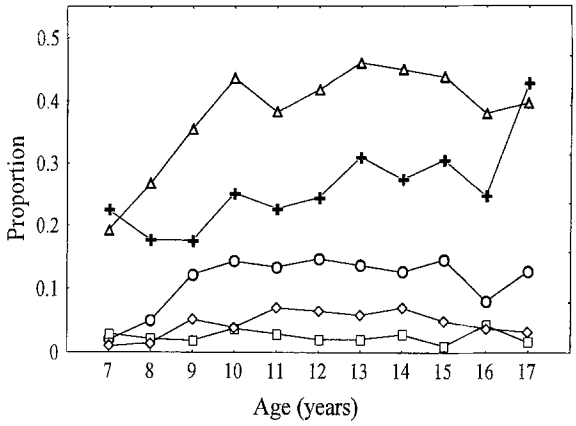

Fig. 1. Relationship between infection prevalence and age for 5 helminth infections recorded in children aged between 7 and 17 years of age in Morogoro Rural District, Tanzania. △, *S. haematobium*; +, hookworms; ○, *A. lumbricoides*; ◇, *S. mansoni*; □, *T. trichiura*.

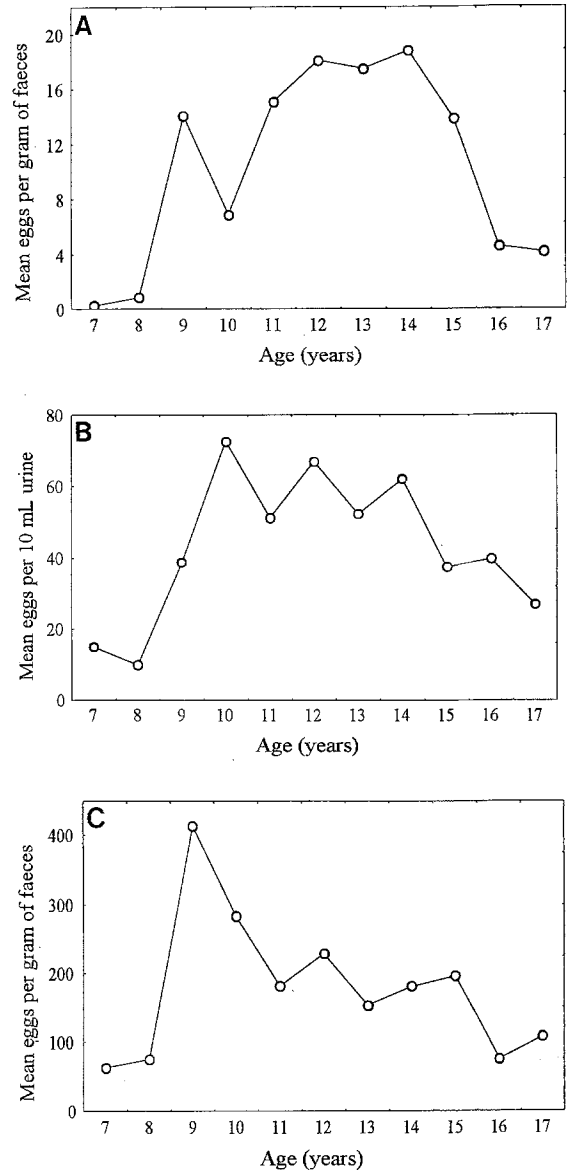

Fig. 2. Relationships between age and mean egg counts of (A) *S. mansoni*, (B) *S. haematobium*, and (C) *A. lumbricoides* recorded in children in Morogoro Rural District, Tanzania.

39·6% (range 6·5–90·4% by school). The overall prevalence of *S. mansoni* infection was low (6·4%), but among schools it was highly heterogeneous—in 2 schools the infection prevalence reached 54·7% and 81·0%, respectively. The most common geohelminth infection was hookworm, with an overall infection prevalence of 26·3% (range 1·6—51·9%). Among the other infections, 13·9% of the children were infected with *A. lumbricoides* (range 0–78·0%), and 2·3% were infected with *T. trichiura* (range 0–9·2%).

Age–prevalence and age–intensity profiles are shown in Figs 1 and 2, respectively. The prevalence of hookworm infection increased continually with age, whereas *S. haematobium* infection prevalence reached a peak in the 13 years old age group. The less common infections showed little variation in infection prevalence with age; nonetheless, infection intensities were highly variable. Both *S. mansoni* and *S. haematobium* egg counts were highest in the 9–14 years age range, and mean *A. lumbricoides* infection intensity reached a peak in the 9 years old age group before rapidly declining (Fig. 2).

Overall prevalences of each recorded sign and symptom are given in Table 1. Perceived infection with schistosomiasis was reported by over 30% of all schoolchildren, and was the most common indicator. The most common sign was spleen enlargement, and the most common reported symptom was blood in urine. The prevalence of reported bloody diarrhoea was very low, and this morbidity indicator was therefore excluded from further analysis. The prevalence of spleen enlargement varied most widely with age, peaking in the 9 years old children and rapidly falling thereafter (Fig. 3). Reported blood in urine and perceived schistosomiasis had very similar age–prevalence profiles, which corresponded closely with that for *S. haematobium* infection (Fig. 2). The prevalence of reported diarrhoea also reached a peak in 9 years old children, and the gastro-intestinal symptoms were generally less prevalent in older children.

Table 1. Overall prevalences of nine morbidity indicators measured during surveys of children from Morogoro Rural District, Tanzania

Indicator	Prevalence (%)
Bloody stool	4·46 (3·78–5·24)
Blood in urine	28·73 (27·18–30·32)
Bloody diarrhoea	1·54 (1·16–2·04)
Abdominal pain	4·06 (3·42–4·81)
Diarrhoea	23·75 (22·30–25·26)
Enlarged liver	5·29 (4·55–6·12)
Enlarged spleen	28·02 (26·49–29·60)
Perceived worm infection	10·54 (9·51–11·66)
Perceived schistosomiasis	31·14 (29·54–32·75)

[a]Percentages reporting symptom or fulfilling case definition for liver or spleen enlargement (see text); 95% confidence intervals are given in parentheses.

Rank correlation analysis

Prevalence relationships between morbidity indicators and helminth infection were assessed by rank correlation (Table 2). *S. haematobium* infection prevalence was highly correlated with the prevalence of perceived schistosomiasis and with the prevalence of reported blood in urine. Also significant were the correlations between the prevalence of *S. mansoni* infection and reported bloody stool, liver enlargement, perceived worm infection, reported abdominal pain and spleen enlargement. There was no significant relationship between the prevalence of *A. lumbricoides* and any sign or symptom, and the apparent negative correlations between hookworm infection prevalence and the prevalence of several signs and symptoms could be explained by the highly significant negative correlation which was found between the prevalence of hookworm and *S. mansoni* in-

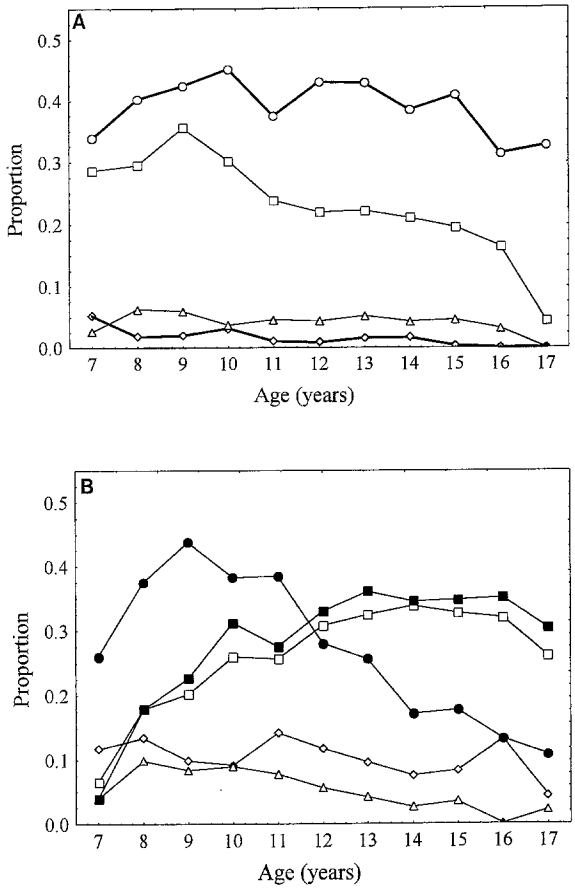

Fig. 3. Relationships between age and prevalence of (A) reported gastro-intestinal symptoms (○, abdominal pain; □, diarrhoea; ◇, bloody diarrhoea; △, bloody stool) and (B) other morbidity indicators (□, bloody urine; ◇, perceived worm infection; ■, perceived schistosomiasis infection; △, liver enlargement; ●, spleen enlargement).

Table 2. Kendall's rank correlation analysis of the prevalences of four helminth infections and eight morbidity indicators in schoolchildren in Morogoro Rural District, Tanzania

	A. lumbricoides		*S. haematobium*		Hookworms		*S. mansoni*	
	τ	*P*	τ	*P*	τ	*P*	τ	*P*
Bloody stool	0·152	0·2560	0·105	0·4305	−0·430	0·0013	0·488	0·0003
Blood in urine	−0·028	0·8305	0·801	<0·001	0·058	0·6630	0·066	0·6243
Diarrhoea	−0·008	0·9488	0·320	0·0167	−0·289	0·0311	0·249	0·0624
Abdominal pain	−0·020	0·8810	0·246	0·0658	−0·368	0·0060	0·343	0·0104
Liver enlargement	0·219	0·1014	0·159	0·2330	−0·398	0·0030	0·488	0·0003
Spleen enlargement	0·042	0·7485	0·294	0·0281	−0·167	0·2127	0·412	0·0021
Perceived worm infection	0·020	0·8788	0·057	0·6720	−0·413	0·0020	0·426	0·0015
Perceived schistosomiasis[a]	NA	NA	0·827	<0·001	NA	NA	0·109	0·4144

[a]NA=not applicable.

fections at the school level (n=28, Kendall's τ=0·41, P=0·0023). The prevalence of *T. trichiura* infection was too low in most schools for this analysis.

The relationship between the prevalence of *S. mansoni* infection and reported bloody stool was non-linear (Fig. 4, A), although a high prevalence of *S. mansoni* infection was accompanied by a relatively high prevalence of bloody stool. The relationship between *S. mansoni* infection prevalence and that of liver enlargement was more linear although, like reported bloody stool, there was wide variation in the prevalence of the morbidity indicator at low *S. mansoni* infection prevalences (Fig. 4, B). The 2 schools with high prevalences of *S. mansoni* infection also had high prevalences of spleen enlargement; however, equally high prevalences of spleen enlargement were found in schools with very low *S. mansoni* infection prevalence (Fig. 4, C).

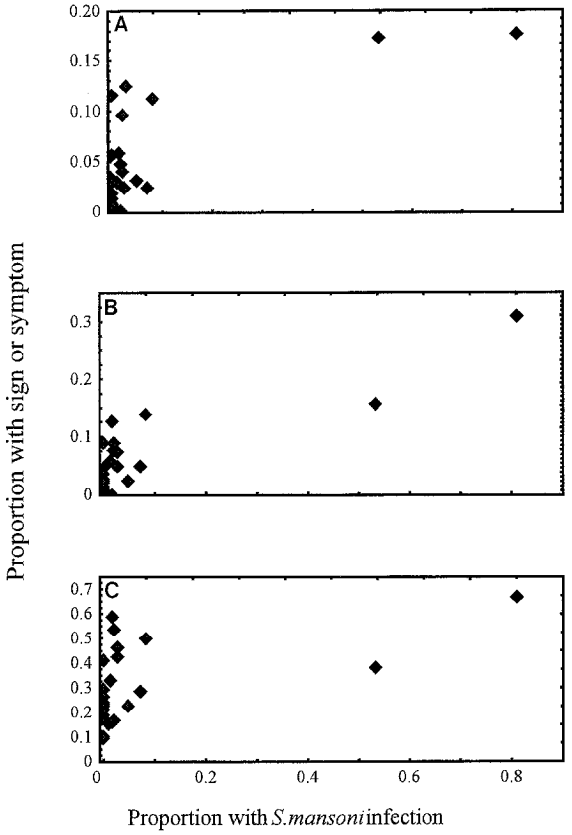

Fig. 4. Relationships between the prevalence of *S. mansoni* infection and the prevalence of (A) reported blood in stool and enlargement of (B) liver and (C) spleen. Each point represents the paired estimates for one school.

Logistic regression

The deviances of 8 models are given in Table 3. Models with deviance values of P>0·9999 could not have been improved by adding extra explanatory variables. Three models had significant deviances (P<0·01), indicating that unrecorded factors contributed to the variation in the prevalences of spleen enlargement, diarrhoea and abdominal pain among schools. Inclusion of a term for hookworm infection in the models affected some odds ratios, and thus the detailed regression results in Table 4 are given for models which included this term. For *A. lumbricoides*, no adjusted odds ratio differed significantly from 1. Individuals with *T. trichiura* infection were significantly more likely to report abdominal pain after adjusting for the effects of all other infections, but not when the hookworm effect was excluded from the models (OR=1·576, P=0·282). The association between *S. mansoni* and reported blood in stool was just non-significant when the hookworm effect was excluded from the models (OR=1·52, P=0·056), and on the borderline of significance when the hookworm term was included (Table 4). Inclusion of an interaction term between *S. mansoni* infection and age in the bloody stool model revealed that the association between infection and morbidity was stronger in older children (Fig. 5).

Both reported blood in urine and a positive answer to the schistosomiasis question were good indicators of *S. haematobium* infection (OR=7·7 and 7·9, respectively) (Table 4). In further analysis, we found that females were less likely to report blood in urine (OR=0·43, P=<0·001) or to answer that they had schistosomiasis

Table 3. Details and fitting statistics of eight logistic regression models for five helminth infections in schoolchildren

Outcome variable	Terms included in model[a]	d.f.	Deviance	P
Bloody stool	age, sex, asc, tri, man, hkw	3175	1018·2	>0·999
Blood in urine	age, sex, man, haem	4065	3419·3	>0·999
Diarrhoea	age, sex, asc, tri, hkw, man, haem	3170	3382·8	0·006
Abdominal pain	age, sex, asc, tri, hkw, man, haem	3169	4163·9	<0·001
Liver enlargement	age, sex, asc, tri, hkw, man, haem	3308	1162·5	>0·999
Spleen enlargement	age, sex, asc, tri, khw, man, haem	3308	3551·1	0·002
Perceived worm infection	age, sex, asc, tri, hkw, man, haem	2928	1999·4	>0·999
Perceived schistosomiasis	age, sex, man, haem, bloody stool	4064	3448·6	>0·999

[a]asc=*Ascaris lumbricoides*, haem=*Schistosoma haematobium*, hkw= hookworms, man=*S. mansoni*, tri=*Trichuria trichiura*.

Table 4. Logistic regression analysis for five helminth infections and eight morbidity indicators in schoolchildren

	S. mansoni		*S. haematobium*		*A. lumbricoides*		*T. trichiura*		Hookworms	
Morbidity indicator	OR[a]	P	OR[a]	P	OR[a]	P	OR[a]	P	OR[a]	P
Bloody stool[b]	1·62	0·045	NA	NA	1·47	0·113	0·3	0·238	0·66	0·117
Blood in urine[b]	0·64	0·023	7·71	<0·001	NA	NA	NA	NA	NA	NA
Abdominal pain	0·78	0·46	0·89	0·235	0·89	0·428	1·53	0·091	0·89	0·186
Diarrhoea	0·70	0·139	0·84	0·100	0·96	0·795	0·995	0·972	0·77	0·781
Liver enlargement	1·18	0·507	1·34	0·17	1·22	0·394	2·02	0·135	1·00	0·991
Spleen enlargement	1·34	0·221	1·14	0·183	1·02	0·906	0·70	0·224	0·89	0·260
Perceived worms	0·92	0·736	0·86	0·297	0·73	0·139	1·32	0·45	0·71	0·032
Perceived schistosomiasis[b]	0·76	0·185	7·79	<0·001	NA	NA	NA	NA	NA	NA

[a]Adjusted odds ratio.
[b]NA=not applicable.

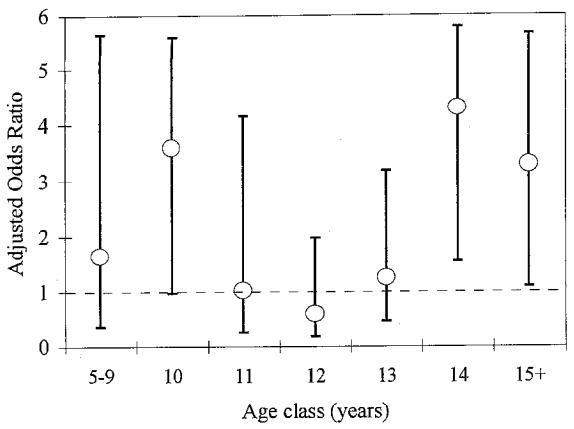

Fig. 5. Relationship between the age and adjusted odds ratio for reported bloody stool and *S. mansoni* infection. Vertical lines indicate 95% confidence limits; the horizontal broken line indicates which odds ratios were significantly greater than 1.

(OR=0·64, P=0·023), even when adjusting for age and infection status in the same model. Finally, we found that children with perceived schistosomiasis were highly likely to have seen blood in their stool (OR=11·52, P<0·001).

Discussion

Although schistosomes and geohelminths represent major public health problems in parts of Tanzania, the resources available for their control are very limited. Therefore cost-effective approaches to screening communities for intervention against major parasitic diseases are required. This project attempted to improve the prospects for cost-effective control by focusing on the potential for rapid identification of communities with a high prevalence of helminth infection. Despite the generally low level of infection in the study schools, the analysis has identified which morbidity indicators might be most useful in Morogoro and elsewhere.

Any indicator which is being considered as a rapid assessment tool must be a covariate of the infection of interest. This means that the indicator and infection must not only have the same geographical distribution, but also be closely associated at the individual level to exclude any ecological basis for the geographical correlation. The rank correlation analysis tested the extent of geographical covariation and revealed strong correlations between several infection/outcome combinations, although these were confined to schistosome infections. The strongest correlation was between *S. haematobium* and reported blood in urine, in agreement with previous studies in Tanzania and elsewhere in Africa (LENGELER *et al.*, 1991b; RUSG, 1995). The results of the logistic regression clearly confirmed the association, and thus further supported the use of reported blood in urine as a rapid assessment tool for *S. haematobium*.

There was very little evidence of association between each sign and symptom and the geohelminth infections, in either analysis. The lack of correlation between the prevalence of *A. lumbricoides* infection and the prevalence of any morbidity indicator recorded in the present study effectively precludes the use of gastro-intestinal symptoms as rapid assessment tools for this infection. This does not mean that there was no morbidity attributable to *A. lumbricoides* infection at the time of the surveys, but does suggest the need for alternative methods of directly estimating the public health impact of this species.

Although hookworm infection prevalence was negatively correlated with the prevalence of diarrhoea, blood in stool and liver enlargement, this is likely to have been a result of negative correlations between the prevalence of the true aetiological agents and hookworm infection. Hookworm infection intensities could not be measured but, with an overall prevalence around 25%, it is unlikely that many people had infection intensities high enough to cause significant morbidity (LWAMBO *et al.*, 1992). As the prevalence and mean intensity of *T. trichiura* infection were low, this infection can also be discounted as a major source of morbidity among schoolchildren from Morogoro.

Significant correlations between the prevalences of *S. mansoni* infection and of reported blood in stool, liver enlargement and spleen enlargement were found in the rank correlation analysis. The geographical distribution criteria for these indicators to be used as rapid assessment tools were thereby fulfilled. However, in the logistic regression analysis there was only a borderline significant association between *S. mansoni* infection and bloody stool. This association was significant only when hookworms were included in the regression equation, and so its true significance is not clear.

Our confidence in the causal relationship between *S. mansoni* infection and blood in stool is none the less supported by 2 precautions taken in the data collection and analysis. First, a distinction was drawn between bloody diarrhoea and blood mixed with solid faecal matter, thus excluding dysenteric agents as the cause of loss of blood. Second, we adjusted for the potentially biasing effect of other helminth infections. Since both *T. trichiura* and hookworm infections may lead to blood loss in stools (ROCHE & LAYRISSE, 1966; LAYRISSE *et al.*, 1967), some bloody stool episodes may be attributable to either of these infections in certain communities. Even if the infection intensities of these 2 worms were too low to cause substantial morbidity in Morogoro rural district, hookworm in particular could be a major cause of morbidity in other areas, since the prevalence has been recorded as 60% and higher in some studies in the adjacent district of Kilombero (TANNER *et al.*, 1991). Thus a high prevalence of bloody stools in some areas may be attributable to helminth infections other than *S. mansoni*.

As competing causes can be largely excluded from the present analysis, a parsimonious explanation is required for the observation that only a small number of *S. mansoni* cases reported bloody stools. Such an explanation can be found by considering the influence of fluctuations in schistosome egg excretion, which can be extreme from day to day (ENGELS *et al.*, 1996). Since on most days a small number of eggs is excreted, sampling only once can easily lead to a large number of false negative results (DE VLAS & GRYSEELS 1993). This means that recall of bloody stool episodes by an infected individual does not guarantee that parasite eggs will be found in a stool sample from the same person. Applying this logic to the present study explains fully why few individuals both reported bloody stool episodes and were correctly diagnosed for infection.

Evidence that a clearer association between reported blood in stool and *S. mansoni* infection could be exploited arose from the logistic regression analysis. An answer of 'yes' to the question 'do you have schistosomiasis?', was very closely associated with the reported presence of blood in stool, as well as with the reported presence of blood in urine. This means that children were likely to have answered 'yes' to the schistosomiasis question if they had observed blood in either their stool or urine. Since the reported presence of blood in urine was not related to the reported presence of blood in stool, we can exclude any ecological basis for this observation. Whether the children recognized that blood in excreta is the result of an infection, or whether they were interpreting the Kiswahili word *kichocho* to mean the presence of blood in their excreta, cannot be answered from the available data, but clearly warrants further investigation.

We can draw on the results of the present analysis to label several symptoms as unsuitable for further evalua-

tion in rapid assessment studies of helminth infections, at least in Morogoro. Perception of worm infection, despite a positive prevalence correlation with *S. mansoni*, was not associated with any helminth species in the regression analysis. This suggests that children were unable to associate any symptom with a local generic term for helminth infection. Reported diarrhoea had a similar odds ratio for all infections, and on this basis alone is unsuitable for diagnosing any one species. Reported abdominal pain is also unsuitable as a rapid assessment tool on this basis.

The prevalence of liver enlargement was strongly correlated with the prevalence of *S. mansoni* infection, but there was no association in the regression analysis. This initially suggests an ecological correlation, but is more likely to have been related to the relative dynamics of *S. mansoni* infection and this form of morbidity (CHAN *et al.*, 1996). None the less, these observations effectively exclude hepatomegaly as a potential rapid assessment tool for *S. mansoni* infection, since the presence of liver enlargement in an individual at the time of a survey may be related more to a history of infection rather than to current infection status, or even to the presence of concurrent infections such as malaria.

Overall, the results of the present analysis suggested that reported blood in stool has the best potential as a symptom-based rapid assessment tool for identifying communities with a high prevalence of *S. mansoni* infection. Further evaluation of this indicator would be worth while, although there will always be a need to account for the potentially biasing effect of other infections and to take into account local definitions of the term 'blood in stool'. Additional evaluation could also involve assessment *in situ* of the potential for schistosome transmission, through identification of water bodies likely to contain intermediate snail hosts (ODERMATT, 1994), and questions related to water contact activities (BARRETO, 1993). A 'gold standard' in terms of *S. mansoni* infection is also required, perhaps based on circulating antigens in urine (VAN ETTEN *et al.*, 1996). With these tools, we can conclude that rapid assessment of communities with a high prevalence of *S. mansoni* infection is a realistic objective for further investigation.

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